

## VERT APPROVAL CRITERIA FOR PARTICLE FILTERS

### *Filtration Rate by Particle Count PC*

- Filtration rate for solid particle number PCFE as defined by UN-ECE PMP according to EC-regulation 715/2007 [10], must be attained in average of all operating points, throughout the particle size range 20-300 nm.

	A	B	C
From year			
	2000	2007	2016
New state	≥95%	≥97%	≥98%
2000 hrs.	≥90%	≥97%	≥98%

- PCFE during regeneration the criterion is the ratio of averaged values during the whole regeneration process as specified by SN-277206  
 Regeneration time < 3 % operation time

	1	2	3
From year	2010	2012	2016
New state	≥ 60%	≥ 70%	≥80%
2000 hrs.	≥ 60%	≥ 70%	≥80%

- Overall PN-peak reduction during free acceleration ≥ 95%  
 The criterion is the ratio of the peak values  
 Measurement as specified by SN 277206

## 2.2. Legislated emission limits

Compared to the baseline engine values, no increase of the limited emissions CO, HC, NOx and PM is permissible in the test cycle weighed average. During filter regeneration limited emissions shall not be higher than engine baseline emissions.

## 2.3. Secondary emissions

Secondary emissions are all compounds which were not present in significant concentrations in the exhaust gas of the base engine before retrofit. Formation of relevant amounts of such toxic reaction products is not permitted following [12, 13].

Compared to baseline engine values, no relevant increase of the following toxic emission components is permissible in the treated exhaust gas after the PFS:

- Gaseous secondary emissions: principally NO<sub>2</sub>, Dioxins and Furans, PAH and Nitro-PAH
- Aerosols of sulfuric acids
- Metal oxides (e.g. ash particles from additives, engine wear, lube oil additive packages )
- Mineral fibre emissions in the WHO defined size range L<3 µm; D<5 µm
- Limit Values for NO<sub>2</sub>

Average NO<sub>2</sub> increase over engines baseline due to catalytic conversion of engine-out NO shall not exceed 20 % in relation to NO upstream filter for all systems certified from 2016. This value shall be determined as per SN 277206 .

A	B
until year 2015	from year 2016
No limit	$\Delta\text{NO}_2/\text{NO} < 20\%$

- Filter systems converting engine-out NO into NO<sub>2</sub> can only be used in environments where the concentration of NO<sub>2</sub> in ambient air is well below the locally valid air quality limits.

Relevance of other secondary emissions

Increase of trace substances like Dioxins, Furans, PAH, Nitro-PAH and metal oxide particles < 400 nm are deemed “relevant” when the exhaust gas after the PFS exhibits concentrations, exceeding thrice the engine emission without PFS, at the same operating points supported by statistic significance of the respective measurement repetitions.

## 2.4. Pressure loss

- Fresh filter: < 50 mbar at high idle
- Regeneration threshold: < 150 mbar
- Maximum soot + ash burden: < 200 mbar (95% percentile)
- Alarm episodes > 5 sec above 200 mbar
- Special cases: If tolerated by the operator and the engine manufacturer, a pressure loss of maximum 300 mbar can be accepted at maximum soot+ash burden. Engines with uncontrolled EGR shall not be operated against more than 120 mbar back-pressure, the permissible level might be even lower and must be agreed upon by the engine manufacturer and the operator.

## **2.5. Additive dosage**

Automatic with interrupt if filter ruptures.

See VERT<sup>®</sup> FBC-System specifications [7].

## **2.6. Function monitoring OBD**

See VERT<sup>®</sup> OBC-System specifications [8]

- Continuous electronic monitoring of backpressure and exhaust temperature
- Measurement every second, storage on 1 minute base
- Alarm signal and alarm logging when maximum back-pressure is exceeded.
- Additive (if used): dosage shut off automatically when filter damage is detected.
- Special situations: For PFS which are externally regenerated or replaced for regeneration as well as for temporary filters (so-called snap-on filters), the electronic monitoring can be substituted. Permitted is instead a simple pressure gauge with visual or acoustic alarm.
- In case the operator does not properly react to the alarms, the OBD-system shall activate an automatic safety feature, which might be torque reduction, re-start limitation of even engine shut-off.

## **2.7. Noise Attenuation**

Attenuation must be at least equivalent to the muffler replaced. For comparison near field measurement is specified [11].

## **2.8. Durability, Maintenance and Warranty**

- Life expectancy > 5000 operation hours
- Usable hours until cleaning > 2000 operation hours
- Maintenance interval > 500 operation hours
- Guarantee on materials and function > 2 years or 1000 op. hours (whichever is earlier)

## **2.9. Labeling**

Main and auxiliary components of the PFS must carry an identification plate in a manner that is durable, unambiguous and legible. This is necessary to determine the filter family clearly in a unique manner and must also contain at least the certification identity, serial number, manufacturing data for quality control and the flow direction. The information on this plate must be identical with the certification data in the VERT<sup>®</sup> filter list; especially the certification identity.

In addition each vehicle retrofitted with VERT<sup>®</sup> approved PFS shall carry a green VERT<sup>®</sup> label with an individual running number to be identified for the VERT<sup>®</sup> data base.

## **2.10. Flow direction**

Flow direction through the PFS must be indicated clearly with an arrow see 2.9. Moreover, unidirectional design must prevent reversed mounting of the filter element.

## **2.11. Safety**

The PFS must be mounted according to the manufacturer's instructions such that no additional risks occur. The assembly must comply with the legislation on health, safety and visibility in the country where the PFS is deployed. Surface temperature requirements must be respected. Heat shielding is recommended and spark arrestors shall be used whenever the filter is operated under fire risk environmental conditions e.g. in forests or indoors.

## **2.12. Bypass**

Bypass arrangements, which permit circumventing the filter during excess back-pressure, are generally impermissible. Both manual and automatic bypass are prohibited.

## **2.13. Diagnosis access**

Access to the mounted PFS is required to measure the raw emissions for engine diagnosis and to determine the filtration efficiency in situ if requested. For this purpose, the filter casing or exhaust pipe must have, upstream of the filter element, a diagnose access of minimum 40 mm inner diameter if opacity is to be measured and >8mm inner diameter if PN and gases are to be measured.

## **2.14. Cleaning and disposal**

The filter element requires periodic cleaning from ash residues and the element must be eventually disposed off. Only methods that are environmentally acceptable, VERT<sup>®</sup>-approved and declared in the application documents for the VERT<sup>®</sup> certification test of the filter system shall be used for cleaning and disposal. The trapped residues are toxic waste. These must be carefully collected and, if in small quantities, disposed together with other industrial waste in a waste incinerator. The local authorities decide how large quantities shall be disposed. Workers must be protected from exposure to fine dust during cleaning and disposal.

## **2.15. Substituting mufflers for PFS**

Employing so-called muffler modules instead of PFS (e.g. during PFS maintenance or filter cleaning) is only permissible with the approval of the regulatory authorities. The only permitted muffler modules are those that are tested during the VERT<sup>®</sup> certification, described in the test reports and clearly identified as such.

## **2.16. Technical reporting the retrofit**

The retrofit DPF must be vibration decoupled from the engine and gas-tight upstream the PFS. An installation report must be prepared for each retrofit and signed by the retrofitter and the vehicle owner. See appendix VERT<sup>®</sup>-acceptance test report and [www.vsbm.ch](http://www.vsbm.ch). The retrofitted vehicle or equipment must display a VERT<sup>®</sup> Label with an individual running number, see Appendix. The installation report must be submitted to the VERT<sup>®</sup> coordination office for registration in the VERT<sup>®</sup> database.

## **2.17. COP = Conformity of Production**

Responsibility of the manufacturers and subject to an annual VERT<sup>®</sup> audit procedure. The rules, for manufacturing quality control, are still to be defined.

## **2.18. IUC = In Use Compliance Tests**

Responsibility of the manufacturers and subject to an annual VERT<sup>®</sup> audit procedure. The rules for periodic field testing of the PFS, are still to be defined.

## **2.19. PTI = Periodic Technical Inspection**

From 1.Jan. 2019 VERT<sup>®</sup> retrofit filters are subject to periodic technical inspection once per year. At least PN-concentration must be measured at low idle speed with warmed up engine and compared to the acceptance test data (see Appendix 11.1.). A conformity factor of 1.5 is permitted. Any higher number requires search of a possible failure either engine failure or filter failure [16, 17] and immediate repair or replacement. Check on gaseous emissions is also recommended.

## **2.20. Local Approval**

In markets where the operating conditions are very different from Swiss standards with respect to altitude, humidity, fuel sulfur content and other crucial operation parameters, a VERT<sup>®</sup> certified DPF-system is subject to an additional test VFT4 = local approval test with endurance testing during at least 500 operation hours with one representative filter running up to max. space velocity SV. [19]

## **2.21. Operation Manual**

Each filter retrofitted must be accompanied by an operation manual in the language of the country where the filter is used. This manual must contain all information on functional, maintenance and safety issues, cleaning procedures and responsibility statements.

## **2.22. Impact on Energy Consumption**

The overall energy impact of the PFS including all effects of back pressure and regeneration integrated over the life cycle must remain below 3 %.

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The VERT Association publishes on its web site information on the topic of particle filter retrofitting. The site also has a comprehensive database of already retrofitted vehicles and machines. The VERT Filter List documents the certified filter systems and their manufacturer: [www.VERTE-dpf.eu](http://www.VERTE-dpf.eu).

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