

7. VERT-Forum – March 18th 2016

DPF Inspection & Maintenance

The Policy

Thomas W. Lutz

Engine life and emission stability depend mainly on maintenance

- **Maintenance** must be a periodic routine
- **Emission control** must become part of maintenance

→ **Guarantees emission stability**

→ **Reduces overall costs**

(preventive repair, avoidance of operation interruptions...)

Technical Requirements

- The vehicles are equipped with **certified filters** ($\eta > 97\%$) and **wireless dataloggers**
- Certified **PN (plus CO) measurement devices**, portable, low cost and highly sensitive are **available**
- The **obligation** for periodical maintenance of emission relevant components, particle emission checks and documentation is **defined by a mandatory regulation**

Potential of PN-Measurement

- Fast, handheld, accurate PN-measurement for:
 - Fleet maintenance and control
 - Roadside measurement
 - Official periodic emission checks
- Verify filter efficiency
- Detect small repairable DPF defects
- Indicate the need for filter exchange
- Detect engine malfunctions

Portable Particle Emission Analyser

Condensation nucleus
counter by TSI - NPET



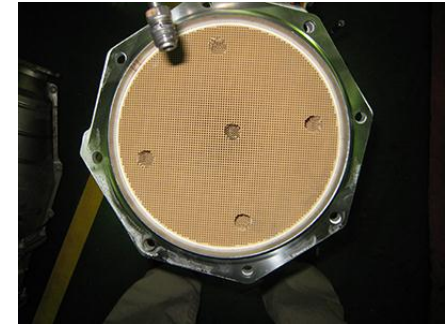
Diffusion charging
by TESTO - PEPA



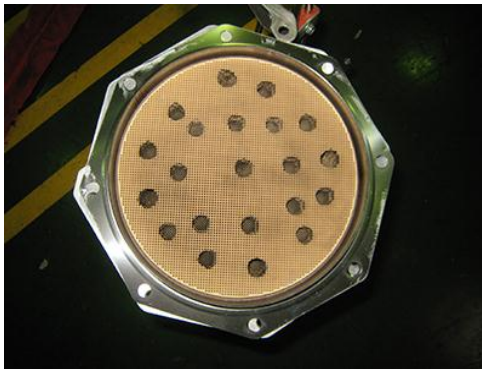
Can small failures be detected by PN at low idle ?



1hole (0.5%)



5 holes (2.7%)



17 holes (9.3%)

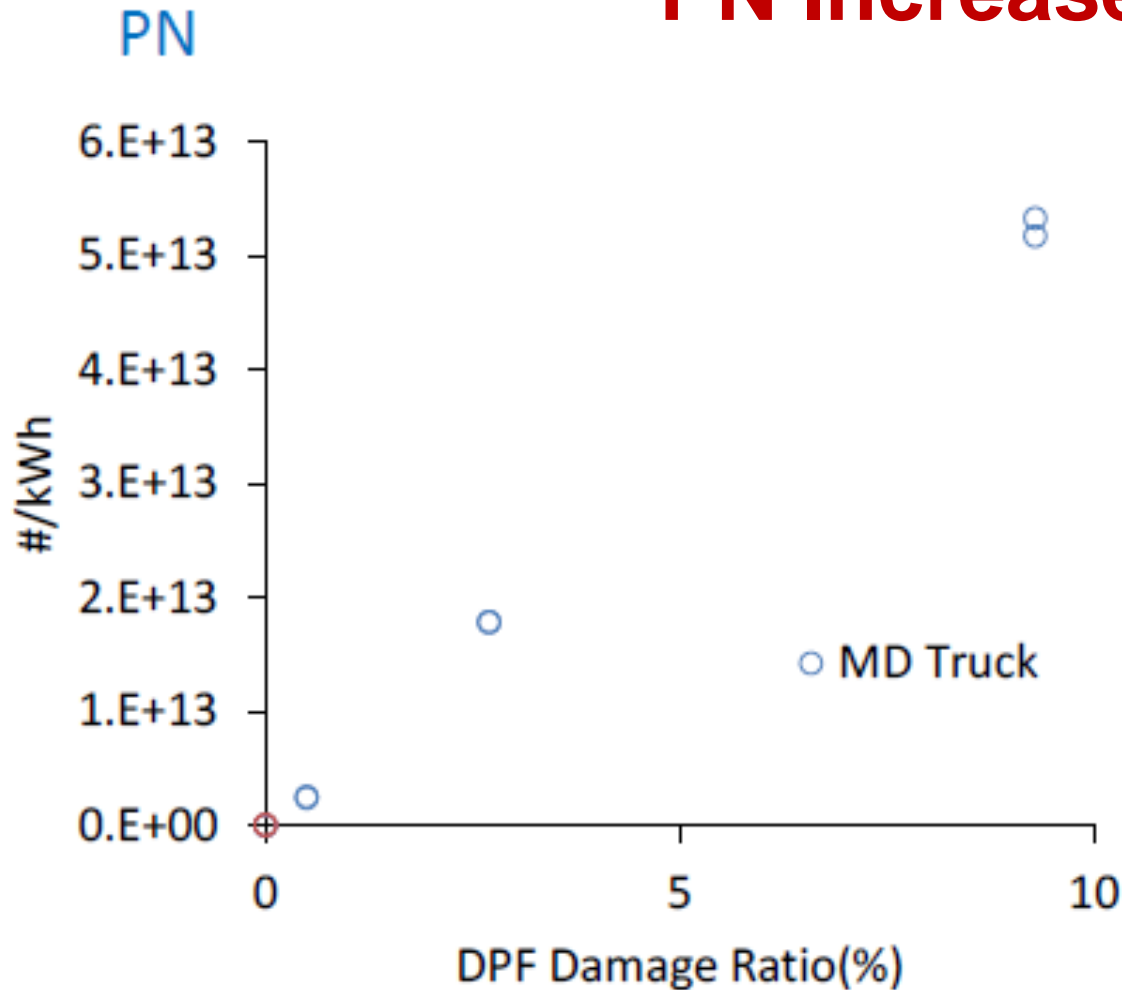


41 holes(22.5%)



Completely (100%)

PN Increase vs. DPF Damage



Measured at low idle

Yamada, ETH-NPC 2015

I&M Organization

Run by:

Test-only-stations

- Authorities
- Authorized private organizations

Test+repair-stations/shops

- Private workshops
- Users/fleet owners

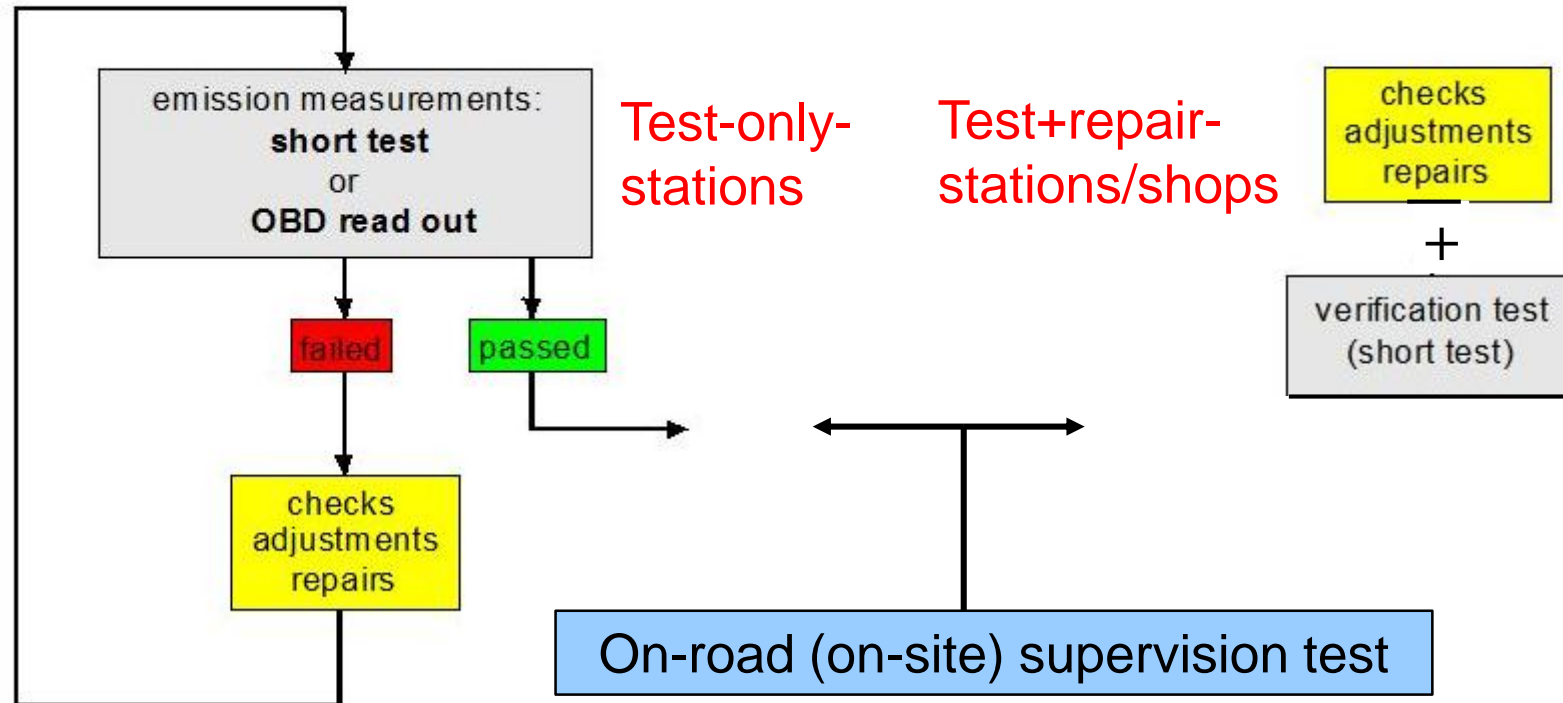
Supervision on-road/on-sites

Authorities

General I&M Strategies

EFFECTIVENESS TEST OF EMISSION CONTROL SYSTEM

PERIODIC EMISSION CONTROL SYSTEM MAINTENANCE



I&M Concept Elements (1)

(to be defined)

- **Vehicle categories liable to I&M**
- **I&M concept**
- **I&M procedures:**
 - tests
 - minimum maintenance
- **I&M intervalls**
- **Quality criteria for I&M performers:**
 - personnel
 - equipment
- **Certification of I&M performers**

I&M Concept Elements (2)

- **Costs**
- **Data collection / individual documentation**
- **Quality control of I&M performers:** e.g. test equipment (periodical calibration)
- **Enforcement by on-road tests:**
 - procedure
 - crew training
 - equipment
 - financing
 - fines

etc.

Typical I&M Procedure - Checks

- ① **Regular inspection** (every x month, ***authorized institution***) (e.g. busses)
- ② **Periodical maintenance of emission relevant components** (***user, workshop***) (e.g. NRMM CH)
- ③ **Supervision on-road (on-site)** (***authorities***)

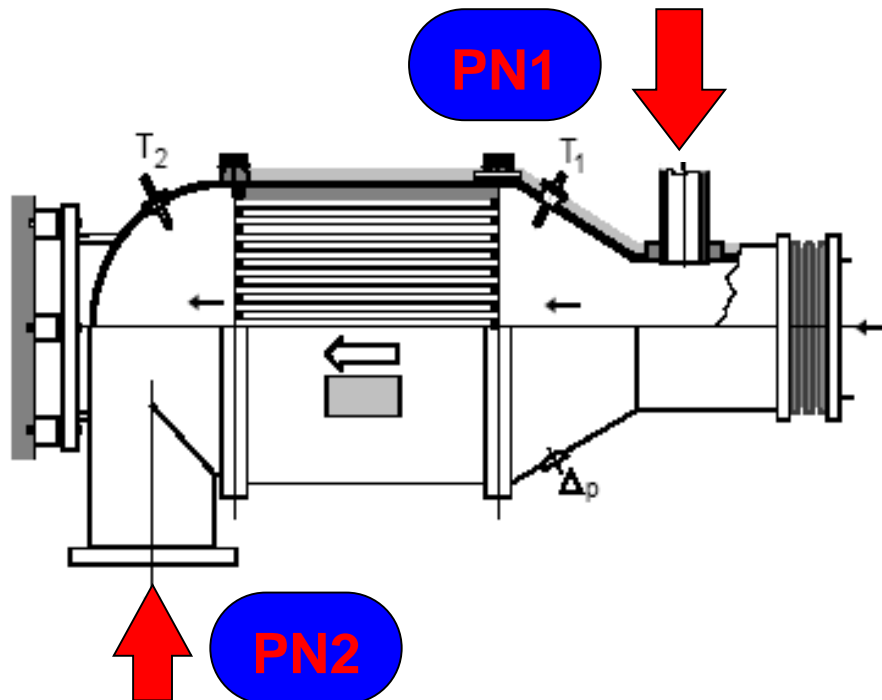
Regular Inspection – Inspection Scope

①

- Identification of the vehicle
- Measurement of PN at **low idle** (end pipe)
- If the allowed limit is exceeded:
 - ▶ Determination of filter efficiency by measuring PN before/after filter at **low idle**
 - ▶ The operator of the vehicle is obligated to a regular engine and filter system maintenance procedure and a retest by an authorized institution
- If the filtration efficiency is below 90%:
 - ▶ Repair or replacement of filter

Determination of Filter Efficiency

The filter masks the engine. Measurement upstream and downstream is needed to get information about engine raw emission and filter efficiency



PN1 before the filter determines the emission status of the engine itself, eventual failures, leakages, deterioration, aging

Filtration efficiency:

$$\eta = (PN1 - PN2) / PN1 \cdot 100 [\%]$$

Repair Small Failures by Ceramic Cement

W.Haldenwanger

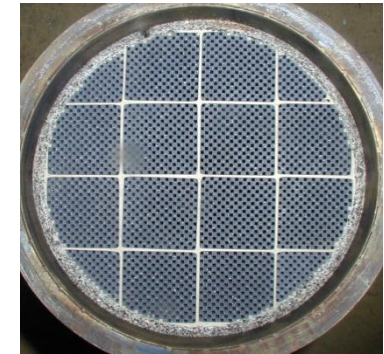
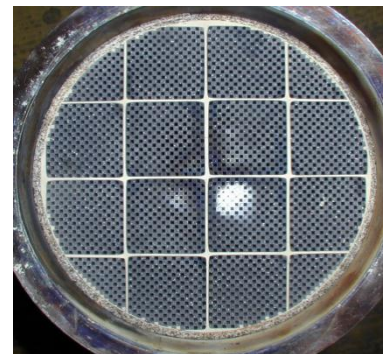
Technische Keramik GmbH

Teplitzer Strasse 27

D-84478 Waldkraiburg

WH Feuerfestkitt Teil A und B

www.haldenwanger.de



Maintenance of Emission Relevant Components: Procedure

②

- **Visual Checks:**
 - tightness of all systems
 - oil and soot deposits in the exhaust pipe
 - signs of overheating of the filter housing
- **Maintenance** of engine, filter system and crank case ventilation (in case of a closed version), corresponding to the instructions of the manufacturer
- **Data analysis** (wireless datalogger), e.g.:
 - too high backpressures (when and where on the route)
 - temperatures (e.g. low idle phases)
- **Cleaning of filter if necessary**, → the cleaned filter has to be checked by a PN measurement at low idle (**end pipe**)

Maintenance of Emission Relevant Components: Procedure (cont.)

- **Determination of filter efficiency**
 - ▶ If the efficiency is below 90% and the PN emission is above the allowed limit:
▼
- **Visual check** of the filter for damages (if less than 10%: → repair, otherwise replacement)
- If a **bad engine condition** is **assumed**: measurement of PN or opacity before filter at free acceleration and determination of the k-value, ev. oil analysis
- **DOC** (CRT systems): CO conversion measurement: If necessary, cleaning of DOC or replacement
- **Confirmation** in the inspection document

Supervision Test – On-road / On-site)

③

- Identification of the vehicle
- Measurement of PN at **low idle** (end pipe)
- If the limit of (*CH regulation*) **250'000 #/cm³** is exceeded:
 - ▶ then the operator of the vehicle is obliged to a regular engine and DPF system maintenance procedure and a retest by an authorized institution



On-road Check

Santiago de Chile,
July 2015

Equipment:
TSI-NPET

Individual Documentation

- Content:**
- Vehicle main data
 - (retrofit date)
 - low and high idle speed
 - (start of fuel delivery)
 - PN before and after filter at low idle
 - rubrics for inspection confirmations

CH Inspection Document

ABGAS-WARTUNGSDOKUMENT
FICHE D'ENTRETIEN DU SYSTÈME ANTIPOLLUTION
DOCUMENTO SULLA MANUTENZIONE RELATIVA AI GAS DI SCARICO
Diesel
<p>Muss stets im Fahrzeug mitgeführt werden Doit toujours rester dans le véhicule Il presente documento deve sempre accompagnare il veicolo</p>
<p>CH</p> <p>Gesetzliche Vorschriften auf Seite 6 und 7 Voir prescriptions légales aux pages 6 et 7 Prescrizioni legali, vedere pagina 6 e 7</p>

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VSBM-Sekretariat, c/o VSG, Postfach 656, CH-4010 Basel

1
<p>① Fahrzeugdaten / Données du véhicule / Dati del veicolo</p> <ul style="list-style-type: none"> ● Marke Marque Marca ● Fahrzeugtyp Type du véhicule Tipo veicolo ● Fahrgestell-Nr. No du châssis Telajo no ● Motor-Kennzeichen Identification du moteur Identificazione motore
<p>② Messbedingungen / Conditions de mesure / Condizioni di misurazione</p> <ul style="list-style-type: none"> ● Motor auf Betriebstemperatur bringen. - Alle elektrischen Verbraucher ausschalten. - Erfolgt die Messung in grösseren Höhen als 500 m ü. M., so sind bei Fahrzeugen ohne Druckkorrektur zur Berücksichtigung des Höheneinflusses vom gemessenen Wert, je 0,25 m⁻¹ bzw. 0,5 Bacharach pro 400 m grössere Höhe abzuziehen. Es ist der korrigierte Wert einzutragen. - Weitere Angaben des Herstellers beachten. ● Chauffer le moteur à sa température de marche. - Déclencher tous les consommateurs électriques. - Pour tenir compte de l'influence de l'altitude sur les véhicules sans correction de pression, lorsque des mesures sont effectuées à des altitudes excédant 500 m, on déduira respectivement 0,25 m⁻¹ ou 0,5 indice de raréfaction Bacharach par tranche de 400 m au-dessus. Il y a lieu d'inscrire la valeur corrigée sur la fiche d'entretien. - Consulter attentivement les indications du constructeur. ● Portare il motore a temperatura di marcia. - Staccare tutti i consumatori di elettricità. - Per poter tener conto dell'influenza barometrica esercitata sui veicoli senza correttore di pressione, nel caso di misurazioni effettuate ad altitudini superiori a m. 500, si dedurrà rispettivamente 0,25 m⁻¹ o 0,5 indice di opacizzazione Bacharach per fasce supplementari di 400 m. Solo il valore corretto viene registrato sul foglio di manutenzione. - Attenersi alle indicazioni del costruttore.

2			
<table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 33%; text-align: left; padding: 5px;">Sollwerte des Herstellers</th> <th style="width: 33%; text-align: left; padding: 5px;">Valeurs du constructeur</th> <th style="width: 33%; text-align: left; padding: 5px;">Dati del costruttore</th> </tr> </table>	Sollwerte des Herstellers	Valeurs du constructeur	Dati del costruttore
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<p>③ Kontrollwerte / Indications de réglage / Indicazioni di regolazione</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 60%; padding: 5px;"> <ul style="list-style-type: none"> ● Leerlaufdrehzahl Régime de ralenti Regime del minimo ● Obere Leerlaufdrehzahl Régime maximal à vide Regime massimo, a vuoto ● Förderbeginn Commencement du débit Inizio mandata ● Plomben und/oder Versiegelungen Plombs et/ou sceaux Piombi e/o sigilli </td> <td style="width: 30%; padding: 5px;"> <ul style="list-style-type: none"> - statisch statique - dynamisch dynamique </td> <td style="width: 10%; padding: 5px;"> <ul style="list-style-type: none"> min⁻¹ min⁻¹ mm² mm² </td> </tr> </table>	<ul style="list-style-type: none"> ● Leerlaufdrehzahl Régime de ralenti Regime del minimo ● Obere Leerlaufdrehzahl Régime maximal à vide Regime massimo, a vuoto ● Förderbeginn Commencement du débit Inizio mandata ● Plomben und/oder Versiegelungen Plombs et/ou sceaux Piombi e/o sigilli 	<ul style="list-style-type: none"> - statisch statique - dynamisch dynamique 	<ul style="list-style-type: none"> min⁻¹ min⁻¹ mm² mm²
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<p>④ Rauchemissionswerte / Valeurs des émissions de fumées / Valori delle emissioni di fumo</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 60%; padding: 5px;"> <ul style="list-style-type: none"> ● Trübungskoeffizient Coefficient d'opacité coefficiente d'opacità ● Schwärzungszahl Degré de raréfaction grado di annerimento </td> <td style="width: 30%; padding: 5px;"> <ul style="list-style-type: none"> maximal maximum massimo maximal maximum massimo </td> <td style="width: 10%; padding: 5px;"> <ul style="list-style-type: none"> m⁻¹ Bacharach </td> </tr> </table>	<ul style="list-style-type: none"> ● Trübungskoeffizient Coefficient d'opacité coefficiente d'opacità ● Schwärzungszahl Degré de raréfaction grado di annerimento 	<ul style="list-style-type: none"> maximal maximum massimo maximal maximum massimo 	<ul style="list-style-type: none"> m⁻¹ Bacharach
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<ul style="list-style-type: none"> ● Der Unterzeichnende bestätigt, dass die Abgaswertung nach Herstellervorschrift und unter Verwendung der vorgeschriebenen Messgeräte ausgeführt wurde. ● Le soussigné atteste que le service d'entretien du système antipollution a été exécuté conformément aux indications du constructeur et en utilisant les appareils de mesure prescrits. ● Il firmatario attesta che il servizio di manutenzione del sistema anti inquinamento conformemente alle indicazioni del costruttore è utilizzando gli apparecchi di misura prescritti. 			

Conclusions

The needs for the implementation of a consistent I&M strategy

➤ The instruments are ready:

- PN-measurements at low idle for **DPF** and **engine** control
- Filter monitoring with remote control (datalogging)
- DOC-conversion activity control is established (CRT systems)

but

➤ Regulations are needed

➤ Periodic independent checks are needed

➤ Documentation is needed (emission document on-board)

**Inspecting vehicles does not
reduce pollution,
MAINTAINING / REPAIRING
them does**

Cliff Grove, Automotive Diagnostics,
SPX Corporation, USA 1996