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Air Pollution Control and Chemicals Division

PTI by PN for Construction Machinery

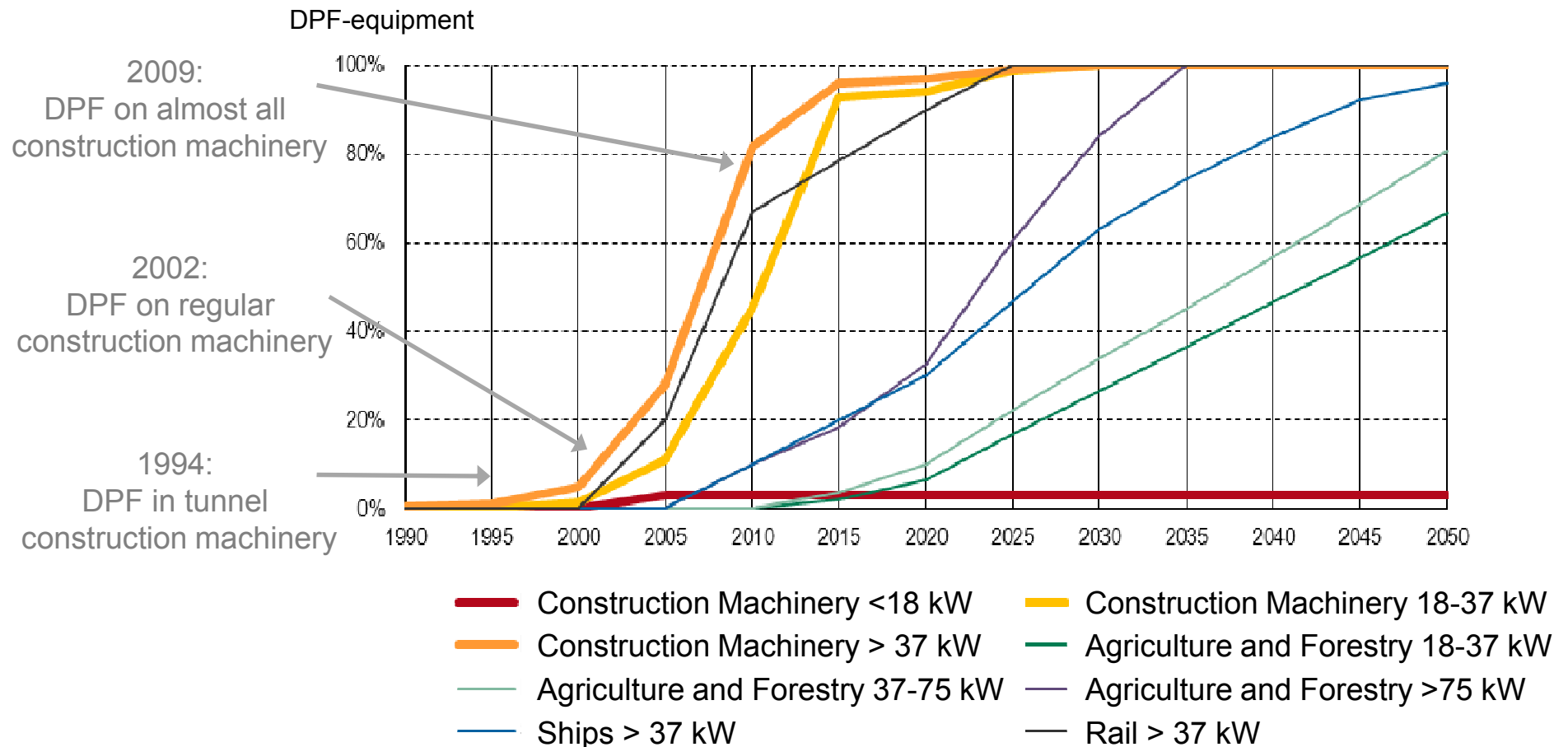
VERT-Forum, 15.3.2018

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Federal Office for the Environment FOEN



Mobile machinery, (post-)equipped with DPF in Switzerland



Source: FOEN, 2015



Results of a Study Commissioned by FOEN ([Report No. B485a](#))

Measurements on construction machinery with DPF
using NPET 3795, P-Track and opacimeter.



NPET 3795:
Condensation Particle Counter (CPC)
+ thermoconditioning
+ dilution



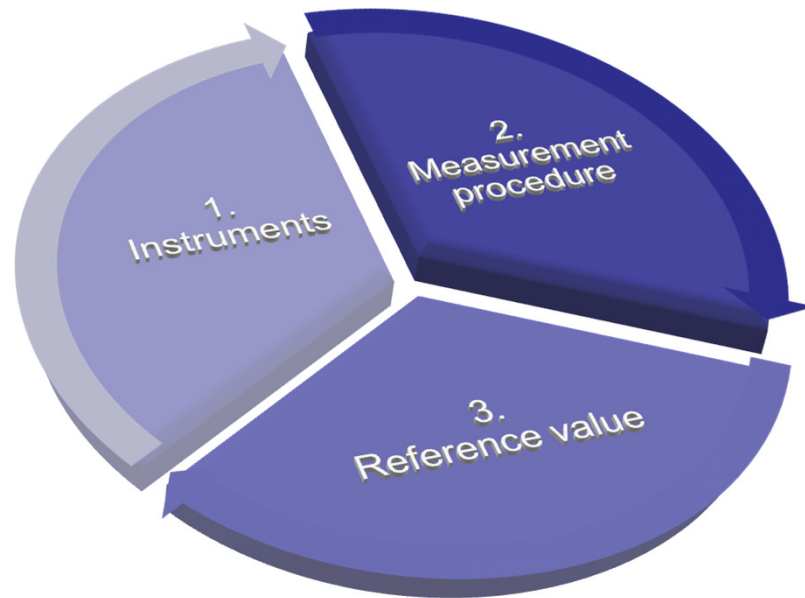
P-Track 8525:
Condensation Particle Counter (CPC)



Opacimeter Dismoke 4000:
Absorption



PN Measurement for Construction Machinery: a well-defined system (I/II)



NPET 3795

1. Requirements for PN-measuring instruments: [VAMV](#)
2. Measurement procedure: [construction guideline air](#)
3. Reference value: [construction guideline air](#)

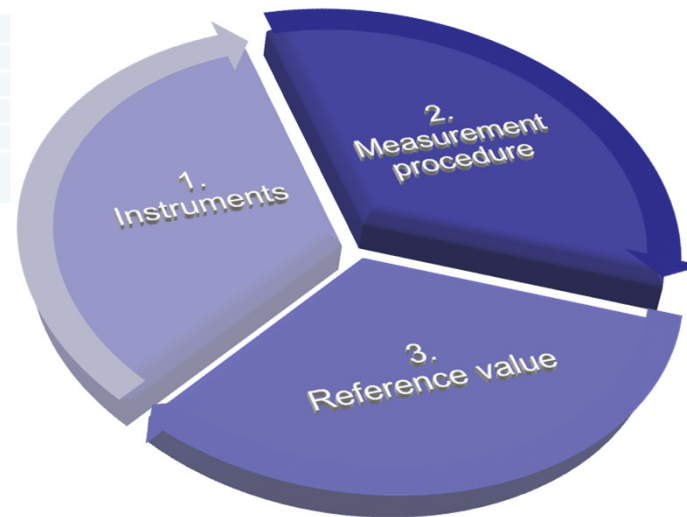


PN Measurement for Construction Machinery: a well-defined system (II/II)

Requirements similar to PN-PEMS for Real Driving Emissions (RDE):

measurement point: high idle
measurement duration: 40s

Mobility diameter	Limits of efficiency E
23 nm nanoparticles	$E < 50 \%$
41 nm nanoparticles	$50 \% < E$
80 nm nanoparticles	$70 \% < E < 130 \%$
200 nm nanoparticles	$E < 200 \% \quad 300\%$
30 nm droplets of tetracontane (number concentration up to 10^5 cm^{-3})	$E < 5 \%$

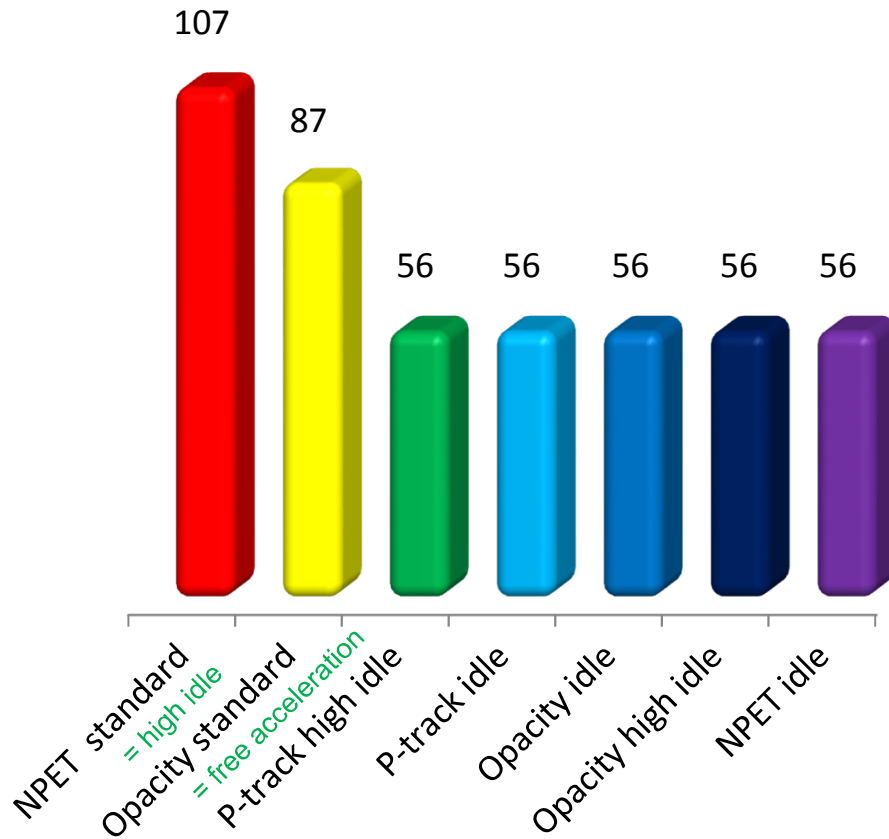


Type approval value $1 \cdot 10^{12} \text{ \#/kWh}$,
converted to other dimensions:
 $2.5 \cdot 10^5 \text{ \#/cm}^3$ (250'000 \#/cm^3)

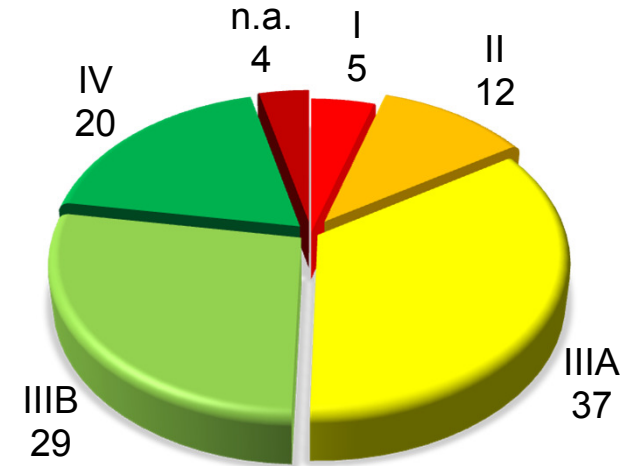


Measurements of Report No. B485a

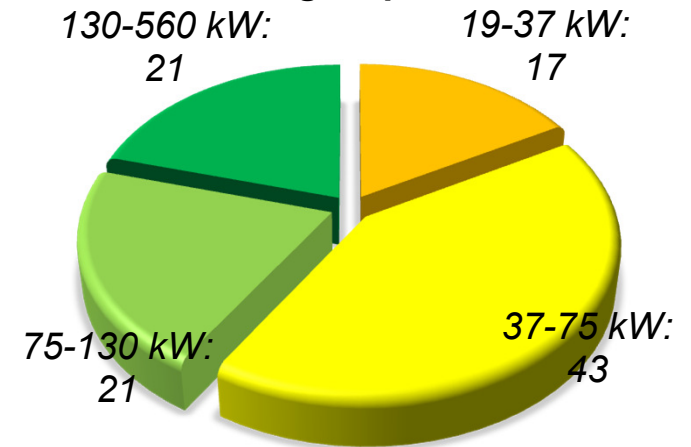
Number of measured construction machinery



emission stage



engine power

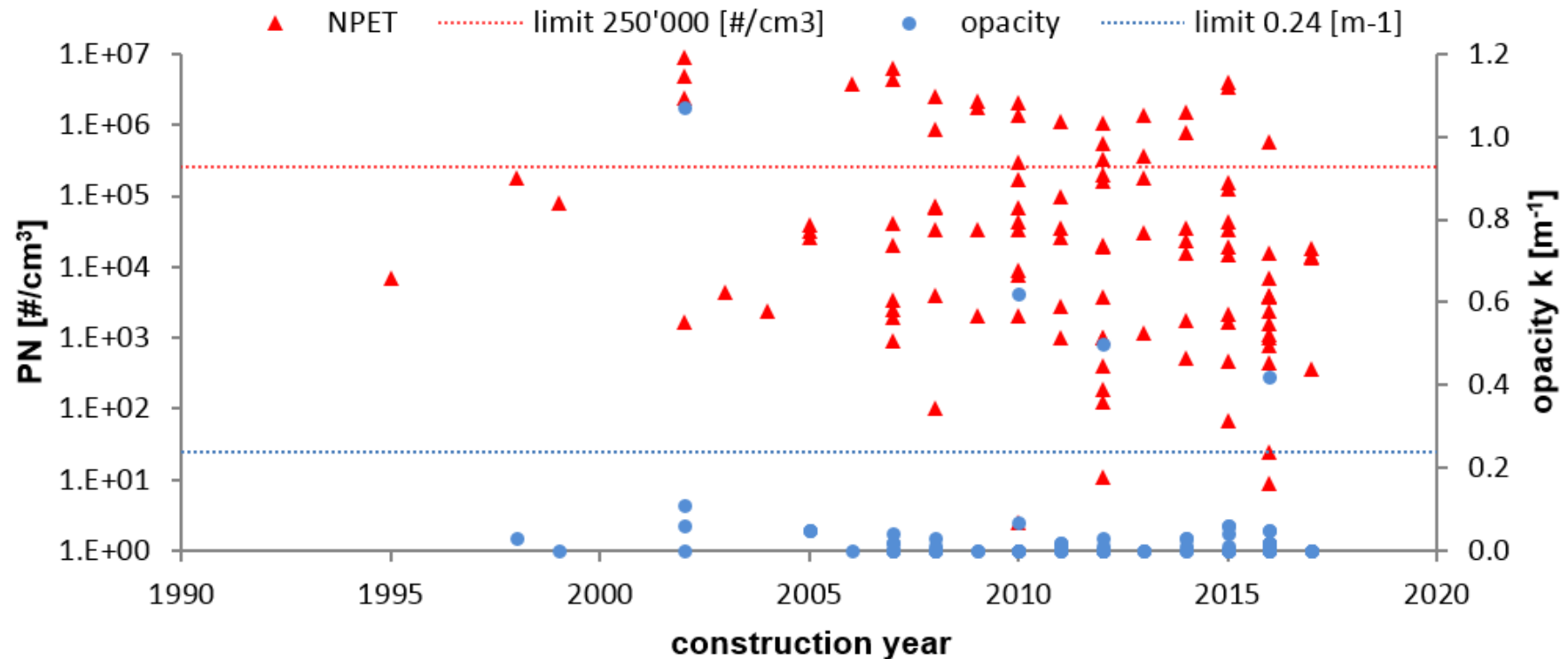


Source: AFHB 2017



Comparison PN (NPET) – Opacity Sorted by: Construction Year

n = 87 machines

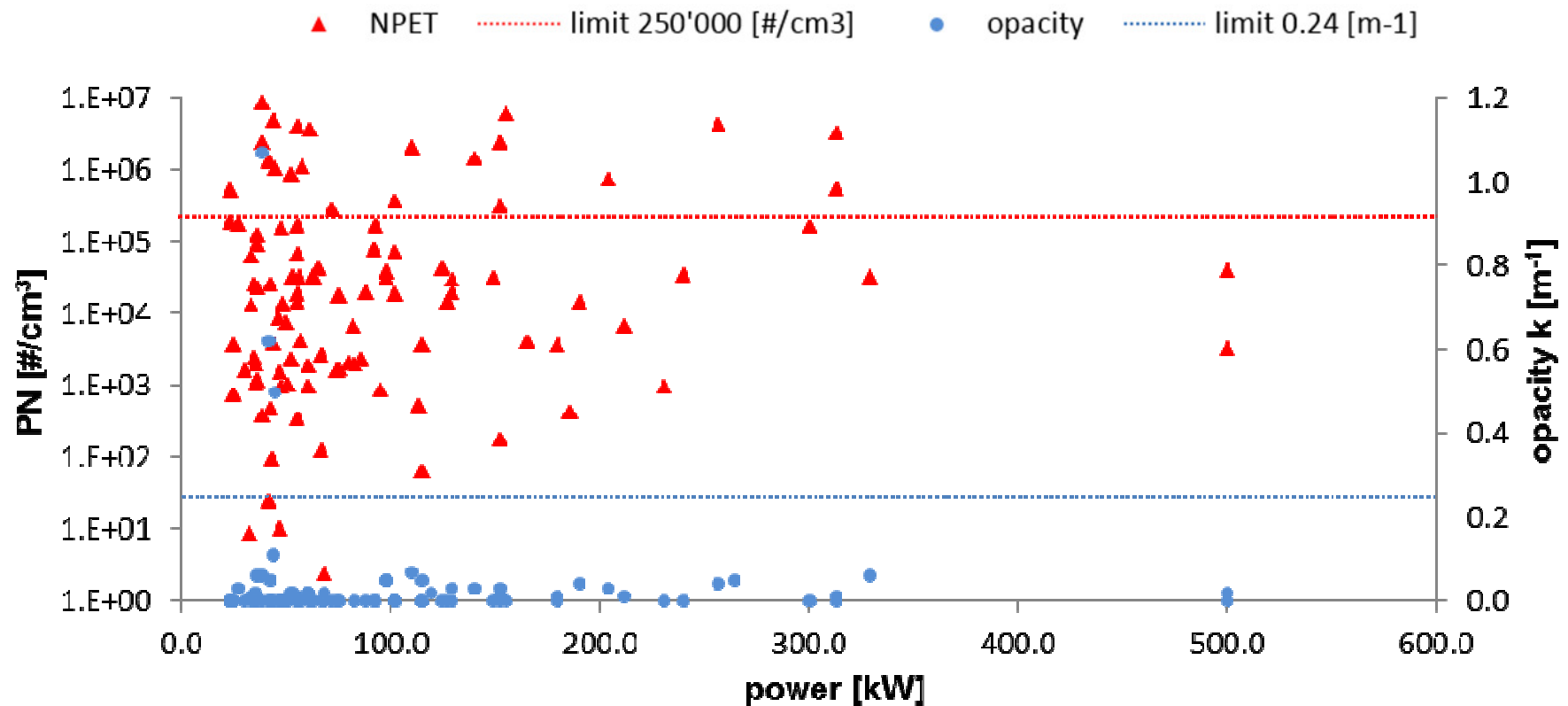


Source: AFHB 2017



Comparison PN (NPET) – Opacity Sorted by: Power

n = 87 machines

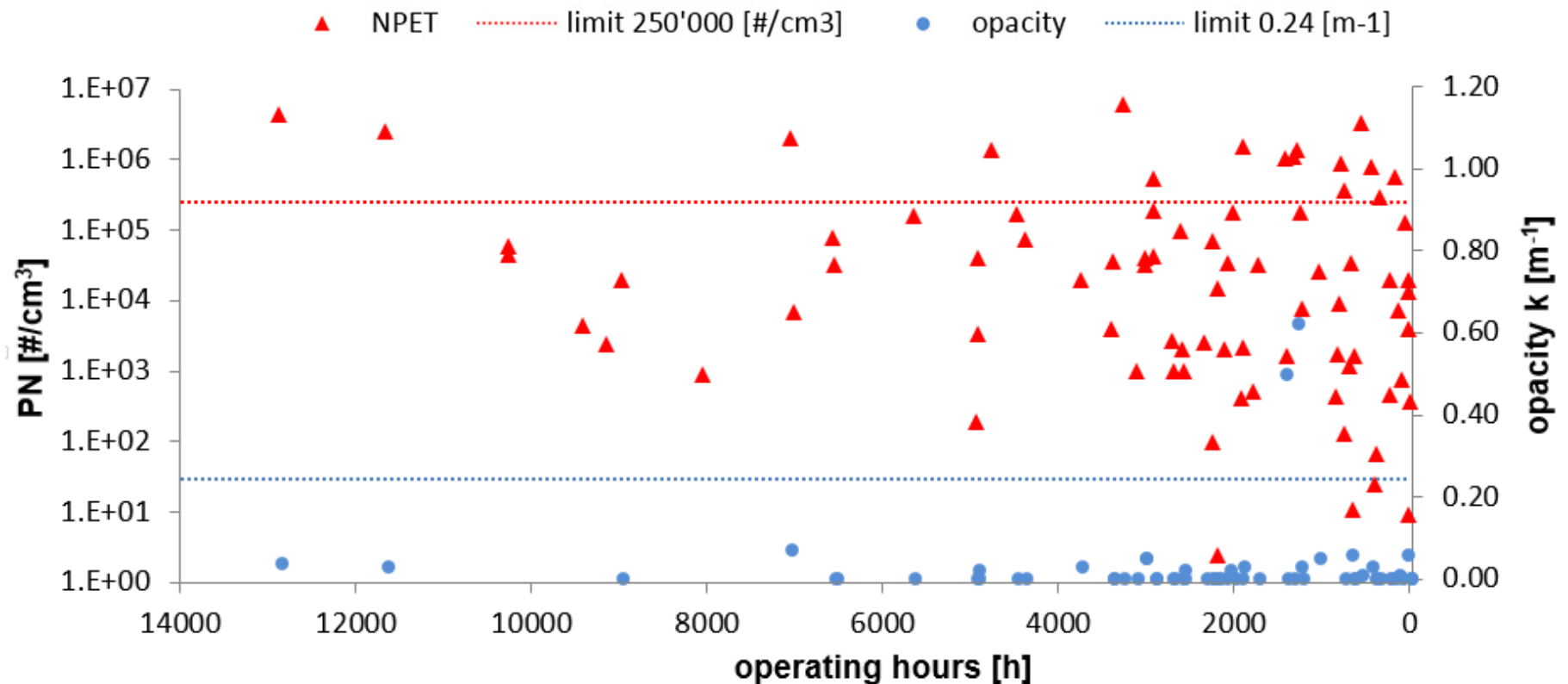


Source: AFHB 2017



Comparison PN (NPET) – Opacity Sorted by: Operating Hours

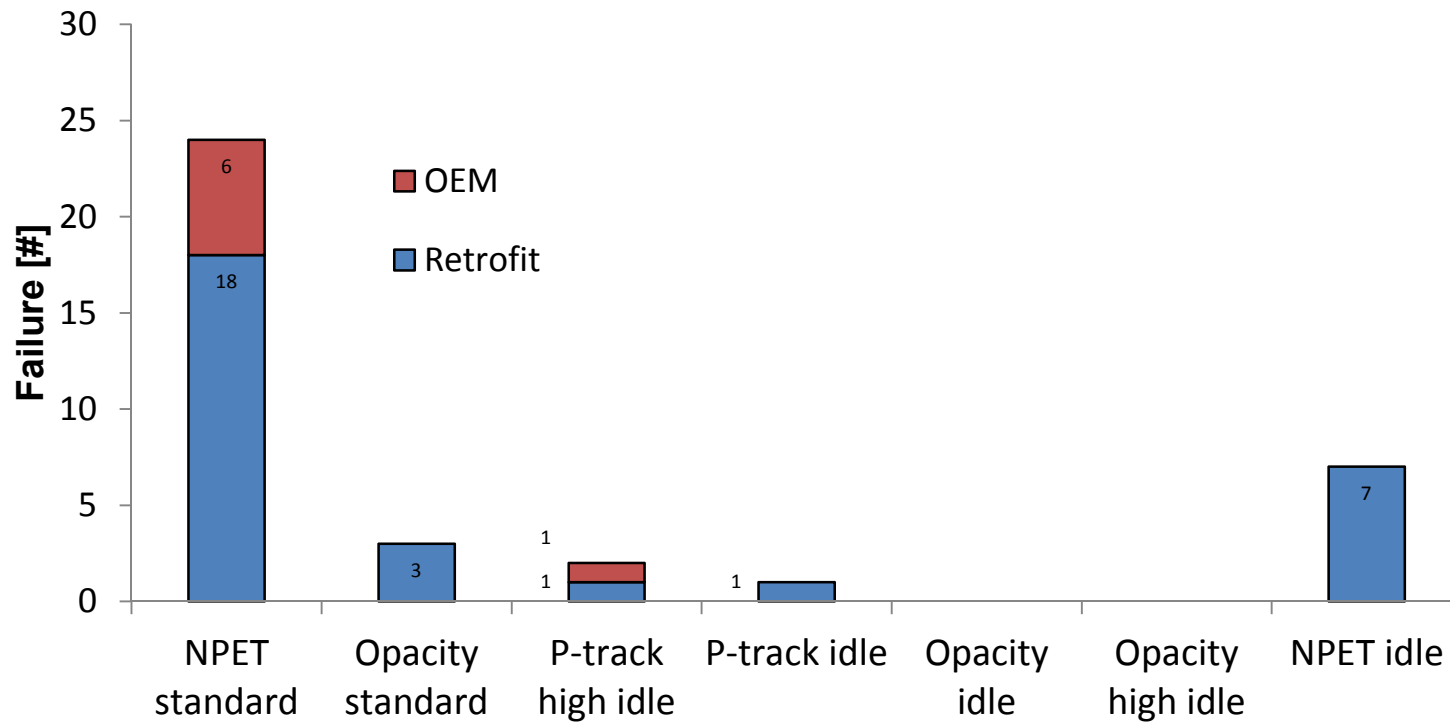
n = 87 machines



Source: AFHB 2017



DPF Failure Comparison, Absolute Number n = 56-107

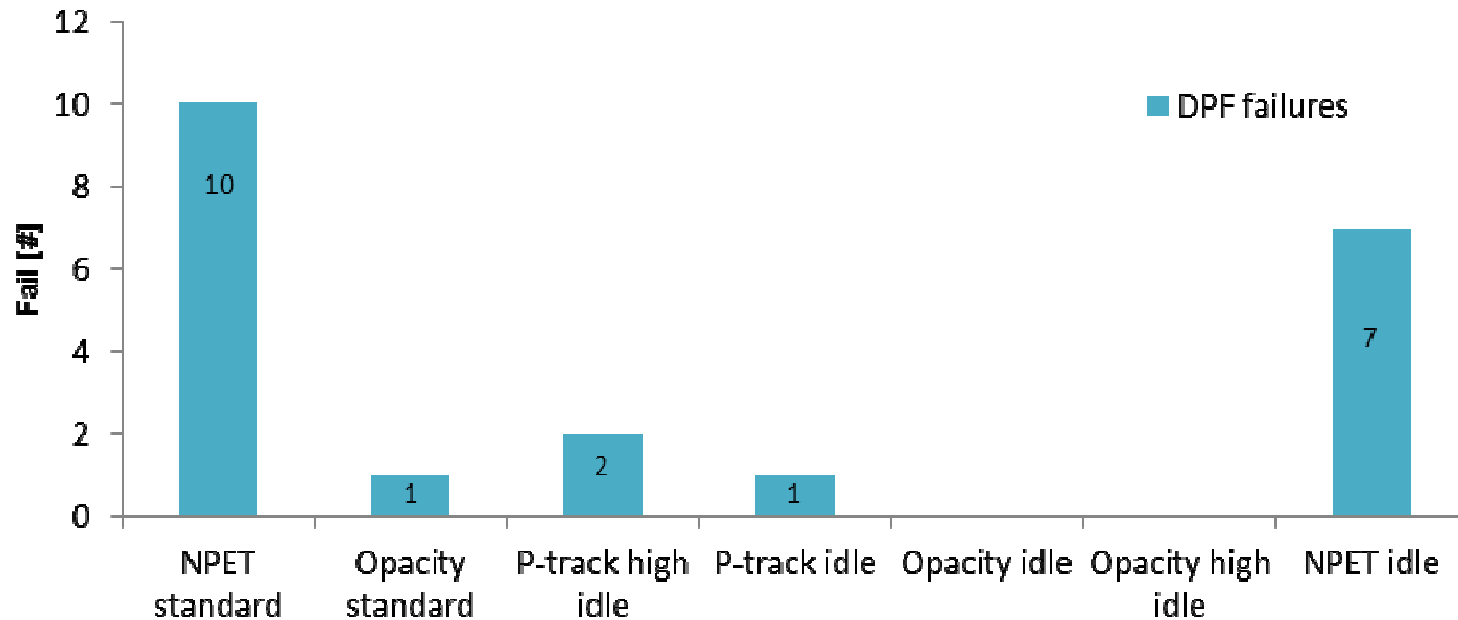


Failure by number	24	3	2	1	0	0	7
Total measured	107	87	56	56	56	56	56

Source: AFHB 2017



DPF Failure Comparison, Absolute Number n = 56

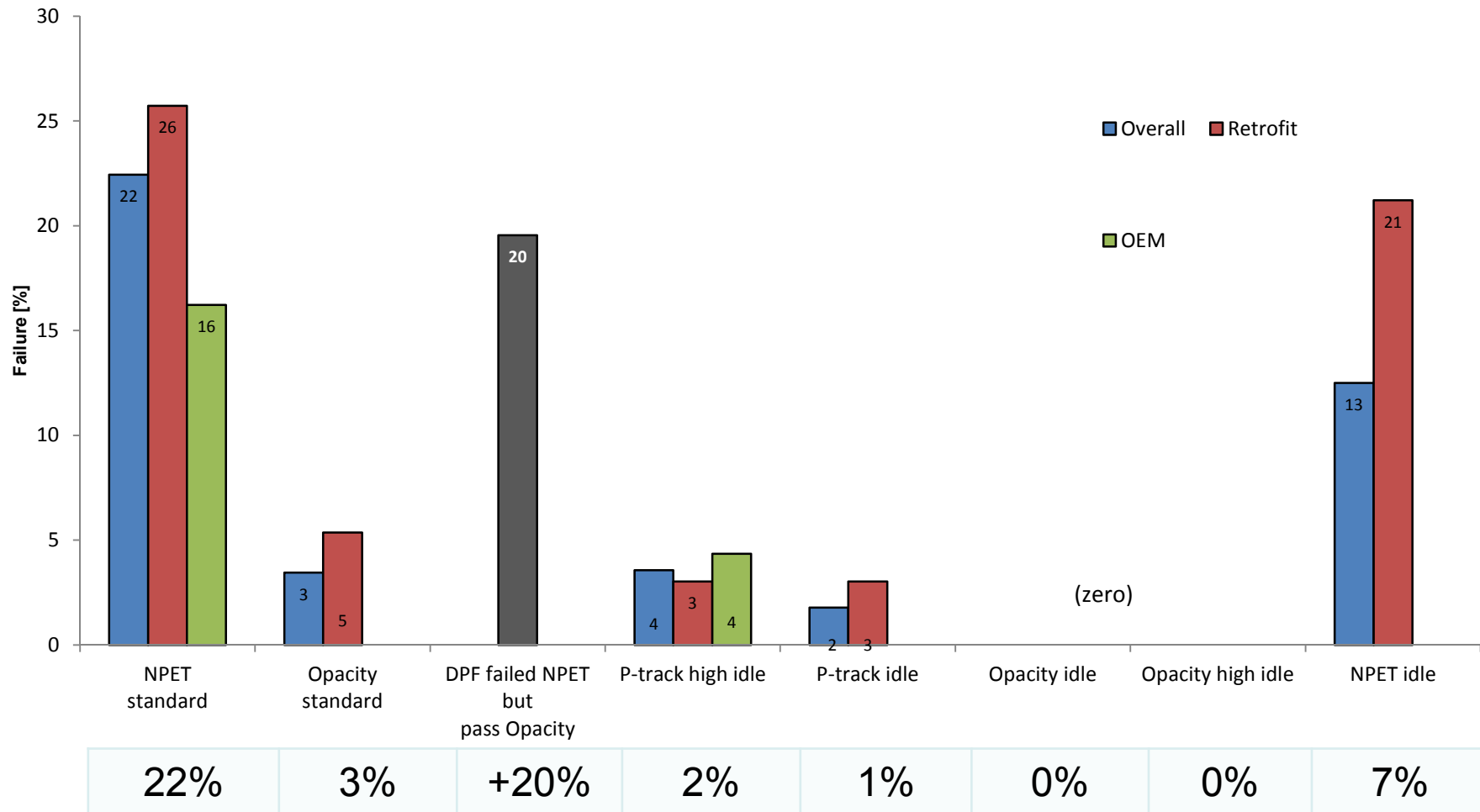


Failure by number	10	1	2	1	0	0	7
Total measured	56	36	56	56	56	56	56

Data: AFHB 2017, Graph: FOEN



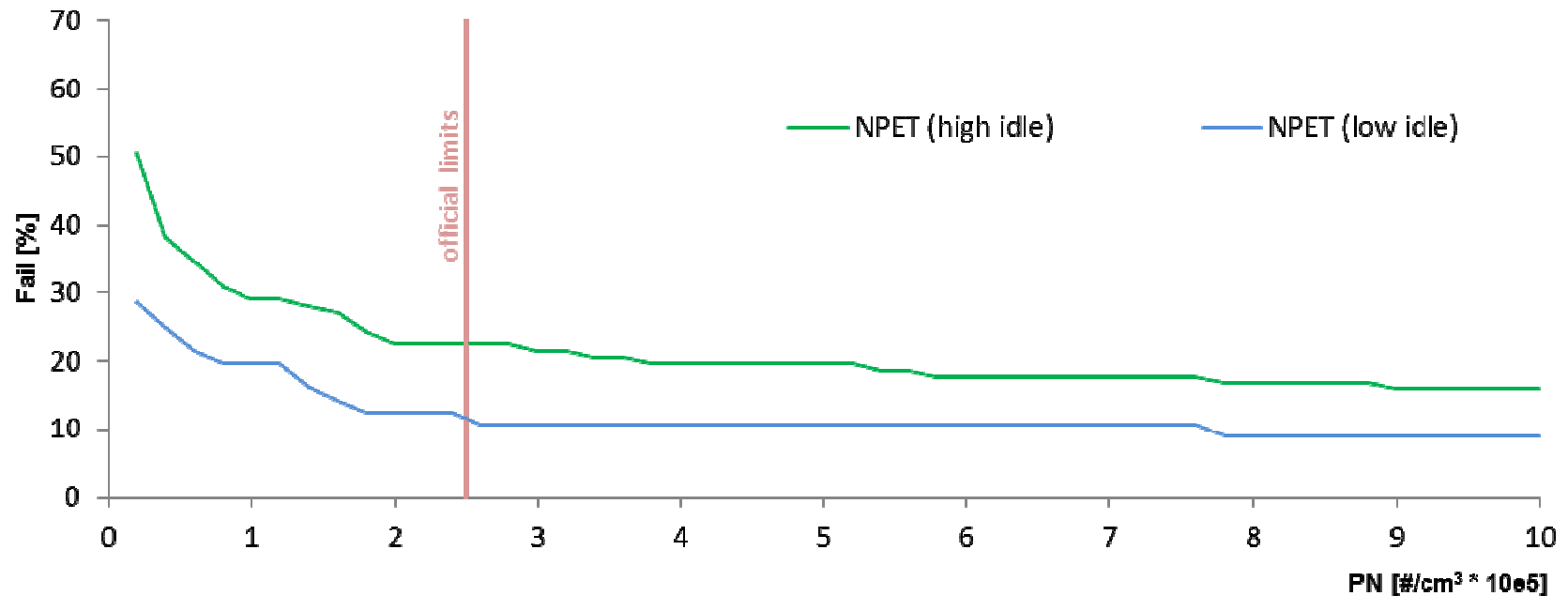
DPF Failure Rate Comparison (%)



Source: AFHB 2017



DPF Failure Rate as a Function of the Limit Value



Reading example:

If the limit value would be $1 \times 10^5 = 100'000 \text{ #/cm}^3$, the fail rate would climb to almost 30% with the NPET (high idle).

Data: AFHB 2017, Graph: FOEN



Conclusions from Report No. B485a

- More damaged DPFs can be detected using a PN-measuring instrument (certified by METAS) than with an opacimeter.
- There are no trends for damaged DPFs depending on: old/new, rarely/often used, small/big construction machinery, with retrofitted DPF or OEM-DPF.
- For construction machinery, «high idle» is a more suitable measuring point than «low idle».
- No additional benefits could be attributed to simplified PN-measuring instruments when compared to opacimeter measurements.



Next Steps:

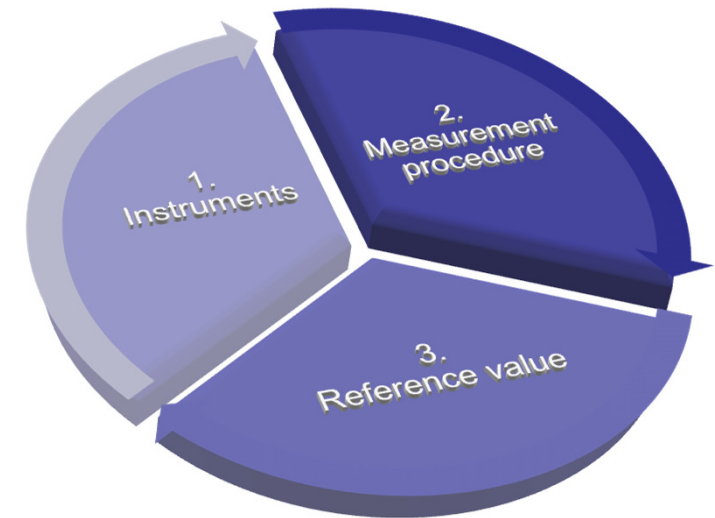
- FOEN and FEDRO assume the next emission stage V for non-road mobile machinery (NRMM, [Regulation \(EU\) 2016/1628](#)) – decision of the federal council is outstanding
- FOEN proceeds with the system of PTI for all NRMM without traffic admission.
- FOEN plans to introduce PN-measurement for all NRMM-engines complying with emission stage V:
→ FOEN prepares a new enforcement aid about the periodical technical inspection (PTI) of all non-road mobile machinery without traffic admission.
- Exception: for passenger ships, PTI by PN starting 1.1.2018



Diesel or Gasoline Passenger Cars: Is the DPF/GPF still working well?

OBD detects blocked DPF, but also cracked DPF?

Failure rate because of cracked OR manipulated DPF?



- FOEN is not convinced of the measurement point «low idle»
→ some 2000 rpm?
- FOEN recommends to carefully evaluate the technical requirements for PN-measuring instruments, not only to fulfill price expectations.



Thanks

- To the Laboratory for IC-Engines and Exhaust Gas Control (AFHB), Bern University of Applied Sciences, Biel – H. Nauroy, P. Comte, J. Czerwinsky, P. Willi.



Bern University
of Applied Sciences

► Engineering and Information Technology

- To the contributor of the P-Track: S. Schär, Canton of Berne.



Volkswirtschaftsdirektion

- To my colleagues at FOEN: G. D'Urbano, P. Hallauer, P. Bonsack, H. Jenk, D. Ochsner



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