TAILPIPE PN EMISSION RESULTS FROM 1,000 GASOLINE IN-USE DI ENGINES/VEHICLES

WP1

DATE OF DOCUMENT:

13/04/2026

DELIVERABLE VERSION:

D1.6, V.05

DISSEMINATION LEVEL:

PU

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DOCUMENT HISTORY

PROJECT ACRONYM	AEROSOLFD
Project Title	Fast track to cleaner, healthier urban Aerosols by market ready Solutions of retrofit Filtration Devices for tailpipe, brake systems and closed environment
Grant Agreement Nº	101056661
Project Coordinator	M + H
Project Duration	01/05/2022 – 31/08/2025 (40 Months)
Deliverable No.	D1.6 - Tailpipe PN emission results from 1,000 gasoline in-use DI engines/vehicles
Diss. Level	Public (PU)
Deliverable Lead	VERT
Status	Working
	Verified by other WPs/Partners
	X Final version
Due date	31/10/2024
Submission date	29/08/2025
Work Package	WP 1 - Tailpipe Retrofit- Development and Demonstration
Work Package Lead	VERT
Contributing beneficiary(ies)	AFHB, BFH, HJS, TCS

DoA	Tailpipe PN emission results from 1,000 gasoline in-use DI engines/vehicles. This deliverable refers to task 1.6.

DATE	VERSION	AUTHOR	COMMENT
06/06/2025	01	LCL	Final draft of deliverable for Peer Review
14/06/2025	02	Teresa Moreno	Peer Review
19/07/2025	03	Martin Lehmann	Coordinator review
25/08/2025	04	Steinbeis	Final Version
13/04/2026	05	Steinbeis	Fixed issue with pictures when converted to PDF

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

Co-funded by the European Union

Project funded by

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LIST OF APPENDICES

LIST OF ABBREVIATIONS

ABBREVIATION	ABBREVIATION DESCRIPTION
ASTRA	Federal Roads Office Switzerland
BFH	Bern University of Applied Sciences
DI	Direct Injection
DPN	Particle flow rate in #/min
HEPA (filter)	High Efficient Particulate Air (filter)
HJS	HJS Emissions Technology
METAS	(Swiss) Federal institute of Metrology
MFK	Motor vehicle inspection
NEDC	New European Driving Cycle
NPTI	New periodical technical inspection
PN	Particle Number Concentration per cm^3
RFZ	Vehicle - Ratio
RPN	PN - Ratio

TCS	Touring Club Switzerland
VIN	Vehicle identification number
V	Volume flow
VTS	Swiss Regulation on technical road vehicles
vg	Degree of pollution

SUMMARY

AeroSolfd intends to reduce the negative health effects of in-use petrol engines by retrofitting gasoline particle filters (GPFs). To estimate this effect we need a baseline, the PN-emission of the fleet without GPF. To assess particle emissions from petrol vehicles, 1017 vehicles in Switzerland were tested for nanoparticle emissions as part of the new periodic technical inspection (NPTI). The aim was to analyse particle number (PN) emissions in relation to vehicle type, engine technology, injection system, and applicable emission legislation, while also identifying high-emitting vehicles within the fleet.

The results confirm that a small fraction of vehicles contributes disproportionately to total fleet emissions. Vehicles with GPFs show significantly lower PN emissions, in some cases below ambient air levels.

Older vehicles (EU4, EU5) dominate the fleet emissions and account for the majority of PN emissions. Emissions scale approximately with the share of each vehicle category. EU6b vehicles follow the same trend, while EU6c and EU6d vehicles, mostly equipped with GPFs, exhibit negligible emissions.

Variability in emissions is unavoidable, but high emitters stand out due to large differences in magnitude. Future PN limits must consider measurement uncertainties, especially for borderline vehicles. The NPTI method must be robust, ensuring precise engine speed control and preventing unintended vehicle regulation processes. Standardized procedures are essential to reduce discrepancies and improve regulatory reliability.

1. INTRODUCTION

The measurement of particle emissions is carried out on behalf of the BFH / VERT Association at the Touring Club Switzerland (TCS) Biel as part of the NPTI. Apart from the fact that the vehicles are equipped with petrol engines, there are no restrictions regarding vehicle type. Due to the Swiss regulation on periodic technical inspections (Art. 33 VTS), all vehicles are at least five years old, as passenger cars in Switzerland are first subject to mandatory PTI five years after initial registration. Vehicles of all ages beyond this threshold, various mileages, and all emission levels are included.

The objective of this study is to gain a comprehensive overview of PN emissions from petrol engines across different vehicle types and emission standards. A key focus is to determine whether elevated PN emissions can be systematically linked to specific factors such as vehicle type, engine characteristics, mixture formation processes, or compliance with EU emission regulations. Additionally, the study aims to identify whether a small subset of vehicles contributes disproportionately to the overall fleet emissions, commonly referred to as heavy polluters.

1.1. CONTRIBUTIONS OF PARTNERS

PARTNER SHORT NAME	CONTRIBUTIONS
AFHB	University of Applied Sciences Biel/Bienne. Responsible for conducting the evaluation of the delivered measurement data
BFH	Data analysis
HJS	Data supervision
TCS	Data collection
VERT	Work package leader and AeroSolfd reporting

2. DESCRIPTION OF TECHNICAL ACTIVITIES

As part of the regular technical inspection in Switzerland, an additional particle number (PN) measurement was carried out in the exhaust tailpipe of one thousand vehicles with petrol engines. Additionally, the tests were conducted under the same time constraints defined by the NPTI, allowing for a maximum of additional two minutes of measurement time per vehicle during normal inspection. The measuring device is the PN-Counter from AVL DiTest.

2.1. MEASUREMENT TECHNOLOGY USED

The primary instrument employed for particle measurement is the AVL DiTest PN-counter. The device was selected for representativeness to reflect the real conditions of a new periodic inspection (NPTI). The AVL device exclusively measures particle concentrations through a manually inserted probe in tailpipe.

The AVL DiTest PN measuring device works according to the diffusion charging measuring principle. The particles are electrically charged and counted (not actually counted one by one but the electric charge of deposited particles is measured and numerically converted into a number) in a constant pump volume flow. In the technical documentation, the device is specified with a measuring range of 0 and 10,000,000 #/cm³. Particle concentrations greater than that are not considered and are acknowledged with an error message from the device. A metrological verification of this instrument type during the project, at METAS, shows for the measuring range 1000 to 10,000,000 #/cm³ assumed. The measuring line of the device is not heated, but a water separator is included.

Figure 1: Used PN-measurement device DiTest from AVL

The AVL DiTest particle (Figure 1) counting device used in the NPTI - 1000 specifications for stationary use by testing organisations and in workshops is the central measuring instrument in these series of tests.

The Device measures and operates as follows:

- Particle concentration PN in [#/cm³] in a measuring range from 0 to 10,000,000 [#/cm³].
    - Operated by the technical inspector, measurement is performed automatically

Further details and description can be found in Appendix 1.

2.2.TEST SETUP AND VEHICLE DATA

The measurements are carried out at the test center from the TCS in Biel/Bienne as part of their regular PTI (MFK). All incoming gasoline vehicles registered have been measured. The vehicle data and conditioning status was tracked. The owner is not recorded, due to privacy protection, the vehicle´s identification number (VIN) is partly anonymised, it allows the type of vehicle to be identified, but not the individual vehicle. An exemplary protocol can is shown in Appendix 2.

The following additional data is collected on the measured vehicles:

- Date of measurement
- Vehicle manufacturer and vehicle type
  Registration date (“first Immatriculation”)
- Mileage
- PN - Measurement result in the tailpipe
- PN - measurement result of the ambient air
- Emission standard
- Engine displacement
- Status of the engine indicator light
- Perceived engine temperature
  (warm or cold)

The correct function of the AVL DiTest PN-counter is first checked daily by the self-test integrated in the system and with the HEPA filter test.

The measurements at the Touring Club Switzerland (TCS) are conducted using a standardized and field-tested measurement procedure, which was developed and validated in advance through preliminary investigations by AVL in cooperation with HJS and is specified in section 2.3. This procedure has proven to be particularly stable and reproducible in practice and is therefore used as the default method for particle number (PN) measurements in this campaign.

The applied method is aligned with the principles defined for diesel vehicles equipped with diesel particulate filters (DPF) in Switzerland [1]. Since January 2023, the Swiss regulation mandates PN measurements for such vehicles as part of the official periodic technical inspection (PTI). The procedure is specified in the official guideline *"Richtlinie über die Abgasmessung bei Dieselmotoren mit Partikelfilter im Rahmen der periodischen Fahrzeugprüfung"* issued by the Swiss Federal Roads Office (ASTRA) [2]. According to this regulation, the measurement devices used must be certified by the Swiss Federal Institute of Metrology (METAS).

These devices are subject to regular calibration and verification. Although the measurements at TCS have been conducted under research conditions, for the purposes of the AeroSolfd project, a metrological verification at METAS was issued.

The vehicles are not conditioned or prepared, as this would only be possible with significantly increased effort as part of the MFK. However, data on the conditioning or condition of the vehicle is collected during the measurement and noted in the measurement log.

2.3.TEST PROCEDURE

The measurement of the PN emissions is carried out at an increased idling speed of 2500 rpm. It is made up of two individual measurements. Measurement 1 takes place in an operating state without engine load, whereas measurement 2 takes place with an increased (internal) load and measurement #3 if for ambient air as reference.

The load is increased when the vehicle is stationary by switching on the air conditioning and switching on additional electrical consumers such as lights or the rear window heating. The averaged PN concentration is then measured in [#/cm³] over a measurement period of 15 s after a steady-state time of at least 15 s in the resulting operating point. An exemplary emission test setup is shown in Figure 2.

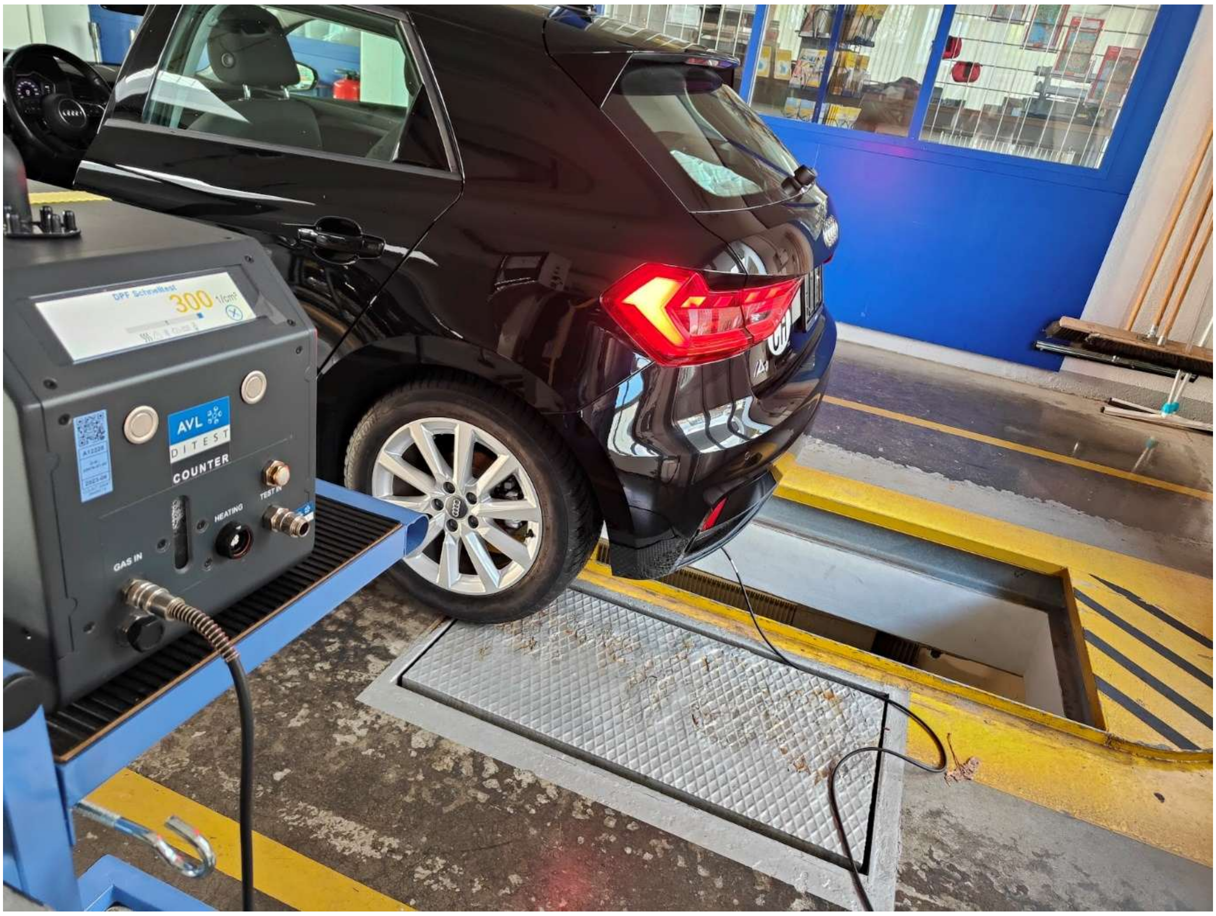

Figure 2: Vehicle in the test hall during the NPTI measurement

Measurement 1:

The measuring probe is then inserted approx. 15 cm into the exhaust tailpipe of the vehicle to be tested, if possible.

For the first measurement, the engine speed is increased to 2500 rpm and the automated measurement (described as “DPF quick test” on the display) is triggered on the device after an initially 15-second stabilization phase. This is followed by a 15-second measurement phase, in which the PN counter continuously records the particle number concentration. The results of this phase are then averaged. The final result is then manually recorded by the technician in the test log.

Measurement 2:

The vehicle's air conditioning system and other auxiliaries are activated to provide additional load on the engine. The emission measurement is then repeated, as described under Measurement 1.

Measurement 3:

The measuring probe is then removed from the exhaust and the PN in the ambient air is measured in the same way as in the previous steps. The result of the ambient air is recorded as measurement 3. From about halfway through the measurement campaign, this test takes place before measurements 1 and 2.

Exemplary measurement data is presented in Figure 3 in the next section.

3. EVALUATION

An additional challenge is the limited comparability of the results, as the measured PN concentration in [#/cm³] could be used to estimate the functionality of a filtration device in future NPTI but does not directly indicate the total particle emissions per kilometer [#/km], which are essential for assessing the overall pollutant load of a vehicle in the Fleet. Therefore, an estimation of the absolute emissions is tried to be established.

The measured PN emissions (measurement 1 / 2) are first corrected by the particle concentration of the ambient air (measurement 3) and converted into a corrected PN flow rate (*DPN*) in [#/min] according to 1.1,

with PN_1 or PN_2 in $\#/cm^3$ as the corresponding particle number concentration of measurement 1 or 2, V_H in cm^3 the engine displacement and n in min^{-1} as the engine speed.

$$DPN_{kor\,1/2} = (PN_{1/2} - PN_{Amb}) \cdot \frac{V_H \cdot n}{2}$$

(1.1)

The calculation of the corrected PN flow rate (DPN) must assume that all thermodynamic losses of the engine, any turbocharging or the amount of fuel introduced are negligible. For simplification, the delivery ratio of the engine is assumed to be 1. On the one hand, the PN flow rate can be used to compare engines with different displacements. On the other hand, DPN can be used to calculate the absolute number of particles emitted over a period, which is the basis for determining the contribution of each vehicle to the overall result. The degree of pollution *vg* [-] serves as an additional parameter for evaluation and comparability. It is calculated according to 1.2, with PN_1 or PN_2 in $\#/cm^3$ the corresponding particle number concentration of measurement 1 or 2.

$$vg = \frac{PN_{1/2}}{PN_{Amb}} \tag{1.2}$$

As the measurements show, the particle concentration in the exhaust tailpipe may be lower than the concentration in the ambient air. The pollution level vg indicates whether the vehicle was acting as an air polluter (vg > 1) or as a "particle filter" (vg < 1) when it was measured.

The vehicles are sorted according to their EU emission level. The percentage share of the respective emission level in the total NPTI-1000 fleet is then determined as RFZ in [%], in 1.3, with $n_{Fzge,EU}$ for the number of vehicles of the corresponding emission stage and with $n_{Fzge,ges}$ the total number of measured vehicles.

$$RFZ_{EUx} = \frac{n_{Fzge,EUx} \cdot 100\,\%}{n_{Fzge,gesamt}} \tag{1.3}$$

A similar procedure is used for the particle flow values. They are cumulated and the percentage shares in the overall result are determined depending on the EU emission stage as RPN in [%], in 1.4. The share is calculated with the sum of all corrected PN flow rates ($DPN_{kor,Eu}$) of one emission standard and the total corrected PN flow rates (DPN_{kor}) of the fleets each in [#/min]

$$RPN_{EUx} = \frac{\sum DPN_{kor,EUx} \cdot 100\,\%}{\sum DPN_{kor}} \tag{1.4}$$

The proportions RPN and RFZ can be used to form a ratio $r_{PN,Eu}$) that shows how many per cent of the vehicles in the individual Emission standard generate how many per cent of the total PN emissions.

$$r_{PN,EUx} = \frac{RPN_{EUx}}{RFZ_{EUx}} \quad (1.5)$$

3.1.OBSERVED MEASUREMENT SCATTER

The measurements of the individual vehicles are sometimes extremely scattered. The overview of the DPN in Figure 3 appears to confirm this, except for the EU2 group. However, an indirectly proportional behaviour of the measured values at different loads can be observed in many measurements (e.g. #997: measurement 1 with 7.391.000 #/cm³; measurement 2 with 2.400 #/cm³). In addition to regularly occurring different particle concentrations in the exhaust gas of the respective engine operating point, the causes can also be attributed to measurement signal scatter and/or engine operating points that are not stably adjusted during the 15-second measurement period.

This scatter is not predictable for the tester, and therefore, a deeper insight into relevant vehicle data, such as that accessible through OBD data, would be necessary to assess the actual conditions of the engine and vehicle. All indicators available on the vehicle to the tester, such as the check engine light or displays, provide no suitable indication of these inconsistencies and cannot therefore offer a reliable basis for predicting or interpreting the measurement results. Figure 3 shows a continuous measurement with additional signal acquisition via OBD to show the better resolution of the vehicle/engine parameters. Data is taken from the NPTI - 1000 number # 894.

Between approx. 120 and 190 seconds, the vehicle tester attempts to set a stable high idle speed at approx. 2500 rpm (shown as identifier OBD_n_Eng) using a pedal tensioner. In the end, it is around 3000 rpm for measurement 1 under normal load. The accelerator pedal is then at a constant 8% pedal travel (shown as identifier OBD_ThrAbs). During the persistence between seconds 195 and 210, the particle concentrations increase from approx. 30,000 #/cm³ to around 120,000 #/cm³ (shown as identifier AVL_PN_kor). During this time, the engine operating parameters, the coolant temperature (shown as identifier OBD_t_EngClt), the intake manifold pressure (shown as identifier OBD_p_SgrAbs) and the air flow rate (shown as identifier LFTDS_#) remain constant. In the measurement phase between seconds 210 and 225, the measurement signal oscillates with a bandwidth of approx. 40,000 #/cm³, which corresponds to a measurement dispersion of 30%. The final values are averaged. For measurement 1, the result at the end is PN = 132,550 #/cm³ and DPN = $2.24 \cdot 10^{11}$ /min.

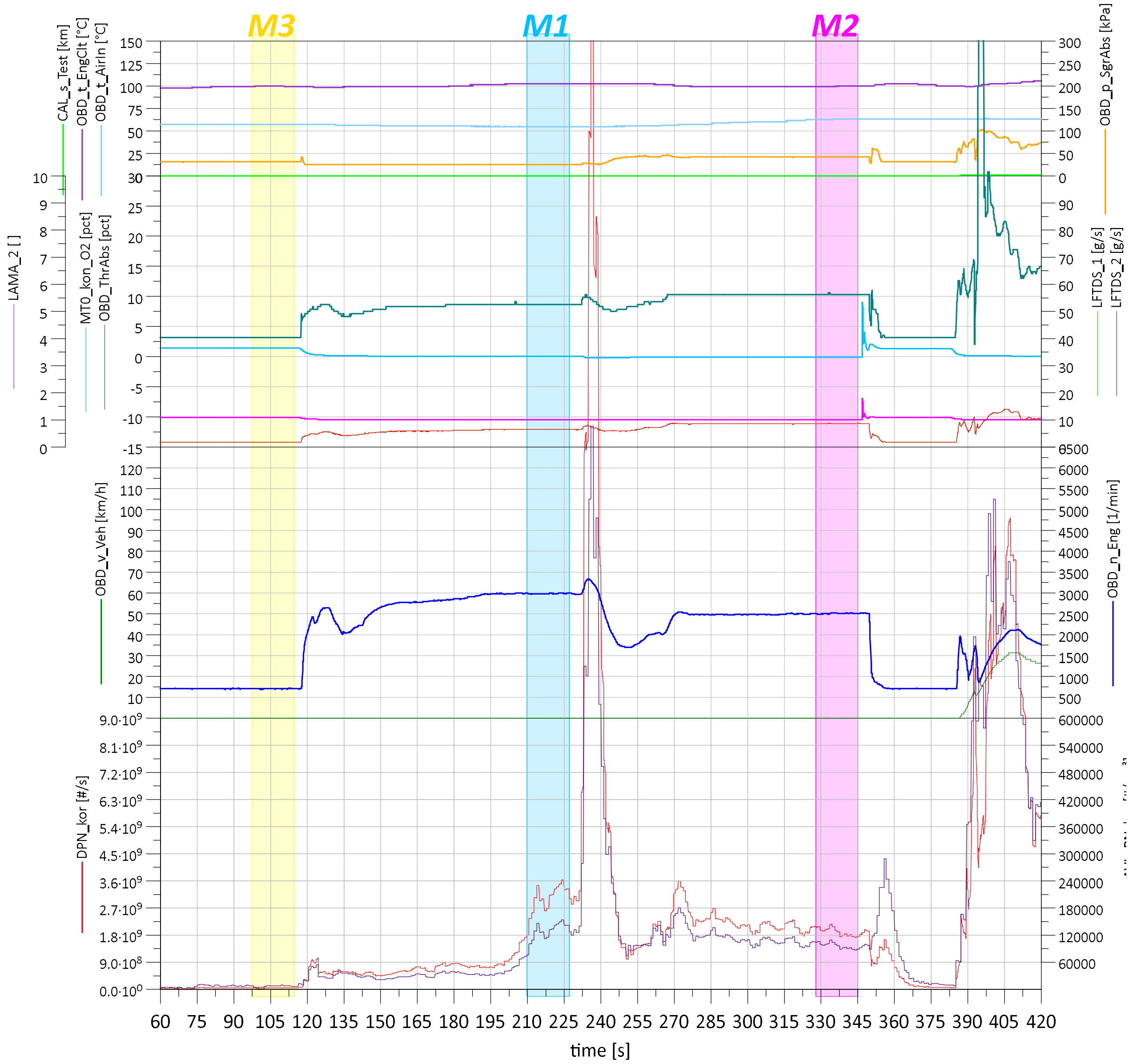

Figure 3: Example NPTI - 1000: practical measurement procedure in detail

In the second part, the increased load case is set by the tester from second 270. The operating point is found more quickly, but the engine speed is now 500 rpm lower at 2500 rpm compared to measurement 1. The accelerator pedal is at a constant 10%. The PN concentration during measurement 2, now with a higher load, is lower and scatters less strongly, but is still within a scatter band of 30,000 #/cm³ (30%) with an average measurement result of around 100,000/cm³. As a result of the lower speed and the lower PN concentration, the result of measurement 2 is: PN = 95.023 #/cm³ and DPN = $1.59 \cdot 10^{11}$ /min. As a result of the different conditions during the measurements mentioned, a conscious distinction is always made in the following graphs between measurement 1 and measurement 2

3.2.FLEET RESULTS

The raw PN results of the fleet are shown in Figure 4 and indicate a pronounced skewness in the distribution of PN emissions, with a small proportion of vehicles contributing disproportionately to the total measured emissions.

- The **top 20%** of vehicles account for:

    approx. 93% of the total PN measured in Series #1

- approx. 90% in Series #2The **top 10%** of vehicles account for:

    approx. 77% of the total PN in Series #:1

    approx. 72% in Series #2

- The **top 5%** of vehicles are responsible for:

    approx. 55% of the PN emissions in Series #1

    approx. 50% in Series #2

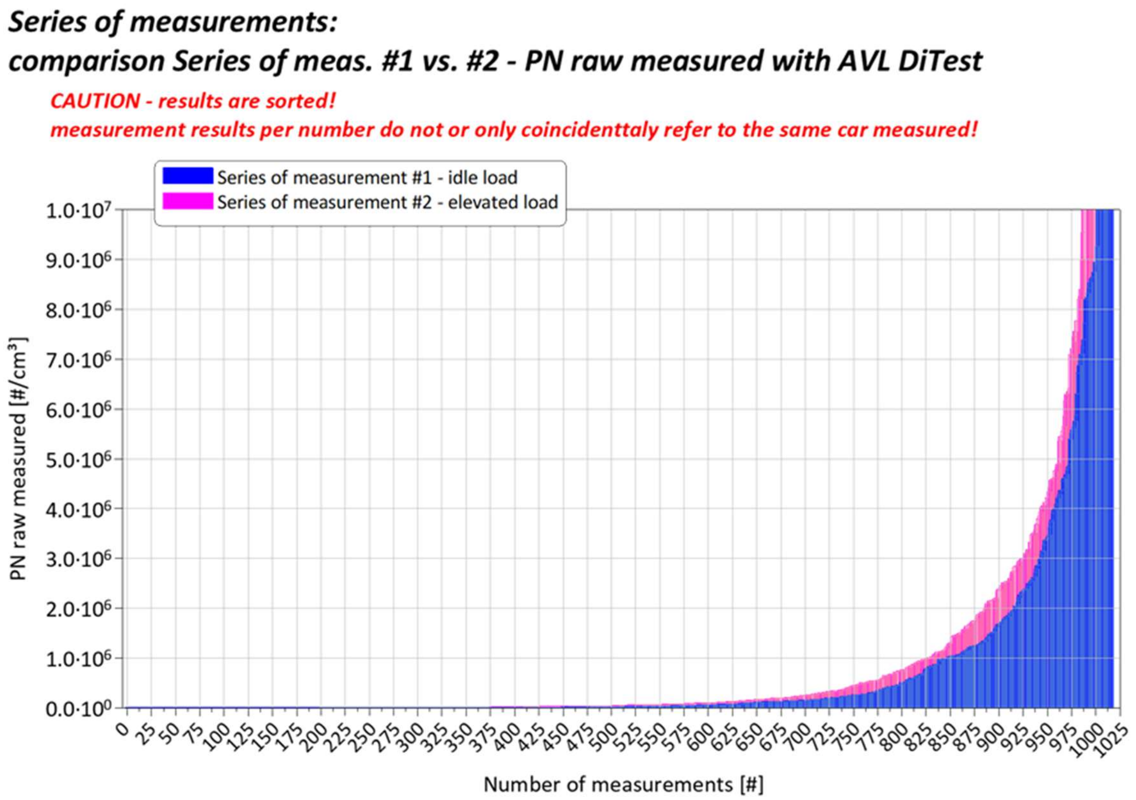

Figure 4: Comparison of measurement series #1 and #2 -raw measured PN

These results provide confirmation of the presence of the so-called "high-emitter" effect, where a small number of vehicles are found to be responsible for the total PN emissions. The effect persists across both idle and elevated load conditions.

The Figure 5 is divided into 3 sections and shows an overview of the measurement results of the NPTI - 1000 for 1017 measured vehicles. Models from a total of 44 manufacturers of all EU levels up to 6d are represented in varying numbers. The engine displacement ranges from 600 cm³ to about 8000 cm³.The top third shows the relative share of vehicles in the fleet RFZ (red bar) for each EU standard and their share of the total emissions RPN in the NPTI - 1000, broken down into measurement 1 (light blue) and measurement 2 (purple).

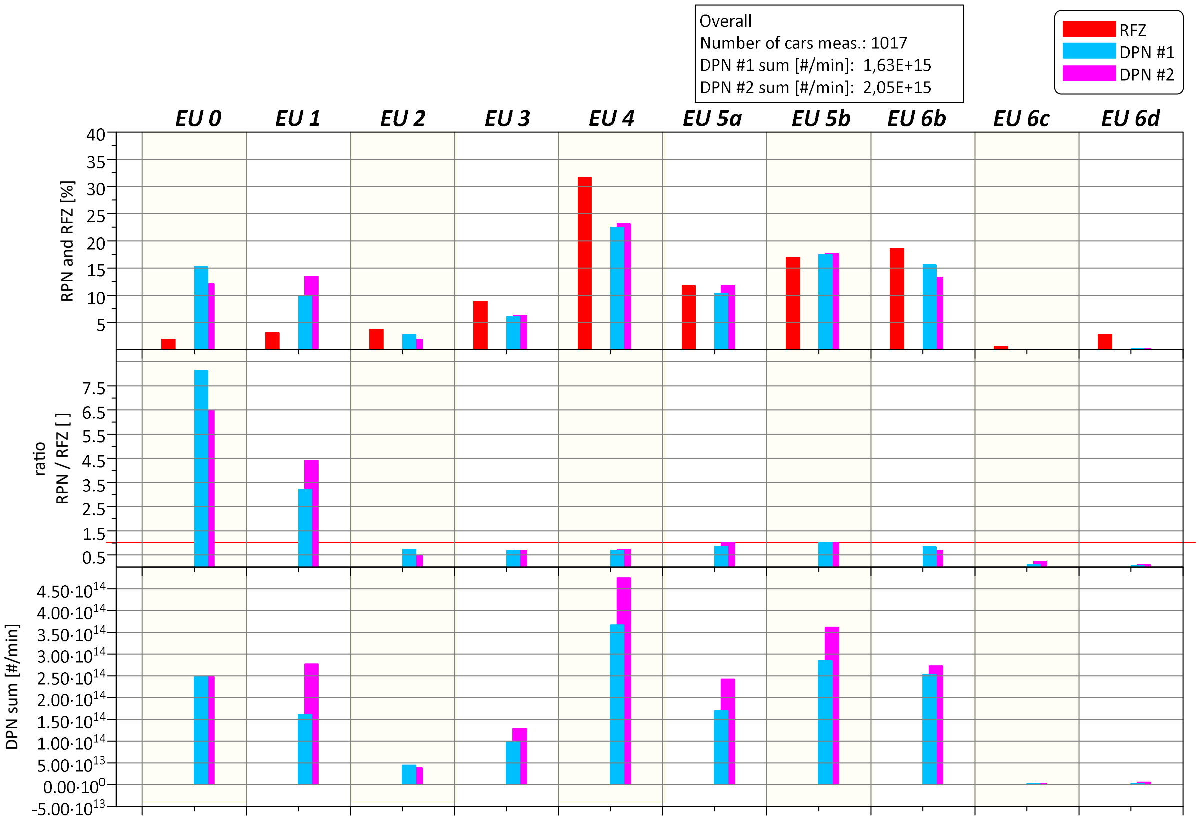

Figure 5: Overview NPTI-1000 results; PN Shares according to the EU emission standards

The ratio r_{PN} from the share of total emissions to the share of vehicles (RPN/RFZ) is shown in the centre area. This area shows whether the vehicles in an EU standard group make a lower contribution (r_{PN}< 1) or a higher contribution to PN emissions (r_{PN}> 1).

In the lower third of the graph, the absolute DPN for an EU standard are shown separately for measurement 1 and measurement 2 to develop a feeling for the absolute emissions occurring.

The corrected PN flow rates for the individual EU emissions levels are evaluated in the following.

EU6:

The gradual tightening of particle emission limits across the various sub-standards of the EU6 has meant that most petrol engines in passenger cars have been fitted with particulate filters as standard since around 2018.

Only in the group of EU6b registrations, which were still homologated according to the NEDC with a PN limit value of $6 \cdot 10^{12}$, are these filters largely absent. Accordingly, the particle concentrations measured in the NPTI - 1000 are higher than in the engines according to EU6c and higher. Compared to the vehicles of earlier EU standards, they are slightly better than the EU5 results with an r_{PN}= ~0.75 and slightly worse than the EU 2,3 and 4 test subjects. The fact that vehicles with direct injection, which dominate the fleet here, produce significantly higher PN emissions is not reflected in the results.

The EU standards 6c ($PN_{max}= 6 \cdot 10^{12}$) and 6d ($PN_{max}= 6 \cdot 10^{11}$) homologated according to the WLTC are unfortunately only represented in the fleet of the vehicles tested with approx. 1% each. However, their particle emissions are almost insignificant with an $r_{PN} < 0.3$.

EU5:

The results from the EU5 groups are slightly higher compared to the EU2, 3 and 4 and compared to the EU6 results. It is possible that a technology-related tendency can be assumed here. However, with an r_{PN}= ~1 compared to ~0.75 for the other groups except EU0 and EU1, the results are not significantly different.

EU4:

With over 30%, most measured vehicles are assigned to the EU4 emissions standard. With an r_{PN} of approx. 0.75, this group produces a lower percentage of PN emissions (approx. 22% of total PN emissions).

EU3:

Just under 10% of the vehicles belong to the EU3 group. With an r_{PN} of approx. 0.75, these vehicles are characterised like those in EU6b, 4 and 2. The result is somewhat surprising, as the vehicles are around 20 years old at the time of measurement.

EU2:

The same result as for the EU3 group also applies to EU2, with the difference that the vehicles with an RFZ = 4% are significantly fewer and even older.

EU1:

Compared to the measurement results of EU2 and higher EU standards, this group shows significantly higher particle emissions. The almost 3% of vehicles (RFZ) emit around 12% of the total PN emissions (RPN) in the NPTI - 1000. The resulting r_{PN} of 4 is significantly higher than later EU standards. The study cannot answer the question of whether this circumstance has technically justifiable causes or whether the total number of ~30 vehicles is too low.

EU0:

The trend from the EU1 group can also be observed in the EU0 group. These 2% vehicles are responsible for around 14% of the total emissions in the NPTI - 1000. With an r_{PN}= 7, the PN emissions in this group are by far the highest. In addition to the fact that there are even fewer vehicles in this group than in the EU1 group, the largest range of engine technologies can be found here, which makes the result difficult to interpret. This group includes vintage cars from 1938 alongside modern US vehicles imported from overseas.

If the results determined in the measurement campaign for measurement 1 and 2 are sorted, it is noticeable that comparatively few measurement results have a disproportionately high share of the overall result, like shown in Figure 6. The graphs for measurements 1 and 2 are shown separately. Each graph shows the relative shares of the measurement results in the total emissions of the NPTI - 1000 test series in per cent.

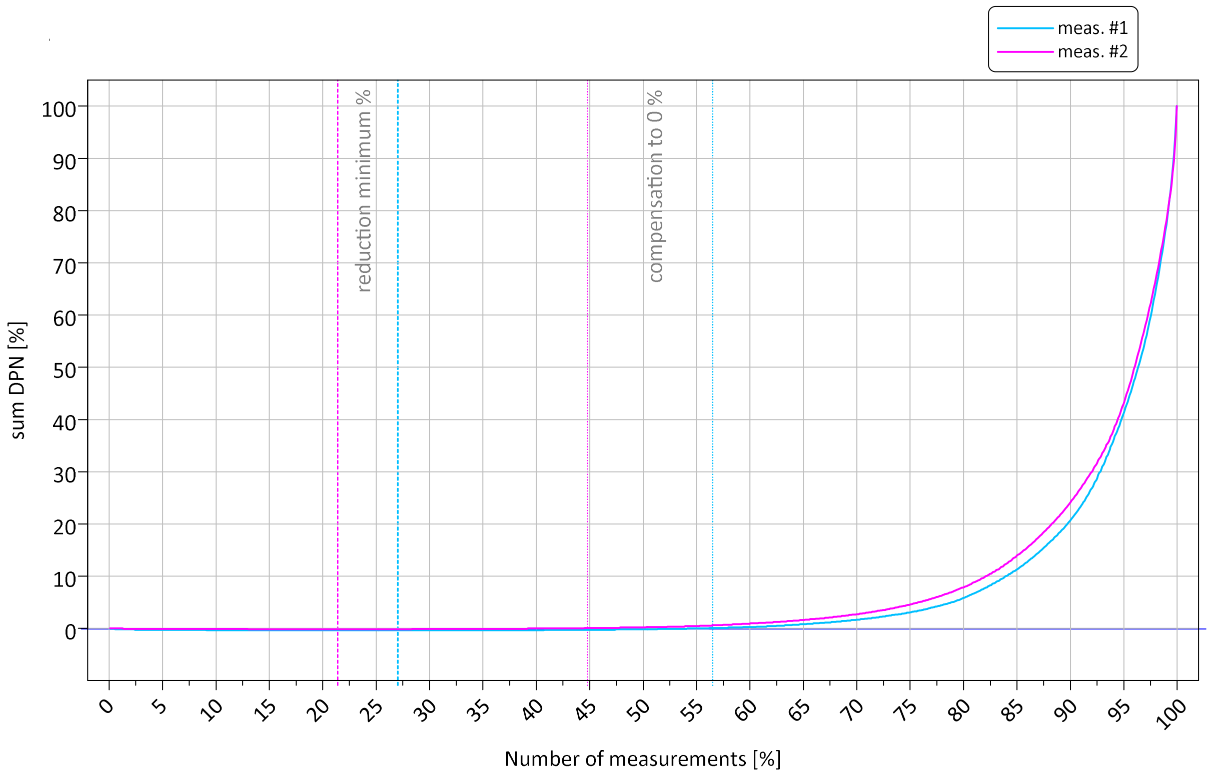

Figure 6: Overall results measurement 1 and 2 - Overview of relative contribution to results

Adjusted for the ambient particle concentrations, the first approx. 25% of the measurement results generate a positive balance. According to these measurement results, the ambient air is cleaned of particles by around -0.4% (dashed lines). The type and size of the particles are not considered here. The neutrality of the particle balance is achieved with approx. 50% of the measurement results (dot lines). The top 5% of the measurement results have a contribution to the total PN emissions of approx. 60%. The remaining 40% account for about 45% of the measurement results. Additional graphs dedicated for each EU class can be found in the appendix 3.

Figure 7 and Figure 8 show in detail the sorted measurement results for measurements 1 and 2 for the degree emission contribution and DPN particle emissions over the number of measurement results. It is important to note here that the results are not assigned to a vehicle but are only shown separately in ascending order. The 25% of measurements with a pollution level of less than 1 are clearly recognisable, as are the top 5% of measurement results, which represent the disproportionately high share of particle emissions.

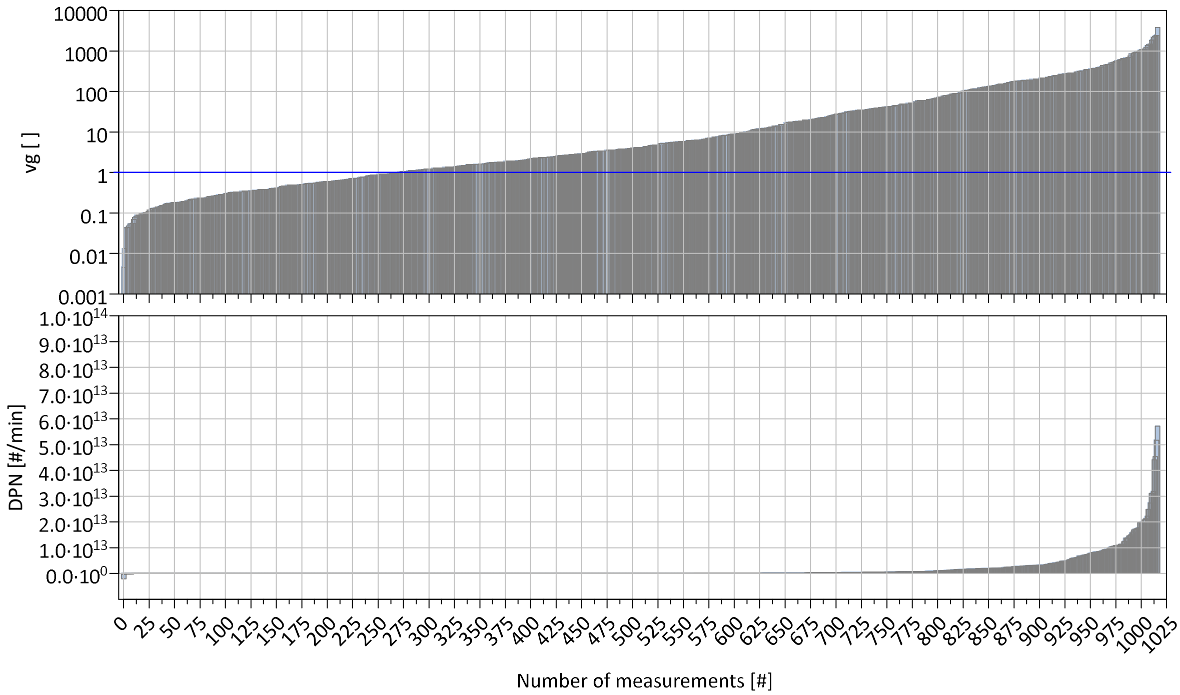

Figure 7: Measurement 1 - PN emissions sorted

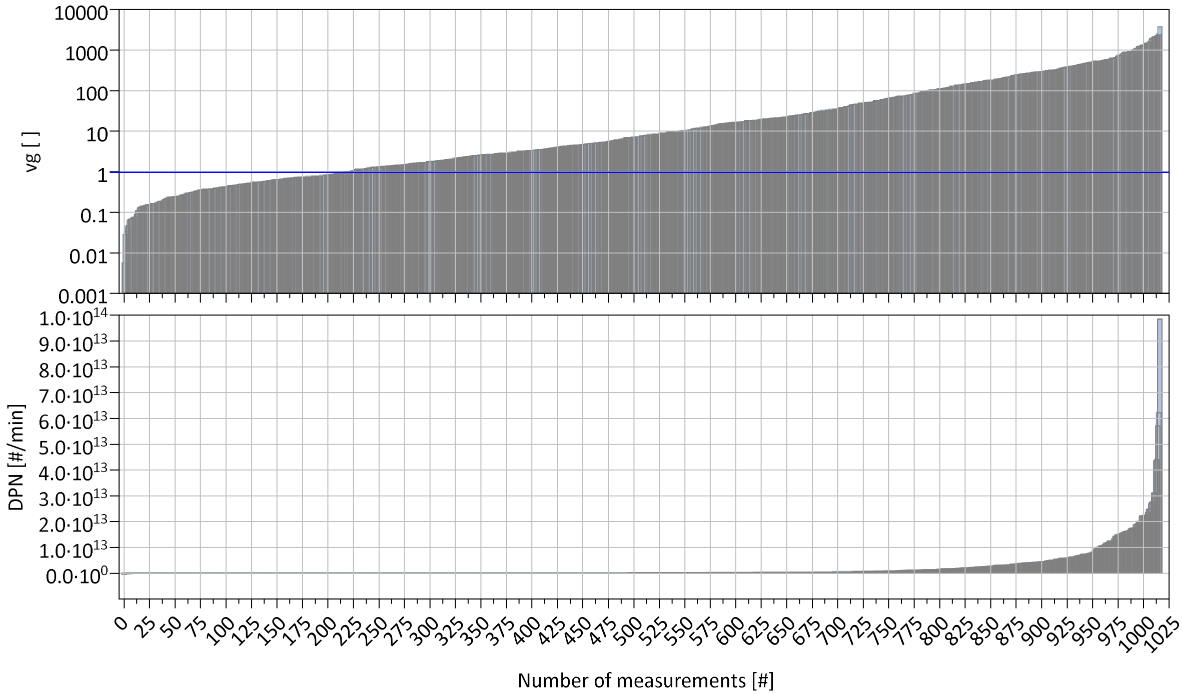

Figure 8: Measurement 2 - PN emissions sorted

4. CONCLUSIONS

With the support of the TCS, 1017 vehicles were measured using the PN-NPTI method as part of their regular periodic technical inspection within the AeroSolfd project. The results confirm findings from previous measurement campaigns from other researchers, e.g. [3,4] demonstrating that a small percentage of vehicles within a fleet contribute disproportionately to the total particle emissions.

Furthermore, the data clearly show that vehicles equipped with a gasoline particle filter (GPF) exhibit significantly lower PN emissions. In some cases, the particle number concentration in the exhaust was even lower than the ambient air levels, highlighting the effectiveness of GPF technology.

When assuming that the sampled vehicle group is representative of the age distribution of vehicles in operation in Switzerland, it becomes evident that older vehicle categories (EU4 and EU5) represent the largest share of the fleet and are therefore responsible for the majority of PN emissions. The data suggest that particle emissions scale of the vehicle population approximately proportionally with the share of each vehicle category. This trend is also observed for EU6b vehicles. However, for EU6c and EU6d vehicles, many of which are already equipped with gasoline particle filters (GPFs), PN emissions are negligible, due to the installed filter.

While some degree of variability in PN emissions is inevitable due to differences in vehicle characteristics and operating conditions, high-emitting vehicles stand out due to their substantially elevated emission levels. These findings underscore the importance of targeted emission control strategies to identify and mitigate the impact of high-emitting vehicles within the fleet. Additionally, the results highlight the effectiveness of particle filter technology in reducing emissions from modern gasoline-powered vehicles.

When considering the potential introduction of legislation with particle number (PN) emission limits, the variability of emissions, particularly for vehicles near the threshold, becomes a critical factor. Measurement uncertainties and natural variations in PN emissions could lead to inconsistent classification of vehicles, affecting regulatory compliance and enforcement. Therefore, it is essential to ensure that the NPTI method is designed to be as robust as possible, both in terms of technical implementation and practical execution.

To minimize systematic variability caused by inappropriate testing procedures, specific attention should be given to factors such as engine speed control and the prevention of unintended vehicle regulation processes during the measurement. Ensuring a standardized and controlled test environment will help to reduce measurement discrepancies and improve the reliability of the assessment. It is recommended that the NPTI procedure be strictly followed, especially for vehicles with PN emissions near potential regulatory thresholds. To improve the reliability of the measurements, integrating OBD-based vehicle state monitoring during the test is advisable in special cases, ensuring that operating conditions—such as engine speed and additional loads—are correctly applied and maintained.

Co-funded by the European Union
Project funded by
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Confederation
Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI

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Appendix 1: DiTest manufacturer description

AVL DITEST

AVL DiTEST COUNTER

VON DER ERSTEN IDEE ZUM FINALEN PRODUKT

Die neue, strenge AU-Gesetzgebung in Deutschland verlangt die Partikelanzahlmessung bei EURO 6/VI-Dieselfahrzeugen. Mit dem AVL DiTEST Counter erfüllen Sie diese neue Gesetzgebung effizient und präzise. Aufbauend auf der jahrelangen Erfahrung hat AVL DiTEST alle Kernkomponenten des Counters selbst entwickelt.

Abbildung: Änderungen vorbehalten

Das zukunftssichere Messprinzip **Advanced Diffusion Charging** (elektrisches Aufladen von Partikeln) ermöglicht eine robuste Bauweise. Auf ein toxisches Betriebsmittel kann im Gegensatz zu anderen Technologien verzichtet werden. Schnelle Messverfügbarkeit, exakte Partikelzählung in kurzer Zeit und geringer Wartungsaufwand runden das Produkt für Ihren täglichen Einsatz in der Werkstätte ab. Falls zukünftig gefordert, können Sie mit dem AVL DiTEST Counter auch Benzinfahrzeuge überprüfen. Die verwendete Technologie wurde in Deutschland, in der Schweiz und in den Niederlanden bereits zugelassen und die Serienauslieferung hat begonnen.

PRODUKTVORTEILE IM DETAIL

EINFACH UND EFFIZIENT
- Ein gemeinsames User Interface, AVL DiTEST DSS, für alle AU-Abläufe
- Selbsterklärende und übersichtliche Bedienung
- Smarte Testfunktionen (gesetzlich vorgeschriebener Nullluftest)

PARTIKELMESSUNG ALS CASHCOW
- Kurze Rüstzeit, jederzeit einsatzbereit
- Maximale Geräteverfügbarkeit
- Besonders kurze Messprozedur
- Keine Verbrauchsmaterialien
- Geringer Wartungsaufwand

HOHER QUALITÄTSANSPRUCH
- Robuste Bauweise für den Werkstattalltag
- Langlebige Materialien, solide Verarbeitung

ZUKUNFTSSICHERE TECHNOLOGIE
- Auch für Benzinfahrzeuge vorbereitet

ZULASSUNG
- AVL DiTEST Counter-Technologie in Deutschland, in der Schweiz und in den Niederlanden durch offizielles Messinstitut bereits zugelassen
- Serienlieferung gestartet

TECHNISCHE DATEN	
Messbereich	0 … 10.000.000 cm^{-3}
Partikelgröße	20 … 300 nm
Aufwärmzeit	< 4 min.
Spannungsversorgung	100 … 230V
Größe	496 x 210 x 309 mm (L x B x H)
Gewicht	ca. 8,6 kg (exkl. Abgassonde)
Schnittstelle	USB 2.0, Bluetooth

AVL DiTEST Counter Info-Plattform

Herausgeber:
Firmensitz: AVL DiTEST GmbH
Alte Poststraße 156, 8020 Graz, AUSTRIA, ditest@avl.com
Niederlassung Deutschland: AVL DiTEST GmbH
Schwadermühlstraße 4, 90556 Cadolzburg, Germany, Tel. +49 9103 713-540, avl.ditest@avl.com
www.avlditest.com

08/2022. Änderungen vorbehalten

Appendix 2: Example protocol from TCS

Centre tcs Center

Touring Club der Schweiz
Centre tcs Center
Lengnaustrasse 7 rue de Longeau
2504 Biel / Bienne

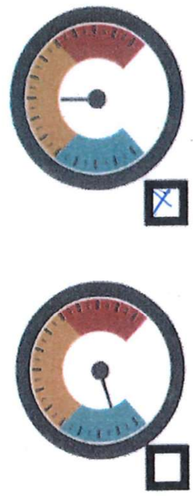
Tel 032 341 41 76
tz.biel@tcs.ch
ct.bienne@tcs.ch

A 15 Schild / Plaque / Targa / Numer	[redacted]			Weiss
17 Bes. Verwendung / Usage spécial / Uso speciale / Diever spezial				
19 Art des Fahrzeugs / Genre de véhicule / Genere di veicolo / Gener dal vehichel	Personenwagen			Code 001
D 21 Marke und Typ / Marque et type / Marca e tipo / Marca e tip	SUZUKI SX4 1.6 4WD			
E 23 Fahrgestell-Nr. / Châssis no / Telaio n. / Schassis nr.	JSAGYB21S0 [redacted]			
25 Karosserie / Carrosserie / Carrozzeria / Carossaria	Limousine			Code 163
26 Farbe / Couleur / Colore / Colur	dunkelgrau met.			
27 Plätze: / Places: / Posti: / Plazs: Total / Total / Totale / Total	5	2 vorne) avant) anteriori) davant)	30 Leergewicht / Poids à vide / Peso a vuoto / Paisa da vid kg	1310 G
18 Stammnummer / N° matricule / N. di matricola / Nr. da matricla	[redacted]		32 Nutz-/Sattellast / Charge utile/sellette / Carico utile/sella / Chargia utila/sella kg	375
24 Typengenehmigung / Réception par type / Approvazione del tipo / Approvaziun dal tip	1SD677		33 Gesamtgewicht / Poids total / Peso totale / Paisa totala kg	1685 F
37 Hubraum / Cylindrée / Cilindrata / Cilindrada cm³	1586		35 Gewicht des Zuges / Poids de l'ensemble / Peso del convoglio / Paisa cumposiziun kg	*******
76 Leistung / Puissance / Potenza / Prestaziun kW	82.00		31 Anhängelast / Poids remorquable / Carico rimorchiato / Chargia annexa kg	*******
78 kW/kg Leergewicht / poids à vide / peso a vuoto / paisa da vid	*******		55 Dachlast / Charge sur le toit / Carico sul tetto / Chargia sin il tetg kg	50
B 36 1. Inverkehrsetzung / 1re mise en circulation / 1ª messa in circolazione / 1. entrada en circulaziun	[redacted] 06.2011		72 Emissionscode / Code émissions / Codice emissioni / Code d'emissiuns	B04
38 (Raum für Ort und D… / (Espace pour lieu e… / (Spazio per luogo e… / (Spazi per lieu e da…	[redacted]			
39 Prüfungen / Expertises / Perizie / Examinaziuns	[redacted]			

1/1

Datum	13. 9	
KM	180 663	
MIL	☐ AN	☒ AUS

Kühlmitteltemperatur



☐ ☒ ☐

Messung 1* *2000-3000 U/min ohne Last*	28 500
Messung 2* *2000-3000 U/min mit Last*	31 300
Messung 3* *Referenzmessung Umgebungsluft / Intake*	5 800

**Messwert in 1/cm³*

NPTI1000 23.08.2023_sts

Co-funded by the European Union
Project funded by
Schweizerische Eidgenossenschaft
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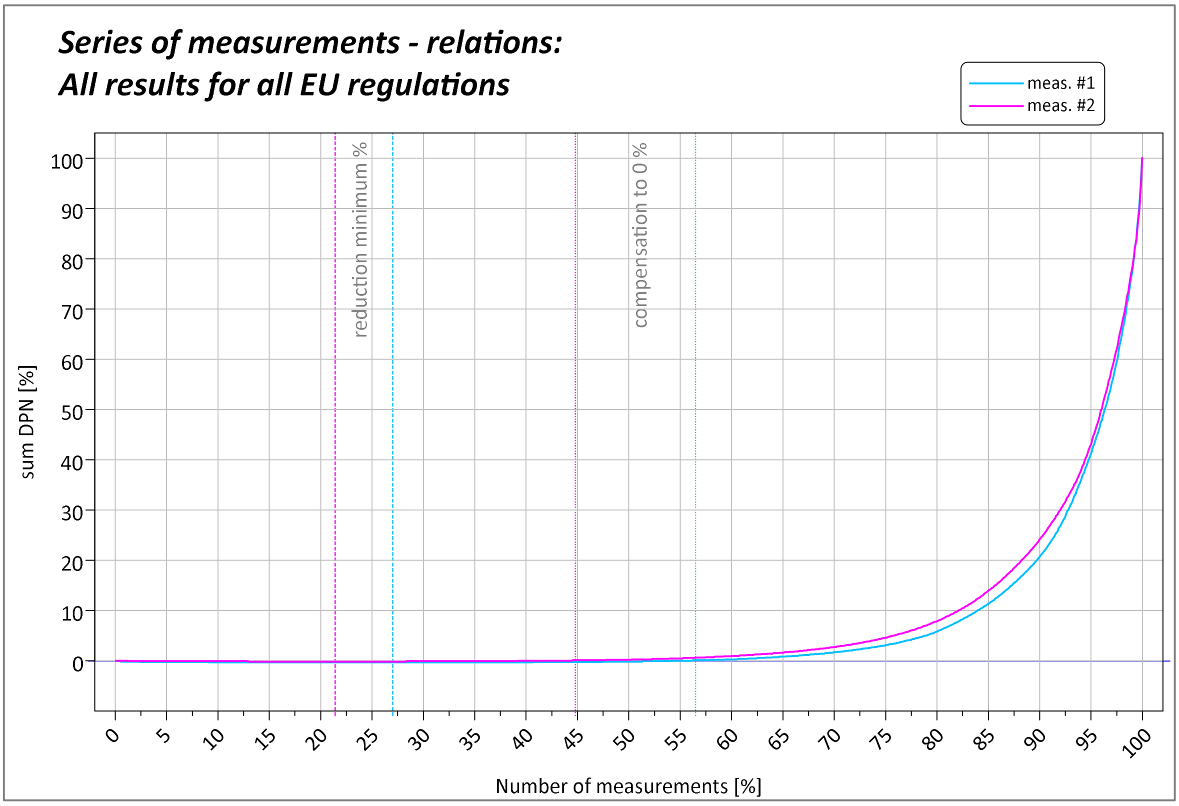
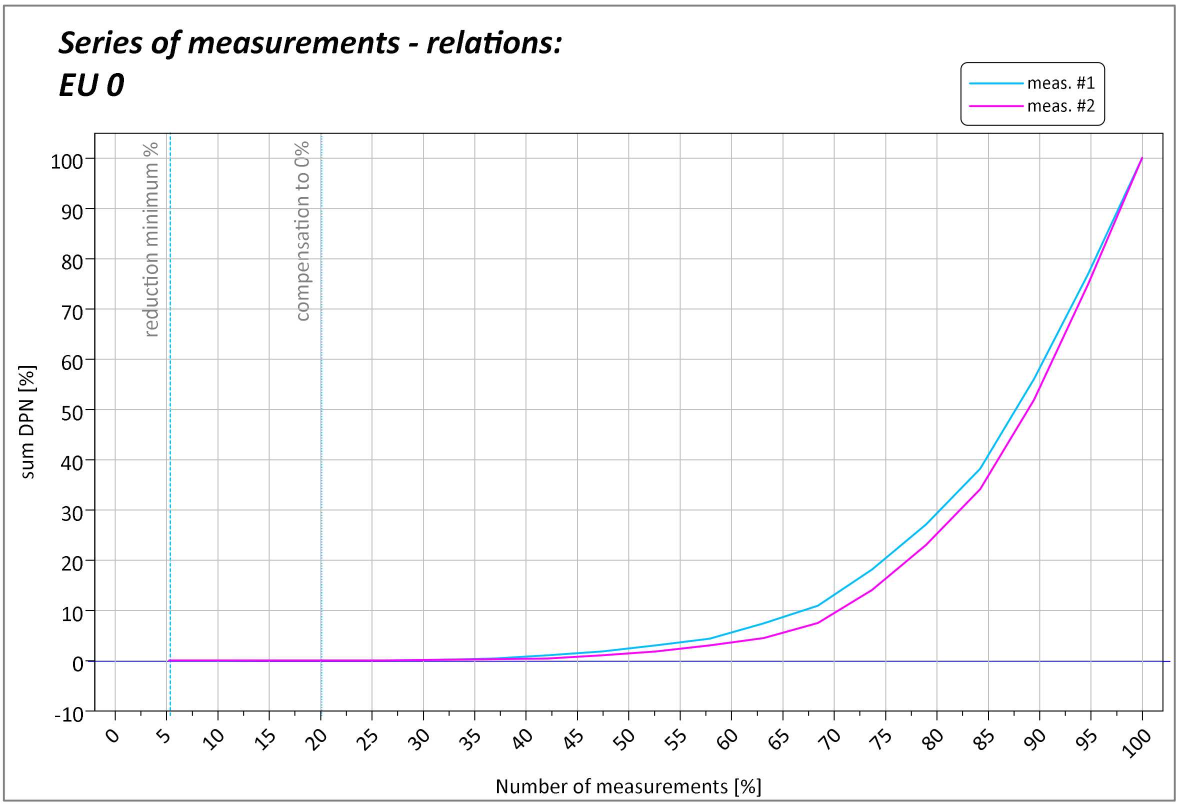
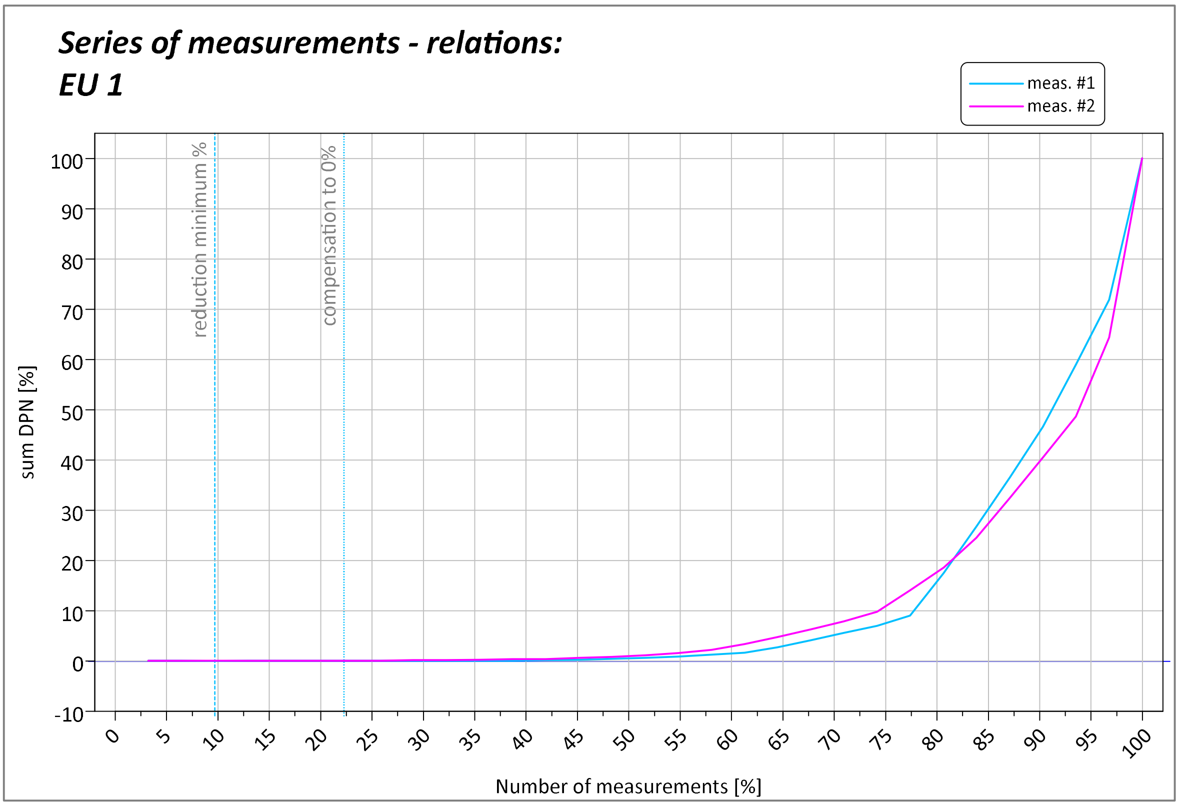
Confederazione Svizzera
Confederaziun svizra
Swiss Confederation
Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI

Appendix 3: relative contribution to results per EU class




Series of measurements - relations:
EU 0
meas. #1
meas. #2
reduction minimum %
compensation to 0%
sum DPN [%]
Number of measurements [%]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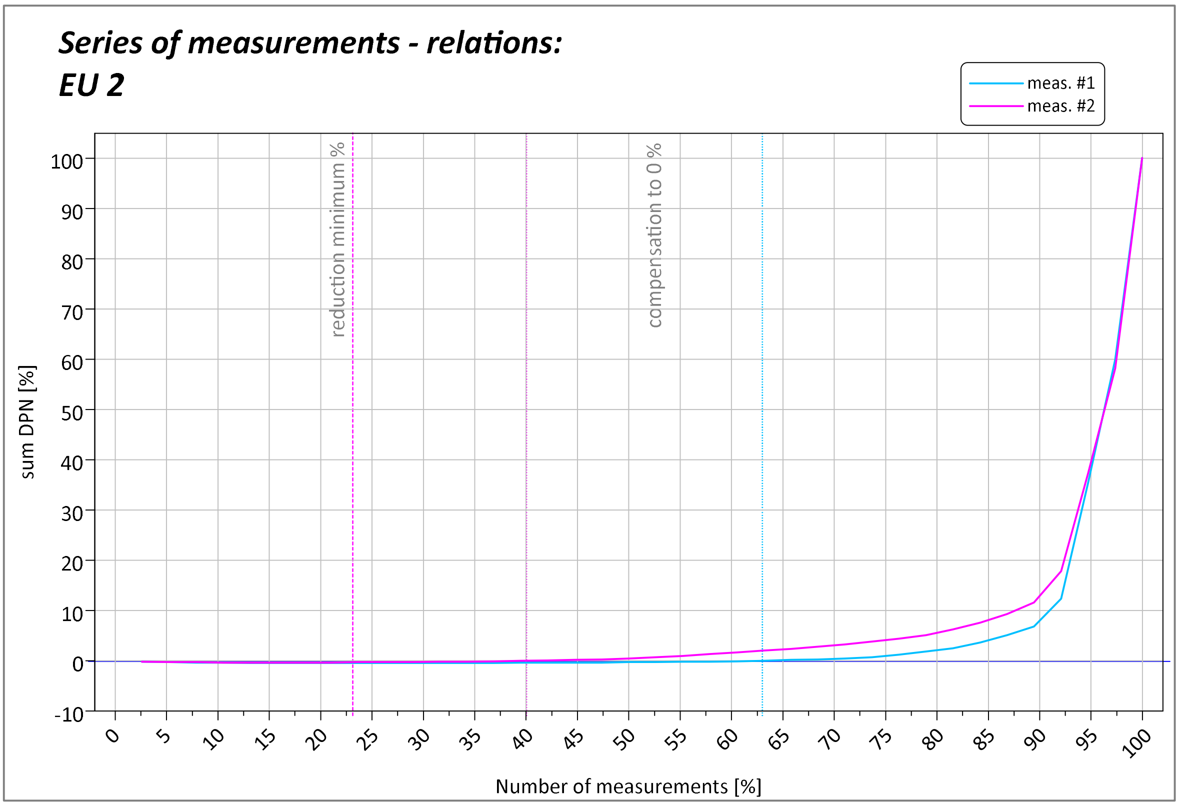
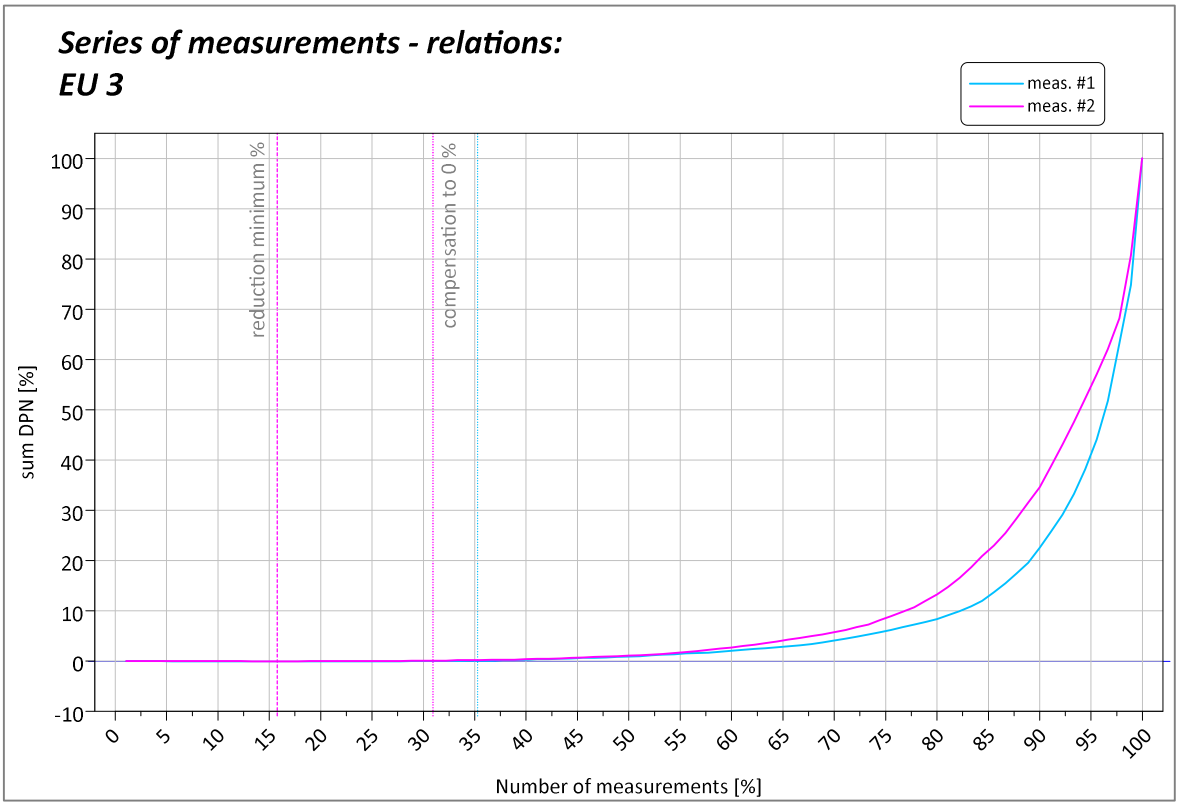
EU 1
meas. #1
meas. #2
reduction minimum %
compensation to 0%
sum DPN [%]
Number of measurements [%]


Series of measurements - relations:
EU 2
meas. #1
meas. #2
reduction minimum %
compensation to 0 %
sum DPN [%]
100
90
80
70
60
50
40
30
20
10
0
-10
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Number of measurements [%]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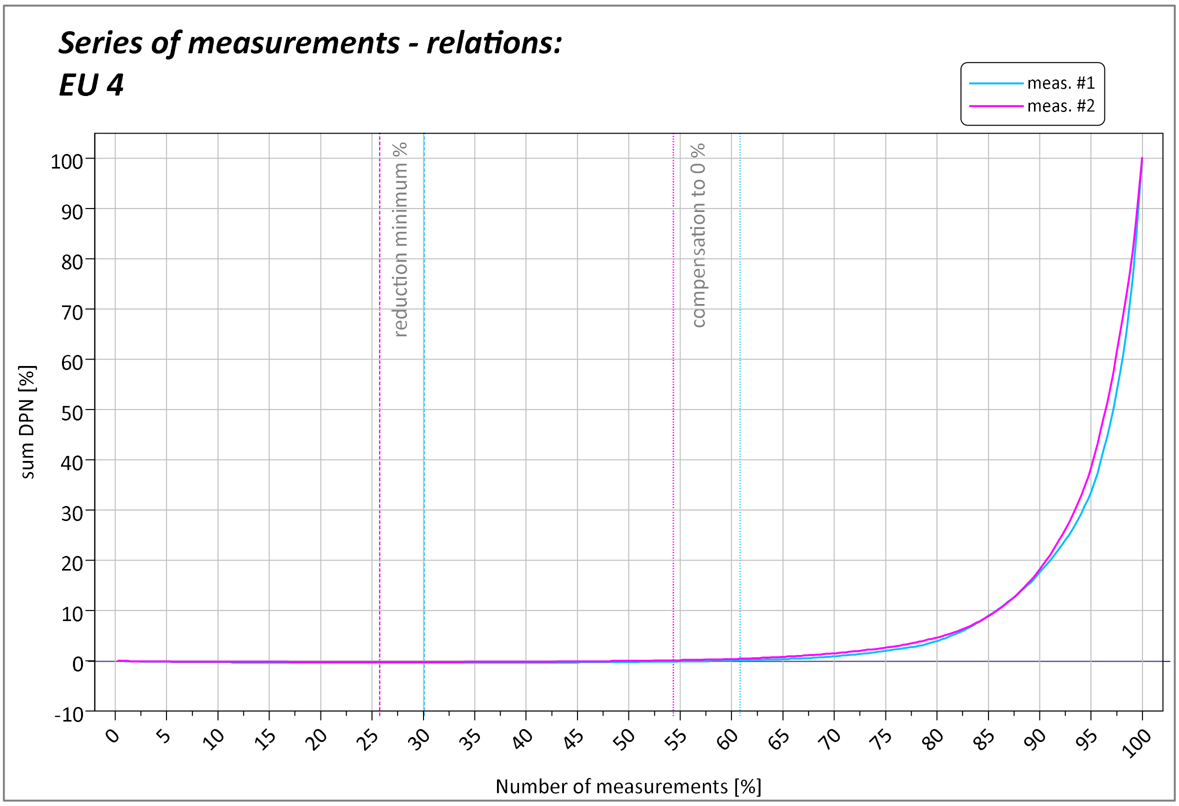
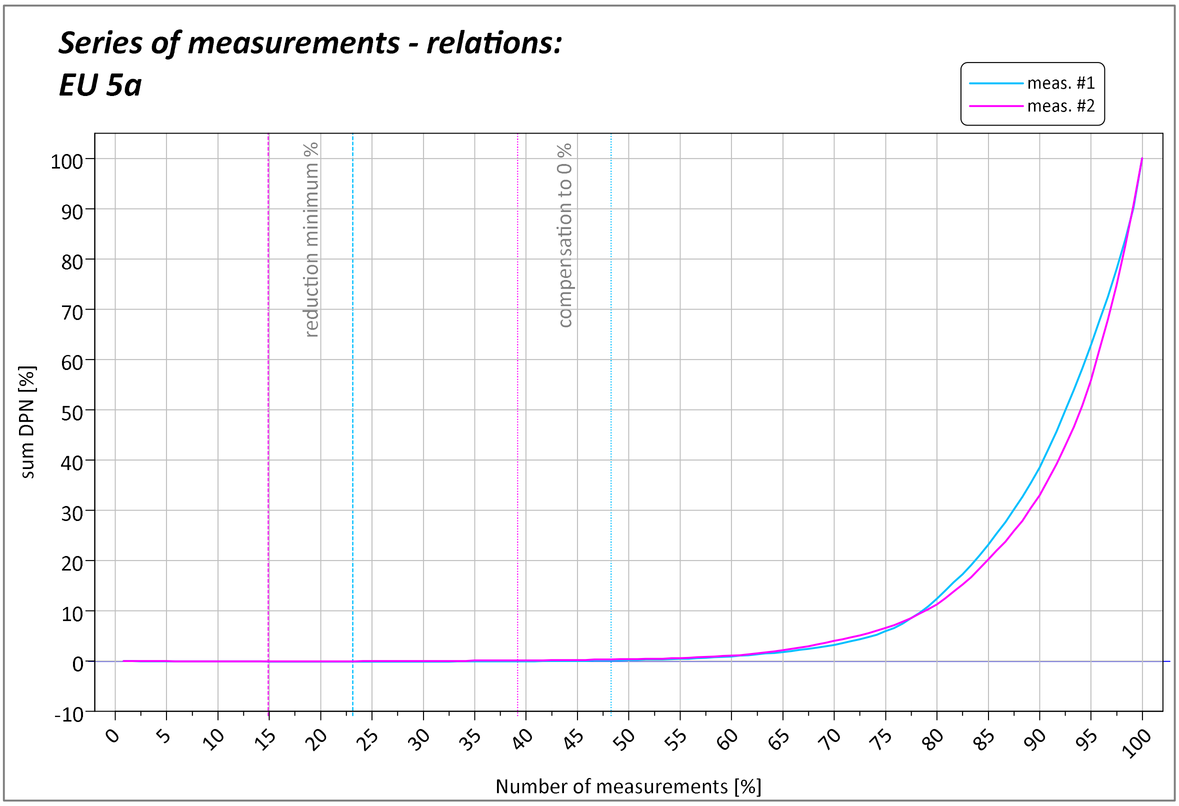
EU 3
meas. #1
meas. #2
reduction minimum %
compensation to 0 %
sum DPN [%]
100
90
80
70
60
50
40
30
20
10
0
-10
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Number of measurements [%]





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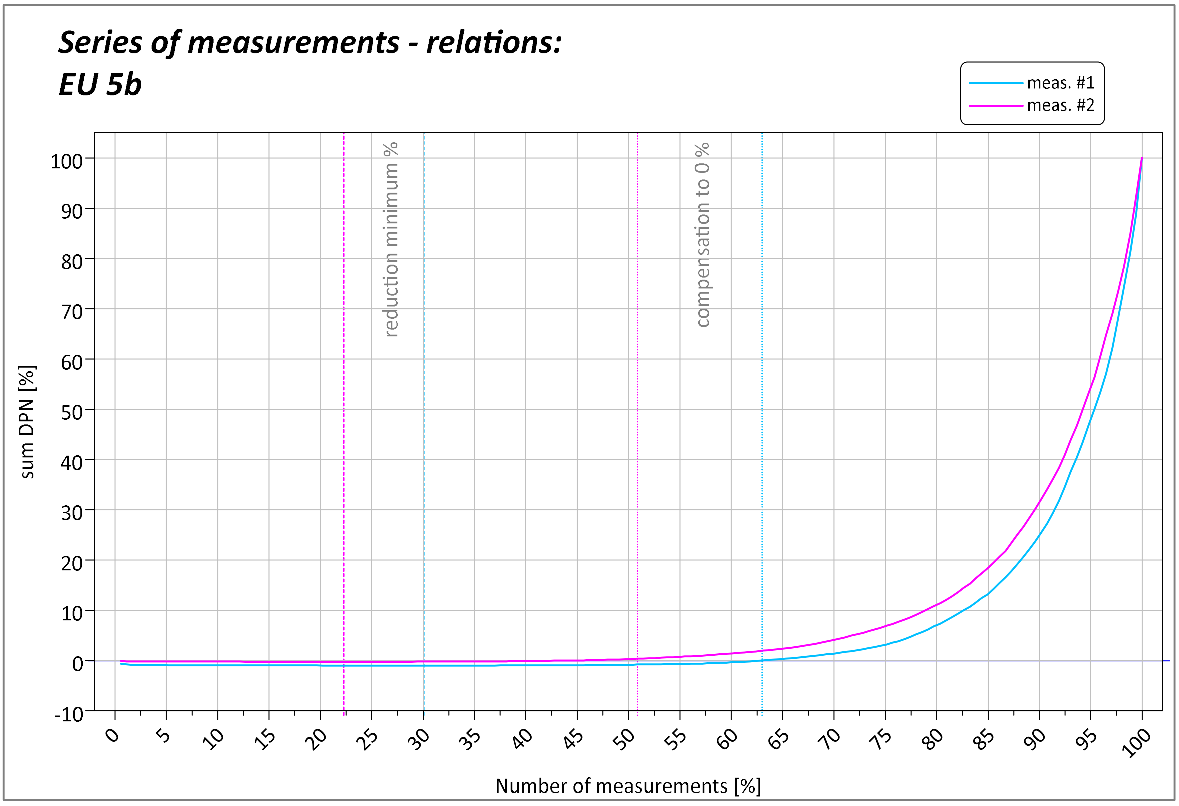
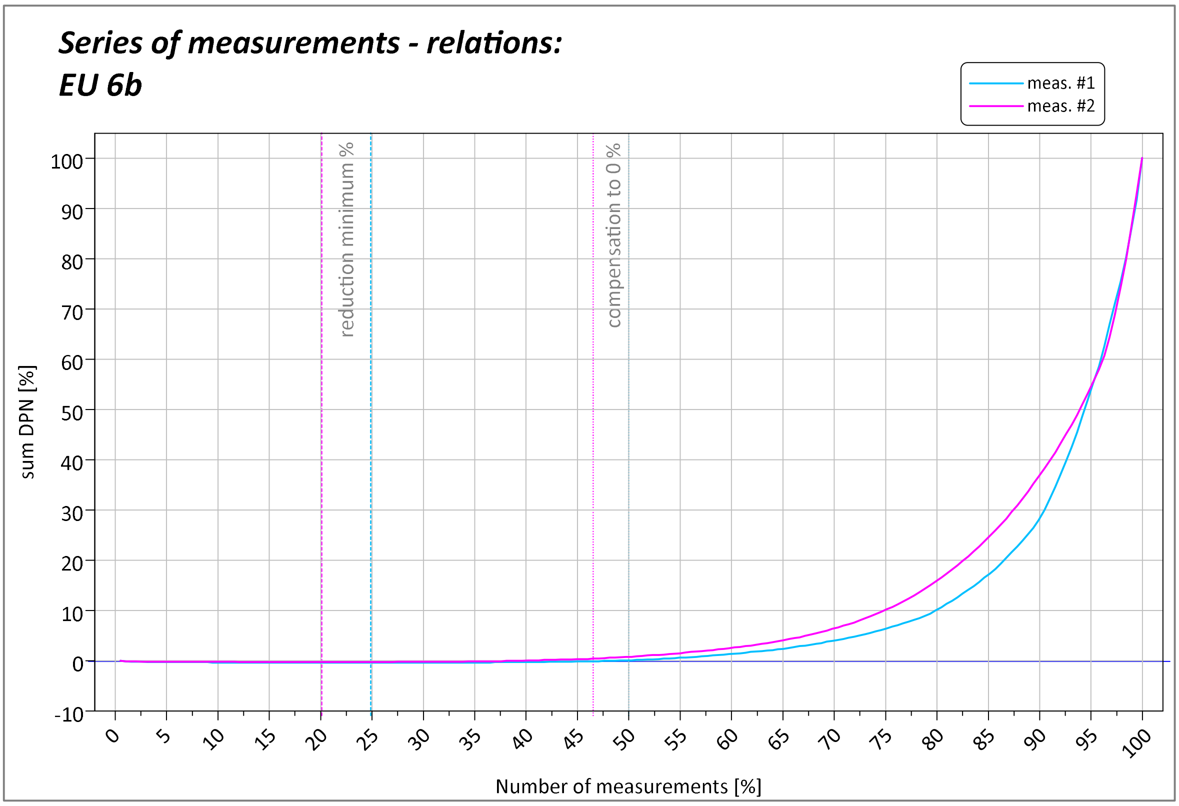
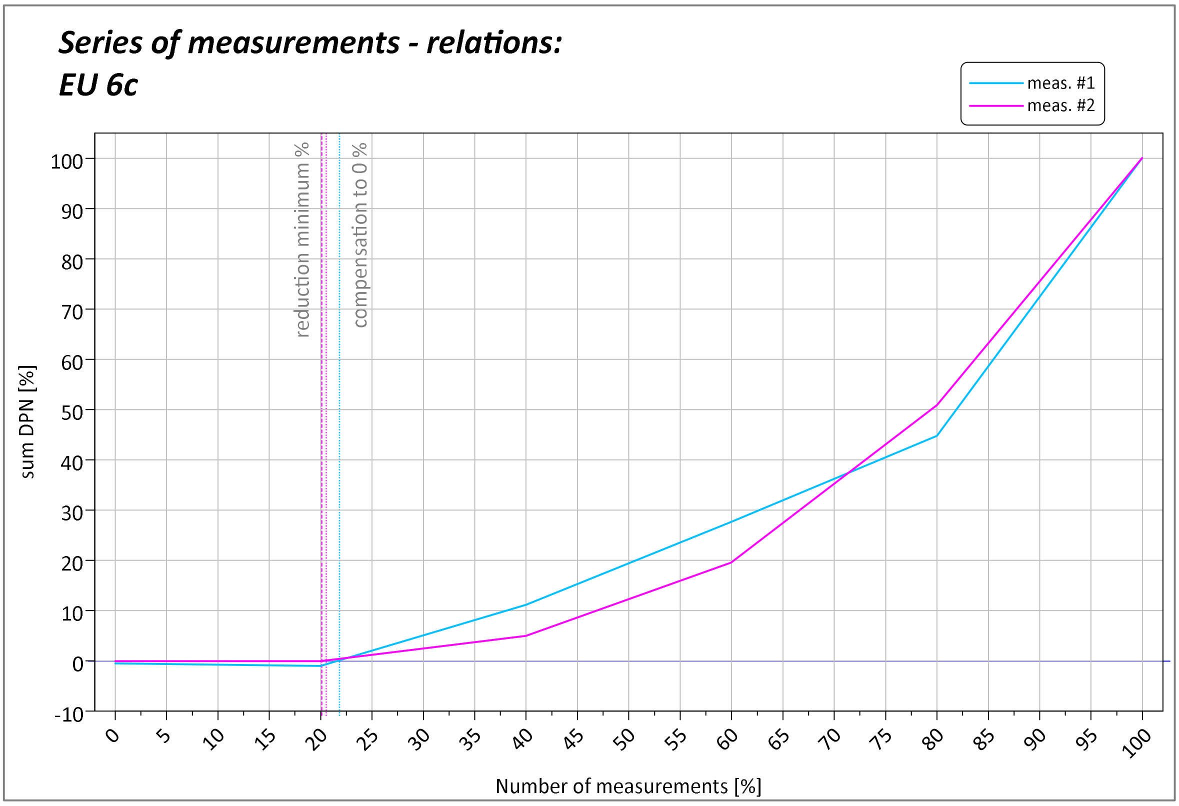
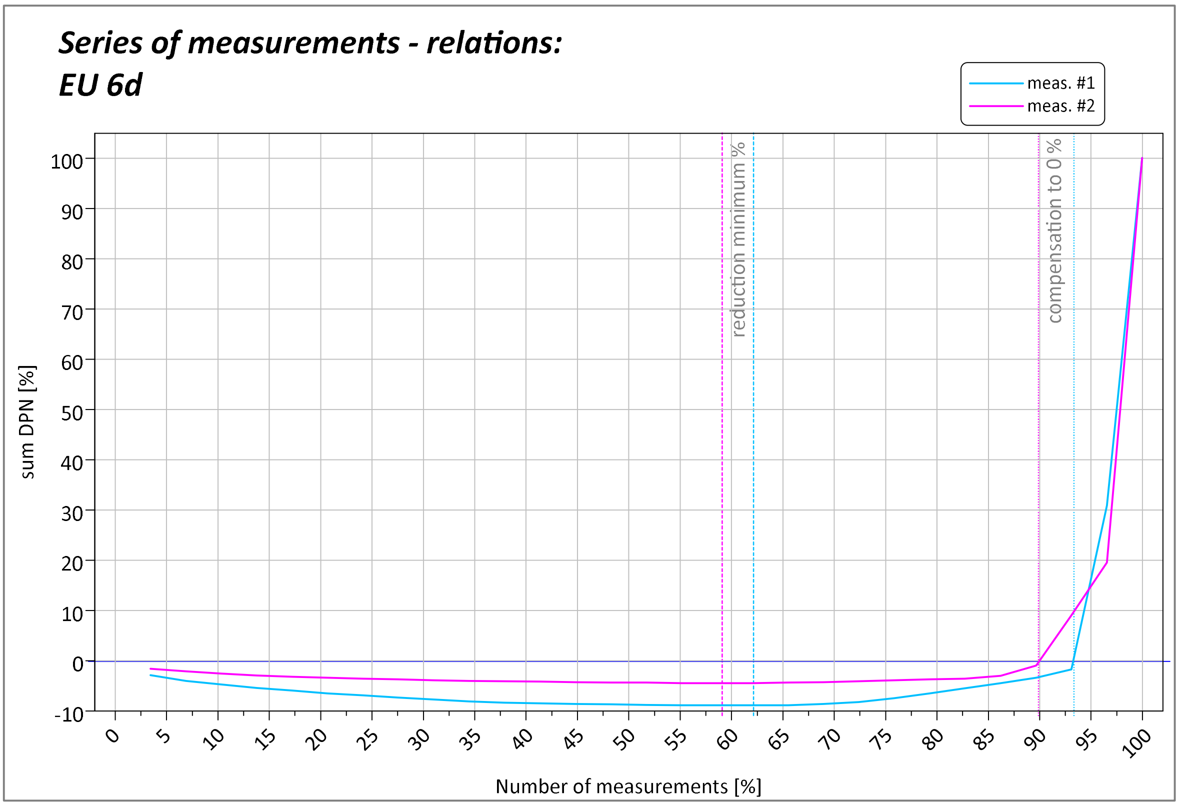

Series of measurements - relations:
EU 5b
meas. #1
meas. #2
sum DPN [%]
Number of measurements [%]
reduction minimum %
compensation to 0 %
100
90
80
70
60
50
40
30
20
10
0
-10
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100


Series of measurements - relations:
EU 6b
meas. #1
meas. #2
reduction minimum %
compensation to 0 %
sum DPN [%]
100
90
80
70
60
50
40
30
20
10
0
-10
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Number of measurements [%]


Series of measurements - relations:
EU 6c
meas. #1
meas. #2
reduction minimum %
compensation to 0 %
sum DPN [%]
100
90
80
70
60
50
40
30
20
10
0
-10
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Number of measurements [%]


Series of measurements - relations:
EU 6d
meas. #1
meas. #2
reduction minimum %
compensation to 0 %
sum DPN [%]
100
90
80
70
60
50
40
30
20
10
0
-10
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Number of measurements [%]