VERT Association

VERT Activities and Experience with DPF Retrofitting

June 21st. 2016

Haifa, Israel

Lars Christian Larsen
VERT President

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Outline

- Presentation of VERT
- VERT Activities
- Experience with retrofit
- Best Practice Guideline for Israel
- Summary

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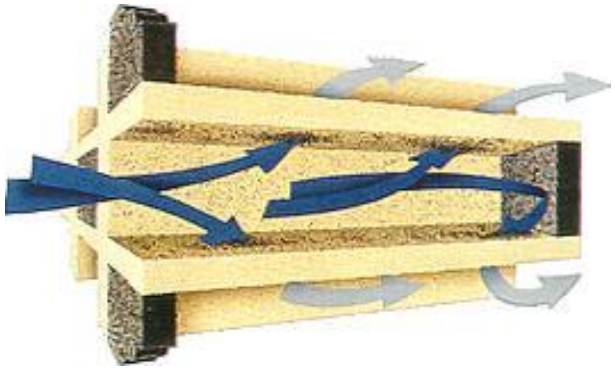
What does VERT® stand for?

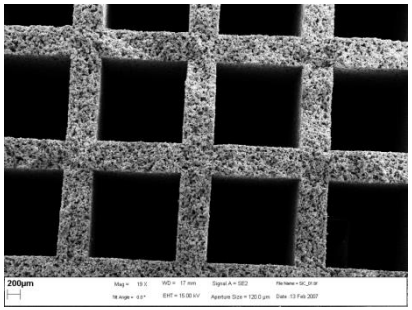
VERT = **V**erification of **E**mission **R**eduction **T**echnologies
for Particle Filters based on **B**est **A**vailable **T**echnology

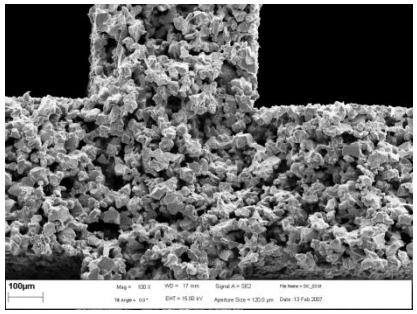
- Non-profit organization with the goal to eliminate particles and harmful substances from internal combustion engines
- Certification of diesel particle filters and Combination systems of filters and SCR. (VERT® filterlist)
- International membership; Manufacturers of DPF and SCR systems, testing devices, substrate manufacturers, chassis builders, engine manufacturers etc.
- Acting as partner in retrofit projects; support and execute pollution reduction programs from road traffic and non road mobile machinery

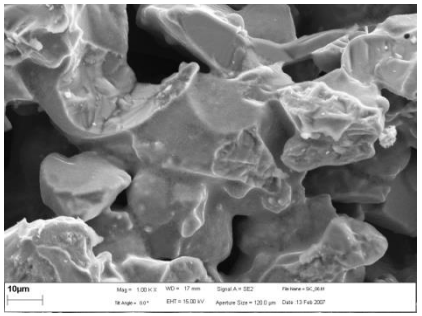
VERT® is a Trade Mark
for Particle Filters based on Best Available Technology

Technical Concept of a Diesel Particulate Filter

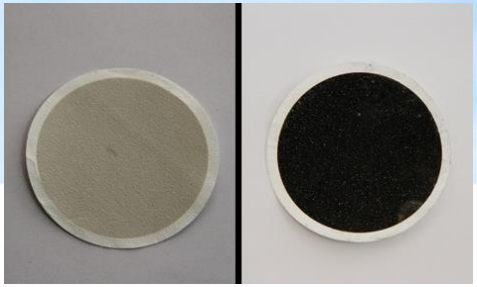








- Channels are reciprocally closed
- Exhaust gas is forced to penetrate the microporous wall
- Soot particles are hold back and collected on the walls of the filter material
- Filtration efficiency 99+% PM & PN



Focused on Particle Number (PN)

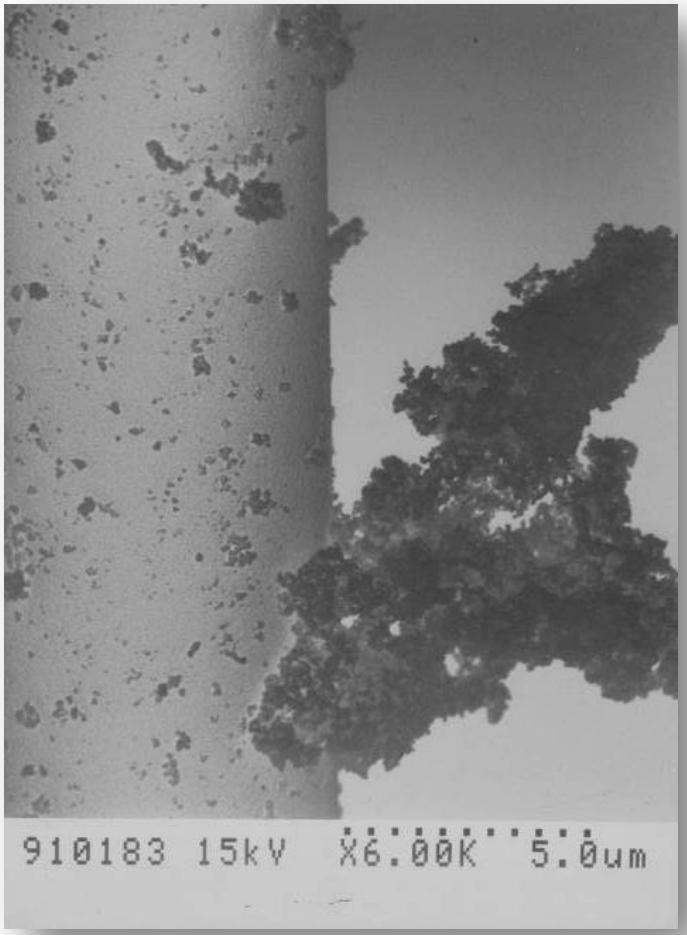
Why?

- PM Measurement is a gravimetrical method. This method is due to the physical limits not able to detect carcinogenic small particles.
- Particles must be counted instead of weight

Characteristics of fine/ultra fine/nano particles:

- Very small < 100 nm
- High surface > 100 m2/g
- Transporting toxics into the organism
- Carcinogenic
- Long life toxic aerosol (weeks to month)

- Diesel exhaust particles defined by WHO 1988 as probably carcinogenic
- Since 2012 as evidenced carcinogenic (class 1 like asbestos)



WHO = World Health Organization

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VERT Influences on International Legislation

- **2002:** CARB starts with support of VERT the retrofit show case in California with leads to a filter legislation
- **2005:** retrofit legislation for Euro1+2 buses in Santiago de Chile
- **2006:** EU adopted VERT principles for solid particle number - PMP-Protocol
- **2007:** EU introduces PN-Limit for LDV
- **2008**: retrofit Euro 3 buses in Santiago de Chile
- **2009:** EU introduces PN-Limit for HDV
- **2010:** UNECE-GRPE starts Working Group for on-road and off-road retrofit
- **2011:** EU parliament decides for PN for NRMM

VERT ww recognition

Switzerland: BAFU, SUVA, ASTRA | Austria: AUVA; Tyrol construction |Germany: BG Bau; UBA; TRGS 554 7 USA: MSHA; NY City | CARB partly | Netherlands: VROM | Italy: alto Adige | Canada: Mining | UK: London TFL and LEZ | Denmark: for all applications | Chile: Santiago Bus, Gensets | China: Hong Kong busses; Beijing | UNECE

EU= European Union | PMP= Particle number Measurement Protocol | PN= Particle number | HDV= Heavy Duty Vehicle | LDV= Light Duty Vehicles
UNECE = United Nations Economic commission for Europe | GRPE= Working Party on Pollution and Energy / CARB= California Air Research Board

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VERT Association Road Map

VERT Support for legislation with BAT and retrofit

Switzerland
PM Legislation for construction equipment

USA/California
CARB Show Case
New York City

Chile
DPF regulation for Euro III buses

Euro 6
Regulation bei PN

Bogotá, Xiamen, Beijing, Berlin,

Tel Aviv…
Demonstation of DPF efficiency, pilot tests, public authority support, guidelines for Air Quality

Past

Present

VERT ww recognition

Switzerland: BAFU, SUVA, ASTRA
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UK: London TFL and LEZ
Denmark: for all applications
Chile: Santiago Bus, Gensets
China: Hong Kong busses; Beijing
UN-ECE

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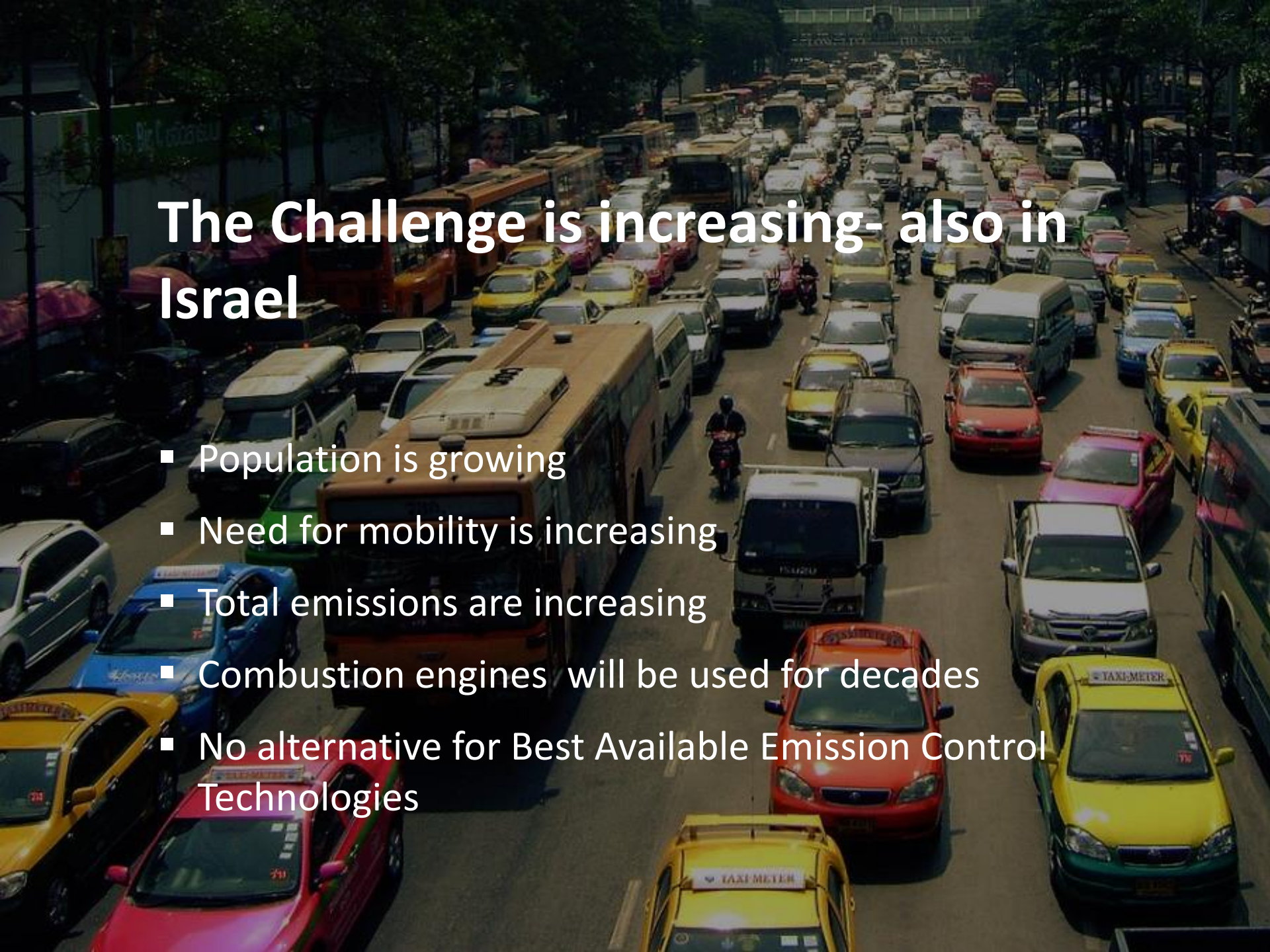
Retrofit examples

- City buses
- Heavy duty trucks
- Distribution vehicles
- Locomotives
- Gen sets
- Off Road Mobile Machinery (Excavators, Mobile cranes, etc.)

- Over 100.000 filters supplied from VERT members installed Worldwide

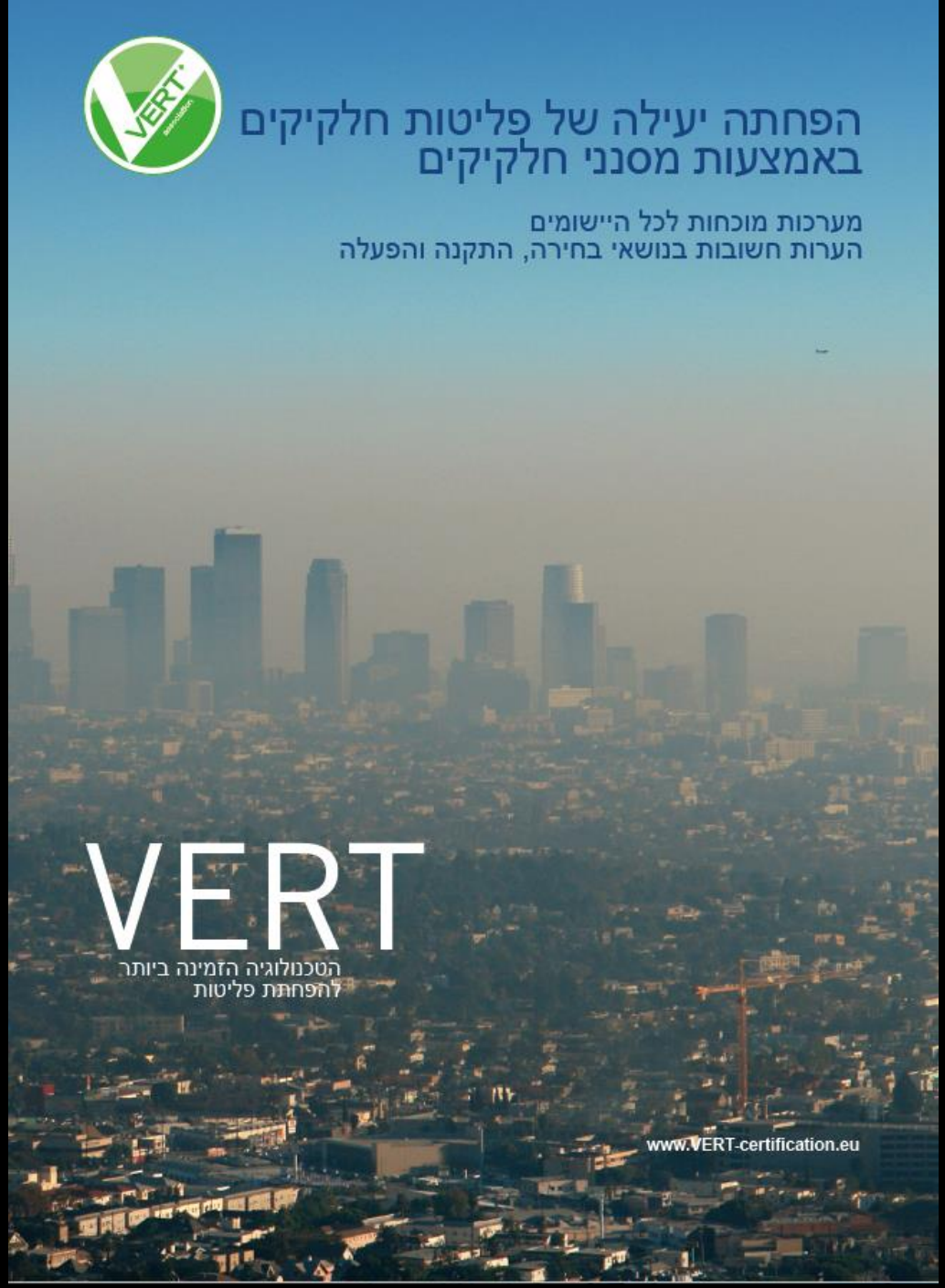


The Challenge is increasing- also in Israel

- Population is growing
- Need for mobility is increasing
- Total emissions are increasing
- Combustion engines will be used for decades
- No alternative for Best Available Emission Control Technologies

הפחתה יעילה של פליטות חלקיקים באמצעות מסנני חלקיקים

מערכות מוכחות לכל היישומים
הערות חשובות בנושאי בחירה, התקנה והפעלה



מניע

את פליטות החלקיקים המסרטנים ממנועי בעירה פנימית ניתן להפחית ביעילות רק באמצעות מסנני חלקיקים. מסנני חלקיקי
ם בכלי רכב כבדים, רכבים לתחזו־
10 לעומת העליות הרפואיות של

כשירות הרכב ובחירת מסנן

נקי:
רכבים עם מסנן

מערכות סינון כיוון שת־

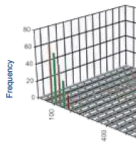
, רכב אשפה, מחפר, מלגזה

יישומים כבר בוצעו ב- 20.
בת. יצרני מסננים של VERT
מסנן הנכון 8,000 מקרים
מאגר של VERT ונגישים באופן

http://vert-certification.eu/j3/inde

ת המסנן דורשת ניתוח של

מתפרסורת גזי הפליטה. לשם
שיר מדידה ואוגר במהלך 2-3
פעולה האופייניים לרכב.



ות להחליט האם ניתן לה־
כית או שנדרשת רגנריצה
מינות בקווי מוצרים רבים.

התקנה / בדיקה / קבלה (עמוד 4)

התפקידים

– הפחתת רעש

שימוש במשאיות בעבודה של משתיק קול המקורי

מערכת CRT שימוש אופייני באוטובוסים

תפקודית / קבלה

יזנקציונלית של המסננים , אלקטרוניקה ותצוגה
דק רמות פליטה עם מד ספירת חלקיקים PN
ווקול קבלה חתום על ידי יצרן המסנן
לי רכב / מכונה
תובת המפעיל

כתובת יצרן המסנן, נתוני רכב ומנוע ,
נתוני מסנן , לחץ נגדי במהירות מנוע מרבית (governed speed)
אטימות גזי פליטה לפני ואחרי התקנת מסנן
אופיצוניאלי: מדידת רעש לפני / אחרי; בדיקה פונ־
קציונלית של OBD (On-Board Diagnostics)
ומערכת התרעה
חתימה של מתקין המסנן ומפעיל

למבחן / טסט קבלה זה יש
מי בין
זכר
רשויות
צאות יש לתעד
בלה עם שתי חתימות ותאריך.
ה מהווה כתב אחריות

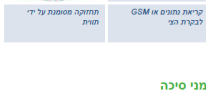
בטיחות

בלה של שדה הראייה
חממת הסביבה, טמפרטורת פני השטח
דת הצורך מגן חום / לבודד את המסנן
הגבלה במרווח נחון
מושי פנים ופעולות ייעור יש לדאוג להגנה נגד ציוץ
לבדוק התקני אחסון / והתקנה. (מסנני חלקיקים הם
רים באופן משמעותי מאשר משתיק קול)

העפלה ותחזוקה

ההוראות הבאות חלות על כל כלי רכב דיזל עם מערכות טיפול בגזי פליטה
מצעות רטרופיטינג

קריאת נתונים או GSM לבקרת הנ׳



מתחזוקה סטנדרטית על ידי תוצרת

מני סיכה

ו רק בדלק דיזל עם תכולת גופרית של < 10
ת לא להרעיל את מערכות הסינון. גם לדלק
סיכה יש רכיבים בלתי דליקים (אפר). אפר
סנן כמו שחיקה מתכתית של המנוע . לכן, יש
ק בשמני סיכה עם היווצרות אפר נמוכה (low
שמנים אלה זמינים אצל כל ספקי שמן ואושרו
רי מנועים. צריכת שמן מעל 1% מצריכת דלק
ן מנוע.

רציה

ות סינון מופעלת עם תוספי דלק (Fuel borne (cat). יש להשתמש בתוספים שאושרו ע"י
ד. כדי לוודא שלתוספים אלה אין השפעה שלי־
ת המנוע, יש לדרוש הוכחות ואחריות מהספק .
תוספים ללא מסנן אטורה בהחלט.

ל המנוע

ון משפיע על המנוע רק באמצעות הלחץ הנגדי
גבוה מאשר הלחץ הנגדי של משתיק הקול
מלחץ . העלייה בצריכת הדלק היא לכל היותר
ניתן לצפות לשפעות שליליות על המנוע ותפעו־
לחץ הנגדי אינו עולה על הערך המותר של 200
ע מראש. התפקיד של ה-OBD הוא להבטיח

באופן קפדני לנוריות האזהרה והתרעות. תפ־
טיות אחרות וליזום את הצעדים הנדרשים. אי־
ההתרעות עלולה להיות גורם מפגע מוגבר, בשל
תר של המערכת. מערכת הניטור רושמת במאגר
לנתי-מחיק **כל התרעה שלא קיבלה מענה, מה**
בדן הזכאות לאחריות.

בעיות וצעדים

רוב ההפרעות והנזקים הם תוצאה של אי-תשומת לב להתרעות,
יכה לא מתאימים.

מסנן במצב משולם ←
משלם מבריק

מתקדמת
ון

בקרה ודיאגנוזה

(עשן)
ופיק רגיש

ספר
מסנני
בשטח,
באים:

של

חלקי־

ht

ם רגי־
חברת
קים של
הוכיחו
תת
באופן
שטח

ב של
נים אח־
נפרא־
קלות

המסנן
זו לא
י הפ־
יש צורך
ובכך
מספק

עריכה:
דר׳ אנדראס מאייר, TTM, טומס וו. לוץ, ETH/LAV פולקר הנזל, aurigna consulting

תרגום לעברית:
מוניקה מלמן

מוציא לאור:
VERT-Association • c/o JCA Treuhand AG
Badener Straße 9 • CH-5200 Brugg • Switzerland Brückenstraße 6
www.VERT-certification.eu

מעודכן:
לחודש יוני 2016

מקורות התמונות/ זכויות יוצרים:
איור קדמי (מעיל׳, lebock עמוד 2 למעלה צד שמאל Lennart Nilsson,למעלה צד ימין, Dr. Belot, PSA עמוד 3 ו- 4, משמאל HJS Fahrzeugtechnik GmbH & Co. KG 4 עמוד 5 תמונה 3 ו- 4, משמאל CPK Automotive GmbH & Co KG; עמוד 6 למטה צד ימין PURITech; עמוד 7 למעלה צד שמאל Paul Nöthiger Electronic, תמונה 2 משמאל CPK Automotive GmbH & Co KG, תמונה 3 משמאל TSI GmbH, תמונה גם 4 ו-5 משמאל Testo.AG.

הודעות משפטיות:
למרות בדיקה קפדנית של כל המידע המופיע במדריך זה, לא ניתן לשלול טעויות בודאות מוחלטת. הדיוק, השלמות והעדכנים של התוכן הם ללא ערבות. לכן, אין הערכים והמל"טשאים בכל אחריות עבור השלכות אפשריות בהקשר לשימוש.

ההתאחדות VERT מספקת באתר האינטרנט שלה מידע על רטרופיטינג של מסנני חלקיקים. בנוסף, ניתן למצוא שם מאגר נתונים מקיף של כלי רכב שבהם כבר בוצע רטרופיטינג. דרך רשימת מסנני חלקיקים של VERT ניתן לקבל מידע על מערכות סינון מומלצות עבור הצרכים אשר יכולים לספק אותן.
www.VERT-DPF.eu

כל זכויות היוצרים של מדריך זה נמצאים בהתאחדות VERT, אלא אם כן צוין אחרת. לשכפול, בכלל קטעים, נדרש אישור מפורש של ההתאחדות.

ניתן להוריד את המדריך כקובץ PDF בכתובת
www.VERT-certification.eu

יוצרים של מסנני חלקיקים ומיזוג מדידה VERT:
Airmeex SA | hcaliskan@airmeex.com
Baumot AG | Marcus.Hausser@twintec.de
Baumüller & Partner GmbH | info@baumueller-partner-gmbh.de
Bersy srl. | davide.fedeli@bersy.it
CDTI | MacDonald@cdti.com
CPK Automotive GmbH & Co KG | kovac@cpk-automotive.com
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Eminox | Martin.Ott@eminox.com
ESW Group | mstreichsbier@eswgroup.com
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HJS Fahrzeugtechnik GmbH & Co. KG | Axel.Middendorf@hjs.com
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Johnson Matthey GmbH | peter.werth@matthey.com
Krone Filtertechnik GmbH | rkrone@krone-filter.de
Paul Nöthiger Electronic | pne@pop.agri.ch
Pirelli & C. Ambiente S.r.l | liana.baldassarre@pirelli.com
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Testo AG | LCachon@testo.de
TSI GmbH | jurgen.spielvogel@tsi.com

מילון מונחים:
CNC: סופר חלקיקי עבודי
DPF: מסנן חלקיקים למנועי דיזל
DOC: קטליזטור חמצן דיזל; Diesel Oxidation Katalyst
GMS: קעברת נתונים אלחוטית
OBD: אבחון תקלות בעת נסיעה
OECD: הארגון האירופי לשיתוף פעולה כלכלי ולפיתוח
PM: רישום מספר של חלקיקים למ"ק
PM: מסת חלקיקים ב- גם"ש
Low SAPS: שמן בעל תכולה נמוכה של אפר־ן, זרחן P ואפר גופרתי SA
VAMV: ההנחיות למדידת גזי פליטה של שוויץ
VERT: Verification of Emission Reduction Technology אימות של טכנולוגיות המפחתת פליטות
WHO: ארגון הבריאות העולמי
אטימות: עכירות גזי פליטה המשמשת למדידת עשן ומנדדת ב- 1/m
סינית דיפוזיה: שיטת מדידת ריסדים מספרים של חלקיקים המבוססת על שיעור דיפוזיבי
נה-חלקיקים: חלקיקים ושיעים שקוטרם קטן מ- 1000 נומטר
נומטר אחד: 9-10 מ׳; החלק המליון מ- מ"מ
פליטה משנית: התחרחשות כתוצאה מתגובות כימיות בפסם חלקיקים
mbar: מיליבר 1/1000 בר
ppm: חלקים למליון (מ"מ)

Summary

- **>10,000 persons die daily** worldwide because of particle emissions from combustion engines
- Only verified filters guarantees efficient removal of PM and PN
- Retrofitted vehicles have lower particles emissions than Euro IV and V
- Retrofit programs to be carefully designed, executed and followed up (Applicability, Regeneration, Control & Inspection)
- Familiarize yourself with the new VERT practice guide brochure and the exhibited technologies

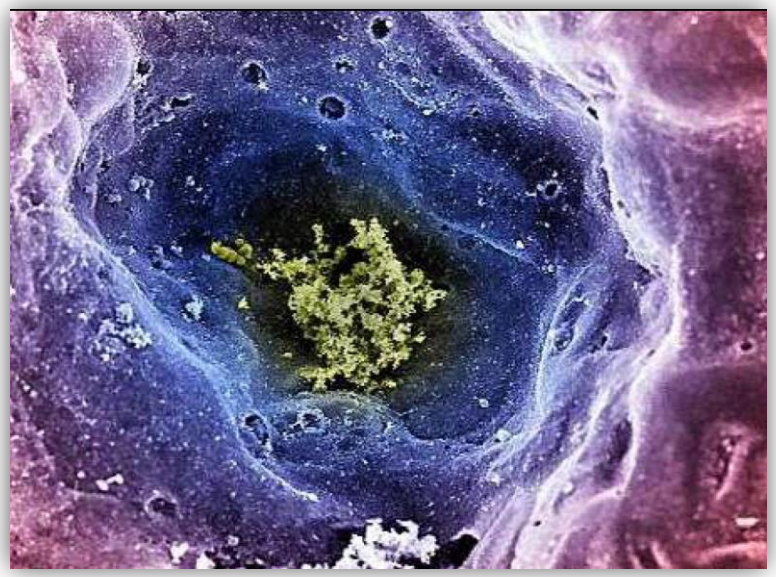
Thank you very much for your attention

Back up slides

Motivation

The Problem

Ultrafine particles from combustion engines



- **>10,000 persons die daily** worldwide because of particle emissions from vehicle engines

  Heart attacks kill about 35%
  Brain strokes kill about 45%
  Cancer kills about 15%

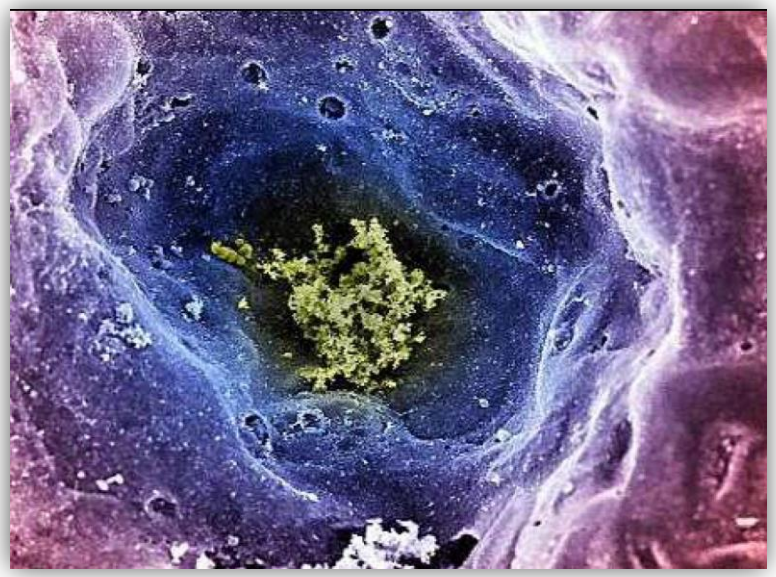
- Carcinogenic pollutants have **no harmless dosage**

- Since 2012, **the WHO classifies Diesel soot as Class 1 carcinogen** just like asbestos

Motivation

The Problem

Ultrafine particles from combustion engines

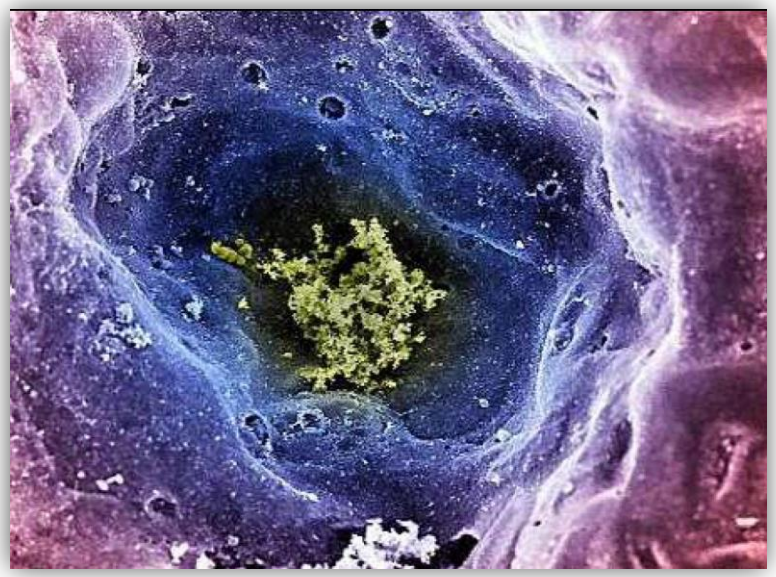


- **Particle size** is the crucial parameter
- Natural **dust particles do not invade** the blood
- Particles from combustion engines are **100 times smaller** about 0.1 µm or 100 nm
- They **easily intrude from the lung into the blood stream** and thus enter the brain and the placenta
- The particles **transport other harmful substances** into the organism and remain there

Motivation

The Problem

Ultrafine particles from combustion engines

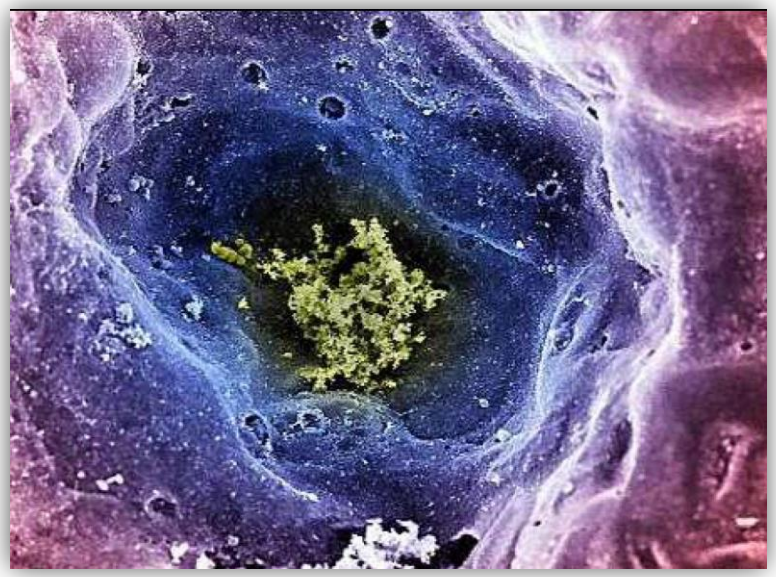


- **Health costs** are $ 2,000 per kg soot
- The OECD estimates 41,000 related deaths annually in Germany
  Costs $ 144 billion

Motivation

The Problem

Ultrafine particles from combustion engines



- New technologies are **only gradually effective**
- Only implemented **in new vehicles**
- Fleet **renewal occurs after 15-20 years** and sometimes longer
- DPF **retrofitting** is therefore **imperative and since 1994 successfully implemented** in many European cities

Motivation

The Remedy

Particle filters (DPF) eliminate ultrafine particles

- **Filtration** is the only way to remove the highly toxic soot
- It also **removes very efficiently highly toxic metal oxide particles** (abrasion and lubricant sources) from the exhaust gas
- Caution: **not all filters are good**
- **Bad filters** only **temporarily store the soot** and release it later or only remove the larger particles and **pass on the toxic smaller particles**
- Some bad filters **generate additional toxic substances**

Motivation

The Remedy

Particle filters (DPF) eliminate ultrafine particles

- On every engine, a good filter attains **filtration rate exceeding 98%** for particles in the toxic size range of 10nm - 500 nm
- These particle filters can be **applied for all combustion engine applications** (on-road and non-road)
- Diesel and Gasoline

Motivation

The Remedy

Particle filters (DPF) eliminate ultrafine particles

- **Regeneration** is controlled combustion of stored soot through **conversion** of the retained soot **into nontoxic gas CO_2**
- **Filter cleaning** is only necessary about once a year to remove ash
- Filters **do not age**
- They do require **careful mounting and regular testing** of engine emissions

Motivation

The Remedy

Particle filters (DPF) eliminate ultrafine particles

- Since 1982, high efficiency soot-particle **filters are available**
- Today **more than 100 million filters** are deployed in road vehicles and machines
- The monetized health benefits for society are at **least 10 times higher than the retrofit costs**
- The US EPA (Environmental Protection Agency) estimates the **benefit/cost ratio is now 13:1**

Vehicle Matching and Filter Selection

- **No Diesel engine without filter** is the imperative for ambient air quality
- One unfiltered vehicle emits **more particles than a fleet of 100 vehicles** fitted with filters
- Every vehicle can be retrofitted
- **High raw emissions are a challenge** - has to be controlled via **maintenance** of the vehicle
- **No age limits** for retrofitting but benefits do diminish **with residual deployment expectancy**

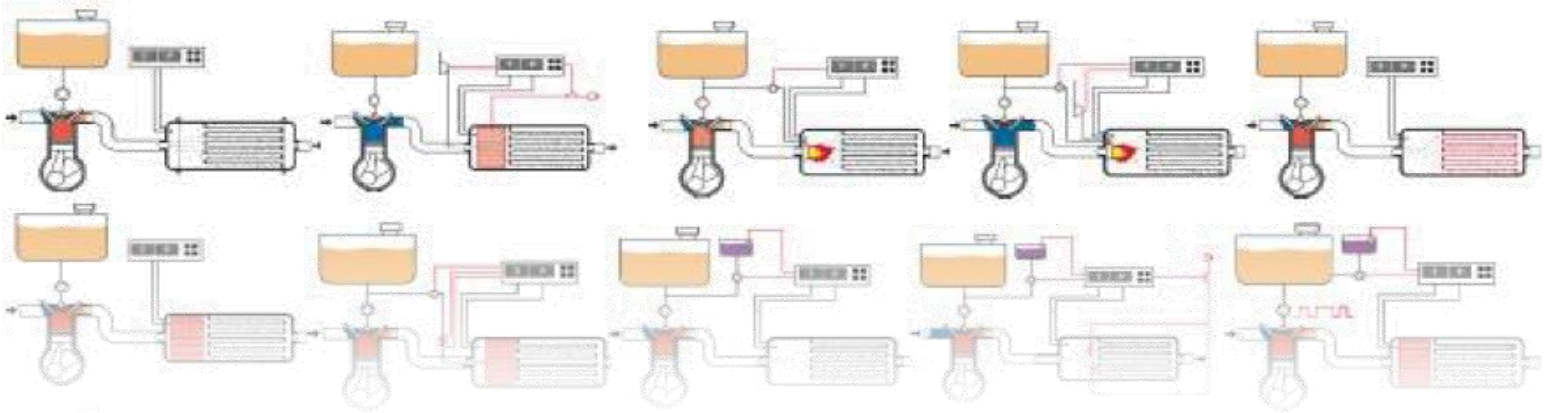
Vehicle Matching and Filter Selection

- **VERT certification requires:**
  - **Filtration > 98%** for particles 10nm-500 nm
  - No toxic **secondary emissions**
  - **Back pressure** when new is < 50 mbar
  - **Maximum back pressure** < 200 mbar
  - **Endurance test** 2000 h without deterioration
  - Electronic onboard diagnosis **OBD integrated**
  - **Design** verified
  - See **VERT Filter List** www.vert-certification.eu

- VERT filter manufacturers are **audited** and give **warranty** for minimum 2 years.

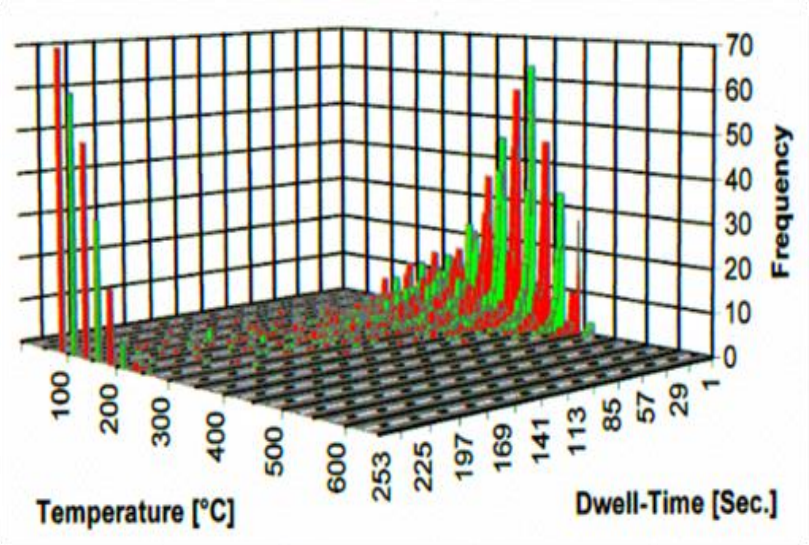
Vehicle Matching and Filter Selection

- **Selection of the right filter systems is necessary**
- **Experience is key**
- VERT filter manufacturers **select the correct filter** from their portfolio
- About **8,000 retrofits are documented and accessible** in the VERT database: www.vert-certification.eu



Vehicle Matching and Filter Selection

- Filter selection **in special cases requires analysis** of the duty profile
- Instrumented **data logger** to determine typical operating conditions during 2-3 weeks



- The results indicate whether the filter can **be passively regenerated or whether active regeneration** is necessary
- Both methods are **available and proven** in many product families

Fitting Procedure

- The vehicle has to be brought in **good technical conditions**

Lubricant consumption	< 0.5% of fuel consumption
Exhaust opacity	k < 1 m−1

Fitting Procedure

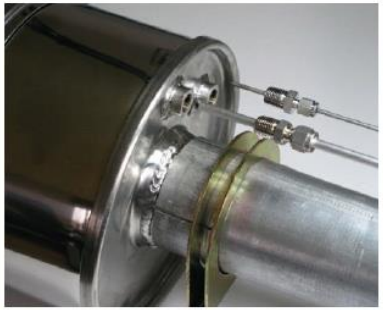
- Filter will be replace the muffler
- Filter will be insulated
- OBD (On Board Diagnostic) will be installed protected from water splash
- Collects continuously data during operation
- Wire the pressure and temperature sensors will be installed
- Alarm display in cockpit or (better) centralized fleet surveillance will give feedback

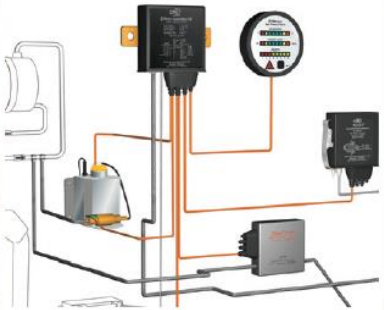
Function, Test and Approval

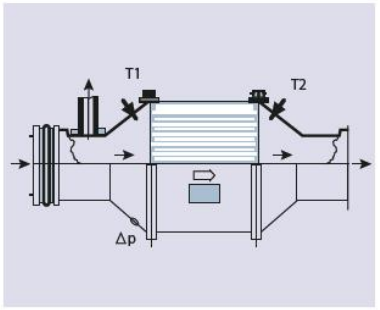
- Test functioning filter, electronics and display
- Verify exhaust gas values with a particle counter
- The filter manufacturer and vehicle/engine owner sign the approval report
  - Addresses of operator and filter manufacturer
  - Vehicle, engine and filter data
  - Back pressure at maximum RPM
  - Opacity before and after filter retrofit
  - Optional: noise level before and after filter retrofit
  - Optional: function check OBD and alarm display
  - Signature of filter retrofitter and operator
- This test /approval has a contractual character between buyer and seller and for the authorities

Operation and Maintenance | General

- To ensure emission stability, the manufacturer prescribed timely **inspection and maintenance** of the filter system and engine is mandatory
- The **electronic monitoring** provides supporting information
- Maintenance must be **documented**
- A **sticker** indicates when the next maintenance is due
- Organized **preventive maintenance** reduces costs

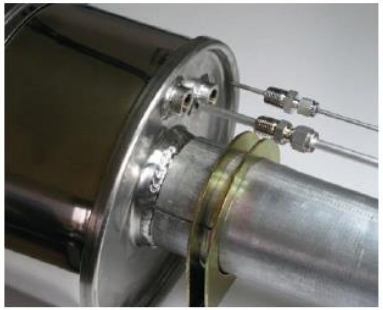


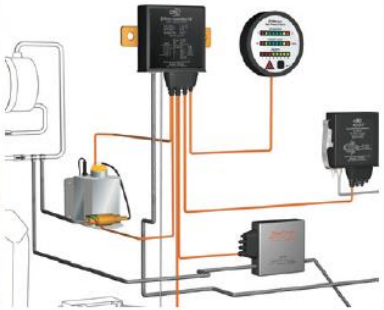


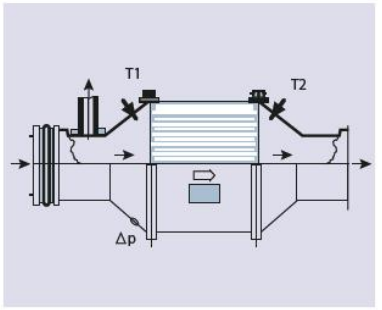


Operation and Maintenance | Diagnosis Data

- During maintenance, the particle emission must be measured at low idling using a certified PN (Particle Number counting) instrument
- If the specified tail pipe PN limit is exceeded, then a second PN measurement must be done upstream of the filter to determine the filtration efficiency
- The cause of low efficiency might be filter damage
- It can be repaired if less than 10% of the filter surface is damaged
- PN count is excessive ahead of the filter, the problem is in the engine

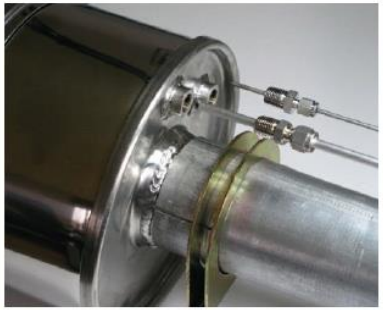


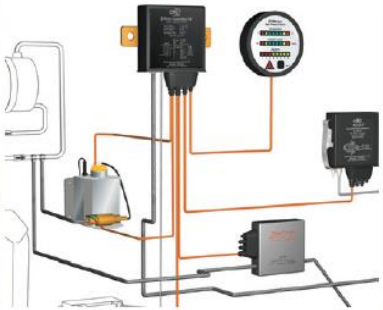


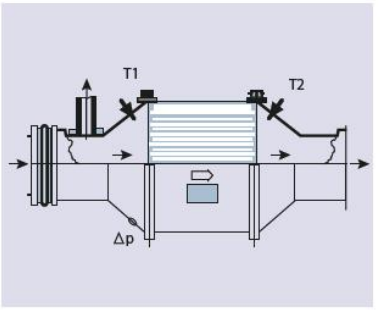


Operation and Maintenance | Fuel and Lubricants

- Only Diesel fuel with Sulfur content less than 10 ppm is permitted
  (Depending on DPF technology also higher Sulfur content can be allowed)
- Diesel fuel and lubricants have incombustible contents that result in ash
- Ash, together with metallic engine abrade, deposit in the filter
- Hence only use low ash forming lubricants (so-called Low-SAPS oils)
- Lubricant consumption exceeding 1% of the fuel consumption requires engine repair

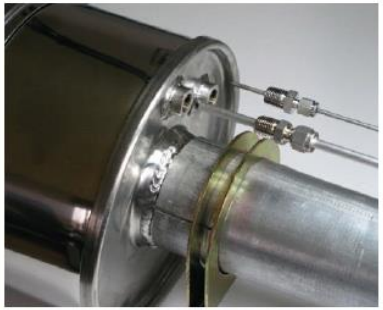


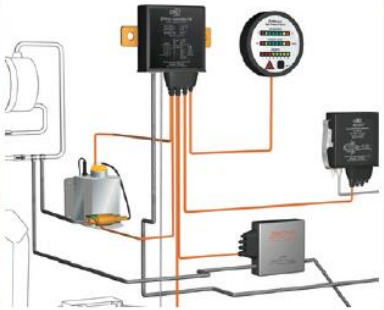


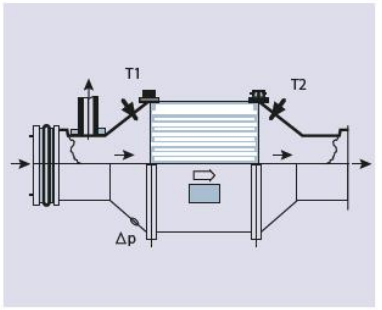


Operation and Maintenance | Regeneration Additives

- Certain filter systems operate with fuel additives (fuel borne catalyst FBC)
- Only VERT certified additives shall be used
- Demand proof and guarantees from the additives vendors to ensure that these additives do not negatively affect the engine
- Do not use additives without filter

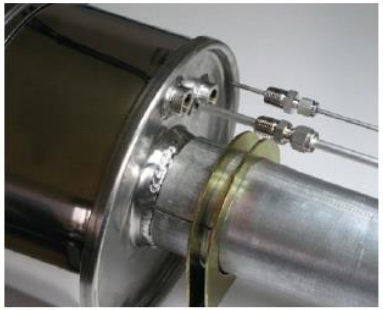


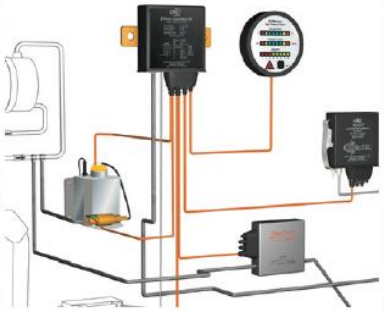


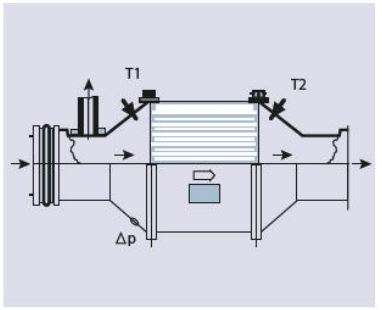


Operation and Maintenance | Impact on the Engine

- The filter system only influences the engine through the backpressure
- It is slightly higher than the backpressure of the muffler that it replaces
- The fuel consumption increases maximum 2-3%
- Unfavorable impact on the engine and its operation is not anticipated unless the backpressure exceeds the 200 mbar limit
- The OBD ensures compliance

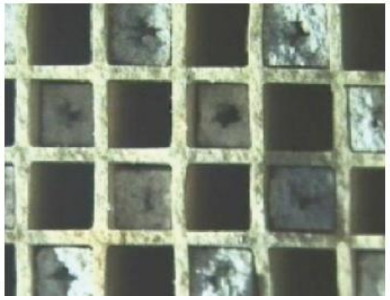






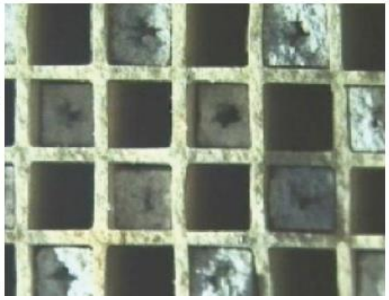
Faults & Remedies | Filter Rupture

- Filter rupture symptoms are visible **soot traces in the tail pipe**
- The outflow surface of the filter element reveals type and extent of the damage
- It could be a **small thermal crack** caused by thermo-shock due to overloading, or perhaps the **alarm was ignored**
- Minor **filter damage can be repaired** by plugging the damaged cells with a special ceramic mass



Faults & Remedies | Fuel Consumption – Power Loss

- **Higher fuel consumption** and noticeable power loss are engine related problems and not in the filter
- The filter's impact on fuel consumption and power delivery are only **consequent to the backpressure**
- The penalty is **only 2-3 % at maximum** backpressure of 200 mbar

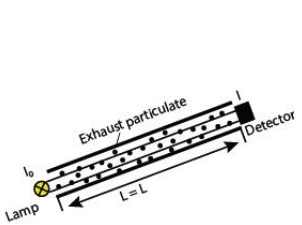


Faults & Remedies | Filter Cleaning

- Due to high **ash burden in the filter** the exhaust backpressure can gradually exceed 200 mbar
- The usual **interval is about 1,000 operating hours**; perhaps much longer when a low-ash engine lubricant is used
- Consequently **the filter must be cleaned**
- **Ceramic filters shall not be cleaned with hot water**, steam or compressed air
- A **special filter cleaning machine** must be used
- Filter cleaning must be **done in a hermetically closed machine**
- **Metal filters can be manually cleaned** with a high pressure water cleaner

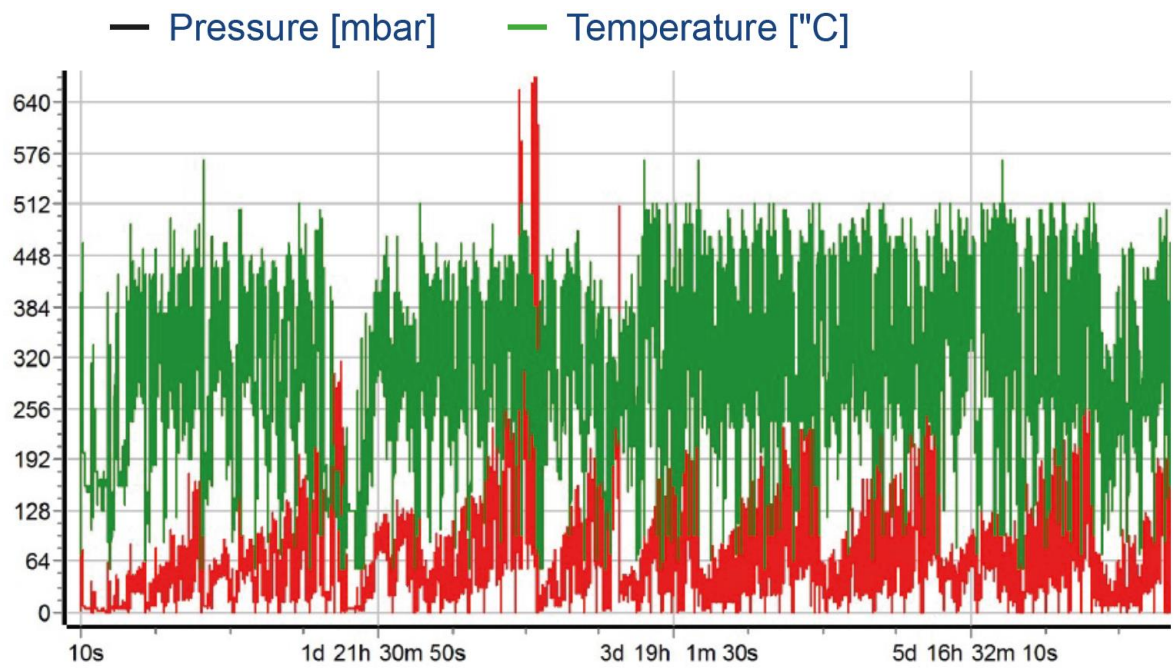
Control and Diagnosis

- Emission curtailment is **only as good as its management**
- These include **onboard diagnosis**, workshop verification and official regulatory inspection
- Electronic **OBD monitoring is mandatory** for all VERT certified filters
- The supplementary **error data is not erasable**
- **OBD the sensors and itself, annunciates alarms**, continuously assesses information on response of filter and the engine and prepares proposals for preventive maintenance



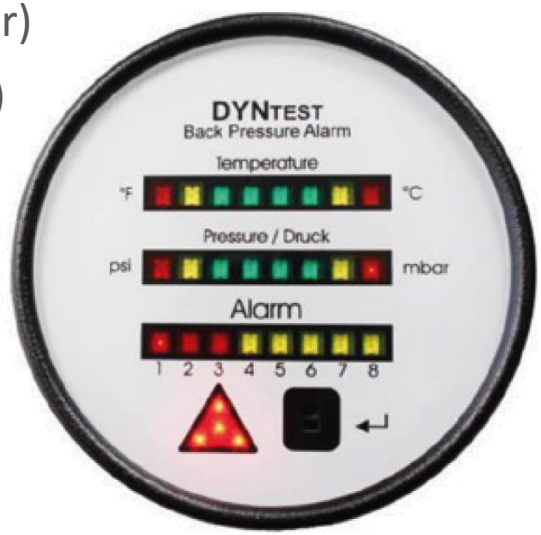
Control and Diagnosis

- **Data is logged every second** for at least backpressure and temperature before filter
- The logged data **must be stored for at least 3 working months**
- The stored data **can be locally retrieved or wirelessly transmitted** via GMS to a central surveillance



Control and Diagnosis | Alarms

- **Alarms annunciated acoustic and optic** to driver or wirelessly transmitted to central supervisor
- Alarms are **stored tamper proof**
- **Enables determining cause of failure** in damage claims
  - Pre alarm if backpressure exceeds 150 mbar (amber)
  - Main alarm if backpressure exceeds 200 mbar (red)
  - Filter damage if backpressure decreases rapidly
  - Cleaning when backpressure exceeds 200 mbar
- **Countermeasures to reduce engine power** are permissible - Operator must approve



Control and Diagnosis | Workshop measurements

- **Nanoparticles**: lung invasive particles < 1000 nm
- **Workshop measurements of particle emissions** are mandatory as particle number PN [1/cc] when particle filters are deployed
- For **onsite and field measurements**, instruments were developed that comply with the following guidelines:
    - **VAMV Guideline 2000** specifies instrumentation for the measurements of gaseous emissions
    - V**AMV Guideline 2012** specifies instrumentation for the particle concentration PN
    - http://www.admin.ch/ch/d/as/2012/5371.pdf

Control and Diagnosis | Workshop measurements

- **Methodology** for the highly sensitive particle number measurements are either the **condensation core counter CNC** from manufacturer TSI or the **electrical diffusion charging** of nanoparticles from manufacturers TESTO and AVL
- These **instruments are available** and proven
- These **enable accurate filtration rate measurements**, even in low idling, 1% filtration deterioration is detectable
- For the measurement of **gaseous emissions, many field instruments** are available from TESTO, AVL, MAHA and other manufacturers

VERT DPF and Measurement manufacturers

- Manufacturers of VERT certified particle filters and instruments
- Airmeex SA | hcaliskan@airmeex.com
- Baumot AG | Marcus.Hausser@twintec.de
- Baumüller & Partner GmbH | info@baumueller-partner-gmbh.de
- Bersy srl. | davide.fedeli@bersy.it
- CDTi | IMacDonald@cdti.com
- CPK Automotive GmbH & Co KG | kovac@cpk-automotive.com
- EHC Tecnic AG | rolf.johnson@ehcteknik.se
- EMINOX | Martin.Ott@eminox.com
- ESW Group | mstreichsbier@eswgroup.com
- GreenUrban Technologies Ltd. | nigel.standley@greenurban.co.uk
- HJS Fahrzeugtechnik GmbH & Co. KG | Axel.Middendorf@hjs.com
- HUG Engineering AG | Peter.Schippers@hug-eng.ch
- Johnson Matthey GmbH | peter.werth@matthey.com
- Krone Filtertechnik GmbH | rkrone@krone-filter.de
- Paul Nöthiger Electronic | pne@pop.agri.ch
- Pirelli & C. Ambiente S.r.l | liliana.baldassarre@pirelli.com
- PURITech GmbH & Co. KG | bernhard.kahlert@puritech.de
- StarfilterSystems Pte. Ltd. | richard.hell@starfilter-systems.com
- Tehag AG | b.franken@tehag.com
- Testo AG | LCachon@testo.de
- TSI GmbH | jurgen.spielvogel@tsi.com

Summary

- Small particles (UFP) have to put in focus due to their health effects
- Diesel particle filtration is a well known and reliable technology
- More than 100 Million applications of particle filters ww
- VERT developed a Best Practice Guideline (in Hebrew) with 20 years experience
- Good technical maintenance of the vehicle / machine is crucial
- There is no known alternative technology to reduce small particles from combustion engines to avoid heavy health effects