LOCAL APPROVAL OF DPF-SYSTEMS

for Option Fit and Retrofit of Diesel HDV
The Iranian Legislation requires DPF for all new Diesel vehicles, whereas implementation is timewise staggered depending on vehicle categories and import/domestic supply from September 2016 to April 2018. It also requires DPF-retrofit for public transport bus fleets and to fight the air pollution it is strongly recommended to extend this retrofit activity also to private HDV-fleets and as a follow up with little delay also to construction machines.

To guarantee that the use of DPF represents best available technology BAT, the highest possible level of reliability, safety and emission stability new governmental rules for the selection of DPF, the installation, the approval of the retrofitted vehicles and the periodic inspection and maintenance must be established and introduced soon.

During year 2015 an interdisciplinary stakeholder group has developed technical criteria for the approval of DPF equipped new vehicles which may be imported or domestic technology. While import technology will be more or less Euro-VI, based on newest engine technology with electronically controlled high-pressure injection and emission control systems, domestic technology must use existing Euro III or Euro IV technology and should be allowed to reach the emission targets by integrating existing DPF-systems. This so-called “Option-Fit” requires rules and quality criteria, which are very similar to “Retrofit” of in-use vehicles.

For “OEM emission control technology” the declaration of limit values for the main emission components CO, HC, NOx, PM and PN, to be fulfilled during a test cycle as part of the vehicle homologation are regarded to be the right way and European homologation will be accepted.

For the Option-Fit emission control solutions, however, based on available engine technology a simplified and immediately feasible entry into the DPF-technology has been opened:

- Engine homologation must not be repeated
- DPF-Systems must be internationally certified in agreement with the standard SN 277206
- The DPF-system supplier must demonstrate application experience
- The DPF-supplier must have a professional local distributor, well instructed and equipped
- The Option-Fit DPF equipped vehicles must undergo a local approval test VFT4 of > 1000 operation hours, monitored electronically and inspected by an accredited laboratory.
- The DPF supplier must submit the Certificate of a successful VFT4 test to the authority, with this he be approved and listed on the official list of Option-Fit and Retrofit DPF-systems
- Approved and listed DPF-systems can be used for other applications within the same application frame (engine family, vehicle application family).

This follows the experience in countries like Switzerland, Germany, California and Chile, where retrofit of DPF has been introduced successfully over 20 years ago with the important advantage that VERT-certification today offers over 70 certified DPF systems from which more than 20 are sulfur-tolerant see www.vert-certification.eu and VERT-certified manufacturer grant a two year functionality guarantee.
The legal approval process to receive official permission to use a certain emission control technology for option fit or retrofit

National List of Approved Emission Control Systems (DPF, SCR ..) for Option Fit and Retrofit

Application for Official Listing

Local Approval VFT4

International Certification Based on best available technology BAT criteria

Stakeholder Document December 2015

Iranian Law April 2014
Iranian Law April 2014 with respect to Diesel with DPF

Act no 49952/12782
§3
Before Euro4 fuel is used all over the country, all manufacturers and importers are required to supply vehicles with active particulate filters which are not sensitive to sulfur content of fuel from March 21, 2015.

§ 5
By March 21, 2017, Ministry of interior (municipality’s organizations) is required to take measures to prevent diesel engine vehicles entrance to the cities if they are without particulate filter. These measures can include prevention of entrance or toll taking for vehicles without particulate filters.

Iranian Legislation to protect the environment

<table>
<thead>
<tr>
<th>Activity</th>
<th>Executor</th>
<th>Supervisor</th>
<th>Time plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-2</td>
<td>Ministry of Oil</td>
<td>Department of Environment</td>
<td>*</td>
</tr>
<tr>
<td>1-3</td>
<td>Ministry of Oil</td>
<td>Department of Environment</td>
<td>36 months</td>
</tr>
<tr>
<td>Moving vehicle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-1</td>
<td>Homeland Ministry(Via municipality)</td>
<td>Department of Environment</td>
<td>6 months</td>
</tr>
<tr>
<td>2-3</td>
<td>Homeland Ministry(For urban public vehicles via municipality) - Ministry of Roads and Transportation</td>
<td>Department of Environment</td>
<td>24 months</td>
</tr>
<tr>
<td>New vehicles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-1</td>
<td>Traffic Police of Iran</td>
<td>Department of Environment</td>
<td>Mar. 21, 2015</td>
</tr>
</tbody>
</table>

Emission Limits timetable for locally produced on-road vehicles

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Petrol light vehicles</td>
<td></td>
<td>Euro 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Euro 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy-duty and Medium-duty vehicles</td>
<td>2015</td>
<td>2016</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Euro 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Euro 4</td>
<td>Most Up-to-date EU standard</td>
<td></td>
</tr>
<tr>
<td>Motorcycles</td>
<td></td>
<td>Production based on Euro 3 standard since Sep. 23, 2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Most Up-to-date EU standard</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This legislation is the basis for all DPF-related activities, retrofit as well as first fit in new vehicles. The terms “soot filters” and “particulate filters” are general terms targeting best available technology DPF. To define detailed specifications and implementation rules an international expert group was formed, called “stakeholder group” under the guidance of DOE and AQCC with TÜV SÜD.
Stakeholder Document

The stakeholder process has been decided in January 2015, started in April 2015 and ended after five plenary sessions in October 2015. The final document was ready by February 29, 2016 under the title:


The target was to introduce BAT-DFP countrywide as soon as possible fulfilling the legal requirement from 4/2014, irrespective of the sulfur content of the available fuel, but at the same time to permit the Iranian industry to build on existing technology in order to compete without delay with imported technologies.

This is still a recommendation and is actually waiting to be put in force by DOE in order to set up legally binding terms and conditions for the different DPF applications. However, it only deals with new vehicles, imported from abroad or produced in Iran and is in summary proposing the following two schemes split between import IVb and domestic production IVa, stipulating that domestic production will reach level IVb by Sept 2018:

---

### IRAN IVa PEEV PARTICULATE EMISSION ENHANCED VEHICLE
### IRAN PRODUCTION VEHICLES

<table>
<thead>
<tr>
<th>VEHICLE CATEGORY:</th>
<th>BUS* TYPE M3 Class I &amp; II</th>
<th>September 22nd, 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application Date</td>
<td>Truck N2, N3</td>
<td>March 21st, 2017</td>
</tr>
<tr>
<td>Ending Sept.2018</td>
<td>Bus* M2 Class A; M3 Class III (Cash)</td>
<td></td>
</tr>
</tbody>
</table>

**ENGINE TYPE:** COMPRESSION IGNITION ONLY

**Application Type Date:** ISSUE LICENSE PLATE BY POLICE

**Reference Fuel:** max. 300ppm Sulphur

**Emission Limits:**

<table>
<thead>
<tr>
<th>Test Cycle</th>
<th>CO [g/kWh]</th>
<th>NOx [g/kWh]</th>
<th>THC [g/kWh]</th>
<th>NMHC [g/kWh]</th>
<th>PM [g/kWh]</th>
<th>PN [#/kWh]</th>
<th>Smoke</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESC</td>
<td>1.5</td>
<td>5.0</td>
<td>0.46</td>
<td>--</td>
<td>0.02</td>
<td>1E12</td>
<td>--</td>
</tr>
<tr>
<td>ETC</td>
<td>4.0</td>
<td>5.0</td>
<td>--</td>
<td>0.55</td>
<td>0.03</td>
<td>1E12</td>
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<tr>
<td>ELR</td>
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<td>--</td>
<td>--</td>
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<td></td>
</tr>
</tbody>
</table>

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### IRAN IVb PEEV PARTICULATE EMISSION ENHANCED VEHICLE
### IMPORT VEHICLES

<table>
<thead>
<tr>
<th>VEHICLE CATEGORY:</th>
<th>BUS* M2, M3</th>
<th>September 22nd, 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application Date</td>
<td>2003/EC Bus Directive, Truck N2, N3</td>
<td></td>
</tr>
<tr>
<td>Ending Sept. 2020</td>
<td>--</td>
<td></td>
</tr>
</tbody>
</table>

**ENGINE TYPE:** COMPRESSION IGNITION ONLY

**Application Type Date:** ISSUE LICENSE PLATE BY POLICE

**Reference Fuel:** max. 100ppm Sulphur

**Emission Limits:**

<table>
<thead>
<tr>
<th>Test Cycle</th>
<th>CO [g/kWh]</th>
<th>NOx [g/kWh]</th>
<th>THC [g/kWh]</th>
<th>NMHC [g/kWh]</th>
<th>PM [g/kWh]</th>
<th>PN [#/kWh]</th>
<th>Smoke</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESC</td>
<td>1.5</td>
<td>3.5</td>
<td>0.46</td>
<td>--</td>
<td>0.02</td>
<td>1E12</td>
<td>--</td>
</tr>
<tr>
<td>ETC</td>
<td>4.0</td>
<td>3.5</td>
<td>--</td>
<td>0.55</td>
<td>0.03</td>
<td>1E12</td>
<td>--</td>
</tr>
<tr>
<td>ELR</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>Not required</td>
<td></td>
</tr>
</tbody>
</table>

This document defines the filtration quality only by a limit value for the particle number concentration at the free exhaust PN [#/kWh] following the EU-policy referring to UN-ECE-PMP (ECE-R49-06) and SN 277206 for particle size and solid phase measurement.
While this might be sufficient for an OEM oriented legislation, assuming that the manufacturer is developing the DPF system in all aspects under production-, operation-, safety-, reliability- and environmental-criteria is not sufficient for option fit solutions as we expect them in many applications in Iran where the manufacturer is not developing the DPF-system but is using an existing DPF-system, selected for and adapted to his existing engine.

To cover the different requirements of these two application schemes the stakeholder document splits the DPF-systems in two categories:

Provisions for „OEM`s“ and „Option-Fit“
Choice Annex OE (OEM): this is a set of system approvals for an Iran domestic vehicle manufacturer using an Iran domestic engine who develops and certifies an engine system equipped with wall-flow DPF.
Choice Annex OF (Option-Fit): this is a the set of system approvals for an Iran domestic vehicle manufacturer that uses a base EURO HD certified engine, but engineers the wall-flow DPF application for the vehicle application.

DPF-Systems which qualify for Option-Fit must fulfil the same requirements as for Retrofit. The following approval scheme is therefore recommended for both categories and requires in principle the following 4 steps

1. International Certification
Particle filter systems operating on mobile internal combustion engines must fulfil a large number of requirements regarding filtration of health effecting solid nanoparticles, reduction of toxic gaseous substances, avoiding formation of secondary emission, reliability, useful life, ash cleaning, safety issues, electronic control etc. To guarantee conformity of production the manufacturer must be audited and in-use-compliance tests must be performed. There are worldwide only a few certification schemes developed over the past two decades, which fulfil all these requirements:

- VERT certification; based on SN 277206; includes sulfur tolerant systems
- FOEN certification, based on SN 277206
- CARB verification; based on PM-mass
- REC certification; EU oriented

VERT has by far the most demanding performance criteria with >97% reduction of PN and requires the most severe endurance tests and safety monitoring, has the longest history and is dominating the market. Over 70 filter systems are certified by VERT (see www.vert-certification.eu) therefore the largest technological portfolio is available for a new market like Iran where CARB and REC could not offer any systems given the high fuel sulfur content.

For these reasons any DPF-systems to be used as option fit or retrofit in Iran must be VERT-certified, listed on the international VERT Filter List and provide VERT-certificate

2. Local approval
Local conditions might be different from VERT certification conditions with respect to altitude, fuel quality, lubrication oil quality, vehicle operation, engine technology, driver habits, inspection & maintenance culture. Local approval does not refer to the DPF-system only but to the combination of a selected DPF with the engine in a given vehicle. Testing this combination provides very useful information on the quality of the filter system selection, the match of filter/engine, the regeneration type selected and the overall integration in the vehicle environment.

In the VERT-systematics the local approval test is called VFT4 and is attached to this document. VFT4 is a 500 operation hours tests with electronic monitoring of temperatures and backpressure and an emission measurement by independent VERT-inspectors before and after. No deterioration is permitted during this period. Filtration as well as backpressure and noise must fulfil VERT-criteria

Local Approval Report signed by VERT and manufacturer and certificate must be provided

See attached
- Appendix 1: Local Approval Procedure
- Appendix 2: Local Approval Certificate
3. Application for Official Listing
The DPF-system manufacturer can apply for official listing of his emission control system by submitting:

- Valid VERT certification
- Report on Local Approval Test performed by an accredited laboratory
- Local Approval Certificate for counter signature by the authority
- Audit report on his local distributor organization
- Report on long endurance experience with the selected DPF-system

4. Listing on the National List of Approved Emission Control Systems
With official listing on the homepage of the responsible Iranian authority (DOE) this approval will receive a legal validity and will be available for enforcement.

This procedure reflects the legal procedure of most countries where the actual testing and certification is delegated to independent professionals (like TUV or VERT), accredited by the government but the government itself checks conformity of tests results with key performance criteria and issues a list of filter systems or other emission control components which have demonstrated to qualify for the emission legislation. This approval usually has a limited validity (in Switzerland 5 years) which means that after a fixed period the procedure must be repeated unless the manufacturer is using identical technology, proven by manufacturing conformity documentation.

VERT-Acceptance Test for Retrofit
Retrofit requires professional skill, care and control. Retrofit is often performed on individual vehicles and even if it concerns small fleets, the individual vehicles may be of different age, different specification, different emission status and different maintenance conditions.
Since the filter integrator must guarantee for perfect function during 2 years (acc. to VERT), he needs to document the technical status after installation and finally the government needs a documentation of the modification of the vehicle in order to adapt the official permits accordingly.
For this reason the VERT-Acceptance Test has been developed in cooperation of the Swiss Road Authority ASTRA

See attached
- Appendix 3: VERT Retrofit Acceptance Test

This acceptance test can be performed by handheld instruments, which each filter integrator will have available, and which must be officially calibrated at least once a year.
The test can be performed at vehicle standstill and requires less than one hour.
The document, signed by both, the vehicle owner and the filter system supplier or integrator is a legally binding guarantee document, as it may be needed in case of failures or suspected problems. In addition this document is accepted by the road authority to adapt the driving permit of the vehicles. For this authority the prove of conformity is the listing code of the filter system in the national list of approved DPF systems, which must be part of the information on the individual filter identification plate.
Appendix 1

VERT Filter Test VFT4 – Local Approval Procedure with/without FBC
Validity: 1st Jan. 2017

VFT4 is a special part of the international VERT DPF-certification, which is required to confirm the functionality of a VERT-certified Particle Filter System in a new environment with particularly demanding conditions like high altitude, high sulfur fuels, special operating conditions or retrofitted to vehicles which are pre-Euro3 or do not comply with EU-emission regulations. VFT4 might be requested by the local authority or the local operator of the vehicles. Like all VERT-tests, VFT4 is based on SN 277206 and reflects best available technology BAT.

VFT4 was developed by VERT in cooperation with emission control authorities of China, Chile, Columbia, Iran and Israel and is now accepted as a basis for recognizing Diesel particulate trap systems by many authorities. This VFT4 test must be performed with a representative filter system of the respective filter system family including regenerating aids and filter control units. Prior to this a full VERT certification procedure VFT1 + VFT2 + VSET + VFT3 must have been successfully completed, the filter system must be been listed in the VERT filter list.

Test-Candidates:
- Particle Filter System: to be supplied by the filter manufacturer with detailed technical description and a VERT-conformity document duly signed by the filter manufacturer
- Vehicle: to be selected and operated by the filter manufacturer or a local fleet operator
- Fuel Additive: to be supplied by the filter manufacturer with detailed technical description including composition, safety data sheet, mixing and preconditioning procedures. FBC-concentration must be adapted by the filter manufacturer to the operation profile and not changed during the test.
- The filter must be installed on the vehicle by or under supervision of the filter manufacturer.
- After installation the filter and the electronic control unit must be officially sealed by the VERT-inspector

Test Conditions and Test Sequence
- System control and measurements shall be performed by a VERT inspector twice: at the beginning of the test and after 10'000 km or 500 hours of uninterrupted regular operation.
- Fuel: local market fuel selected by the fleet operator
- Lubrication oil: selected by the fleet operator, preferably LowSAPS
- Filter-conditions: new

Measurements and system controls acc. to SN 277206 and VERT rules
- Check cleanliness, leakages, lose parts, noise etc.
- Check all connections, cables, sensors, FBC dosing
- Check alarm functions
- Measurement of emissions PN, NO, NO₂, O₂, CO, H₂O, CO₂, Opacity
- Measurement of operation parameters: engine RPM, exhaust temperature, filter backpressure
- Measurement of noise: 1 m from exhaust opening at 45° against flow direction at intermediate RPM
- All measurements without filter and with filter or upstream/downstream filter
- Operation points: low idle, high idle, intermediate speed at idle, part load e.g. at torque converter stall and free acceleration only for opacity measurement.
- Simulate alarm situations by creating high backpressure
- Download data of electronic control unit
- Interview the driver and the workshop manager

Reporting acc. to attached VERT example – English hardcopy and electronic copy
- Identification data of vehicle and filter system
- Weather, time, present witnesses
- Pictures
- General observations
- Measured data and interpretation
- Signed by VERT inspector and vehicle operator

Procedure: application with the form D1 of SN 277206 duly signed by the filter manufacturer. This form contains all important system parameters and will be treated strictly confidential - addressed to the VERT Certification

After approval of the test report by the VERT certification officer the test report shall be submitted by the filter manufacturer to the local approval authority for listing in the official filter list.
# Appendix 2

## VERT®-Local Approval Certificate for IRAN

<table>
<thead>
<tr>
<th>No</th>
<th>LA123/07.17</th>
<th>3. July 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>DPF-System</td>
<td>HABAKUK Filter Substrate</td>
<td>VERT-Certificate B423/2/17 Corinente, 200 cpsl FBC Infineum F7993 ECU XX 277</td>
</tr>
<tr>
<td></td>
<td>Regeneration Electronic Monitor</td>
<td></td>
</tr>
<tr>
<td>Manufacturer DPFS-System</td>
<td>HABAKUK, Esfahan Imamsquare</td>
<td></td>
</tr>
<tr>
<td>Engine-Family</td>
<td>Diesel Euro III Y = 4-6 ltr No EGR</td>
<td></td>
</tr>
<tr>
<td>Vehicle-Family</td>
<td>City-Bus 12 m</td>
<td></td>
</tr>
</tbody>
</table>

We herewith apply to be listed in the national list of approved Retrofit and Option Fit DPF-applications in Iran and we accept rules and conditions as being published by DOE.

**Manufacturer DPF-System**

**Date**

**Signature**

**Certified by the VERT®**

**Approved by DOE for listing**

**Name**

**Name**

**Name**
# VERT® Acceptance Test Report for PFS

<table>
<thead>
<tr>
<th><strong>Particle filter</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer (Brand)</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>Certification/Conformity number (VFT3 test number)</td>
<td></td>
</tr>
<tr>
<td>Serial number</td>
<td></td>
</tr>
<tr>
<td>Fitting Date</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Data logger</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type and serial number</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Additive dosage system</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type and serial number</td>
<td></td>
</tr>
<tr>
<td>FBC-supplier and FBC specification</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Vehicle / Machine</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Category (construction, bus, truck, pick-up, car ..)</td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>Manufacturing year</td>
<td></td>
</tr>
<tr>
<td>Chassis number</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Engine</strong></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>Manufacturing year</td>
<td></td>
</tr>
<tr>
<td>Rated power [kW]</td>
<td></td>
</tr>
<tr>
<td>Operating hours or km</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Measurements without PFS</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Opacity K-value [1/m] during free acceleration</td>
<td></td>
</tr>
<tr>
<td>Noise [dBA] in near-field 45°/0.5 m at RPM [1/min]</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Measurements with PFS</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Opacity K-Value [1/m] during free acceleration</td>
<td></td>
</tr>
<tr>
<td>Noise [dBA] in near-field 45°/0.5 m at RPM [1/min]</td>
<td></td>
</tr>
<tr>
<td>Back-pressure [mbar] at RPM [1/min] and load [%]</td>
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<table>
<thead>
<tr>
<th><strong>Opacimeter</strong></th>
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<tbody>
<tr>
<td>Manufacturer, Type</td>
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<table>
<thead>
<tr>
<th><strong>Sound Level Meter</strong></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer, Type</td>
<td></td>
</tr>
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<table>
<thead>
<tr>
<th><strong>Safety-Check</strong></th>
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</thead>
<tbody>
<tr>
<td>Thermal Insulation and heat shield installed</td>
<td></td>
</tr>
<tr>
<td>Distance to inflammable material</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Test-Date and Responsibilities</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Test date</td>
<td></td>
</tr>
<tr>
<td>Test center</td>
<td></td>
</tr>
<tr>
<td>VERT® label running number</td>
<td></td>
</tr>
</tbody>
</table>

Retrofitter stamp
Date/ Signature of the PFS retrofitter

Operator stamp
Date/ Signature of the operator

Please note:
- The vehicle owner retains the original together with the vehicle registration certificate.
- A copy of this form should be submitted with the original vehicle registration certificate to the pertinent vehicle licensing authority.
- For registration in the VERT database, submit this document to TTM [ttm.a.mayer@bluewin.ch](mailto:ttm.a.mayer@bluewin.ch)
What is Best Available Technology BAT with Respect to Traffic Related Emission of Ultrafine Solid Particles?

Can the definition of BAT replace DPF by PFF or SCR or DOC and how is DPF defined?

1. **The Priority: why has the elimination of traffic related particle emission priority over NOx-reduction?**

The Government of the Islamic Republic of Iran has taken decisions (April 2014, [1]) to clean the air in highly populated cities from Toxic Air Contaminants TAC which are a health burden for the society, in particular for children, pregnant women and elderly. The main source of TAC in Tehran is traffic and mainly Diesel engines [2]. The most toxic substance within Diesel emissions are ultrafine solid particles, consisting of soot and metal ash. These particles enter the blood system from the lungs, they trigger cardiovascular and cerebrovascular mortality and cancer; in 2012 WHO has classified them carcinogenic No.1 as asbestos [3]. They are responsible for 95% of traffic related mortality [4]. In Tehran die probably 25 people every day and overall cost to the society due to these health effects are > 1000 € per inhabitant per year [5]. NOx-emissions however, are not a critical TAC in Tehran, but they should be reduced in due time.


The following two slides summarize the «EU-Philosophie» based on R595 containing the main requirements of parliament and council of the EU-ministers in 2008 to introduce Euro 5/VI

- The main environmental objective are **reduction of UFP**
- Elimination of UPF needs **particle filters**
- To evaluate the quality of these DPF, the **PN-criterion** must be introduced
- Limit values for PN shall be established and enforced, which reflect best available technology **BAT**

3. **What is BAT in physical and chemical terms?**

Which emission limit can be reached by available (and affordable) particle filters?

This question is answered by the Parkin-Report, a statistic survey made by the British Department of Transport for the EU-commission in 2009 – [7]:

- SCR and PFF can reduce PN moderately by less than one order of magnitude
- while DPF can **reduce PN more than four orders of magnitude** of PN (left diagram)
which is very well supported by the much larger Swiss statistics (right diagram) [8]

This statistic was the basis

- for the introduction of PN in addition of PM
- for the definition of the PN limit value of $6 \times 10^{11}$ particle/kWh
  which could be reduced in further steps by a factor of ten - this defines DPF
- for replacement of EEV by Euro VI – EEV can no longer be offered on the EU-marked since 2014
- for the selection of DPF and not PFF by the industry

Besides high filtration these DPF do also reduce toxic chemical substances like PAH and Nitro-PAH and their technical quality is guaranteed by technical standards like the Swiss SN 277206 and certification systems like www.VERT-certification.eu

4. The Parkin Report is still optimistic with respect to SCR (EEV) and PFF (partial flow filters)
(because of very limited data and use of the German Anlage XXVII protocol which overestimates the performance of PFF by far)
- Open cell catalysts (SCR, DOC) cannot reduce PN emission – see M.Mariqc / FORD, HEI 2009 [9, 10]
- PFF can reduce PN-emission by 10-30% but at the same time acts as store and release systems – see [11]

Comparing Daimler Benz Euro V EEV with SCR and MAN Euro IV with PFF with Euro III DPF (the IRAN target) [12]

EU-vehicles were not able to reduce particle emissions before introduction of DPF [13]

- SCR does not reduce PN nor PM – see [12] in cooperation with Daimler Benz
- All technologies Euro II to Euro V including DOC, PFF, SCR do not reduce PN – see [13]
- SCR can produce additional particles instead of eliminate them – see [14]
5. Emission risks with EEV containing SCR-technology
SCR depends on the correct injection of Adblue – a solution of urea and water – and the catalyst temperature. At low exhaust temperatures, as they usually prevail in city driving this system is out of function and the very high raw engine NOx concentrations are emitted. This can lead to NOx-emissions, which are several times higher than even today’s engines NOx emissions [15]. The risk for higher NOx in cities instead of lower NOx is very high and European cities do actually suffer from this risk.
SCR function furthermore depends on the correct refill of Adblue, which requires the respective infrastructure. Without re-fill the engine will operate normal and the cost will be lower which is a strong temptation for operators to manipulate the system, as has been observed in Iran already.

6. The urgent need for Inspection and Maintenance
Modern engines with emission control by aftertreatment have better fuel economy and higher performance. But stability of the emission level, high fuel economy and good performance are only guaranteed over time with proper maintenance. Maintenance however, must be regular and monitored by periodic independent inspection. I&M is even more important with this new emission control technology. For this purpose new handheld instruments have been provided and new test protocols for a quick check on roadworthiness even roadside and for information on preventive repair - an important cost reduction tool. Regular I&M is the only way to not only clean the air but keep the air clean from toxic air contaminants

References
Acronyms:

BAT  Best Available Technology
EEV  Enhanced environmentally friendly – an outdated European emission definition, related to Euro III
EU  European Union
DOC  Diesel Oxiation Catalyst
DPF  Diesel Particle Filter
I&M  Inspection & Maintenance
NOx  Sum of Nitrogen Oxides
PFF  Partial Flow Filter
PM  Particulate Matter Mass
PN  Particle Number per cc; per km; per kWh
SCR  Selective Catalytic Reaction: the NOx reduction process with a reductant like Adblue
SN  Swiss Norm
TAC  Toxic Air Contaminant
UFP  Ultrafine Particles (< 500 nm)
VERT  Verification of Emission Reduction Technologies – a nonprofit organization
WHO  World Health Organization

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