

BAT

What is Best Available Technology BAT with respect to traffic related emission of ultrafine solid particles?

1. Priority: Elimination of traffic related Particle Emission has Priority over NOx-reduction

Governments have taken decisions to clean the breathing 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 cities is traffic and mainly internal combustion engines [2]. The most toxic substance 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; They are responsible for 95% of traffic related mortality [4].

In 2012 WHO has classified UPF ultrafine solid substances “carcinogenic class 1” as asbestos [3]. For the elimination of carcinogenic substances legislation all over the world requires “Best Available Technology” since carcinogenic toxics have no “no-effect limit” at low concentrations. NOx-emissions however, are not carcinogenic but also toxic and should be reduced in order to reach the air quality limits given by WHO.

2. The EU Emission Principle Rec.15/Art.12 R 595/2009 [6]

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

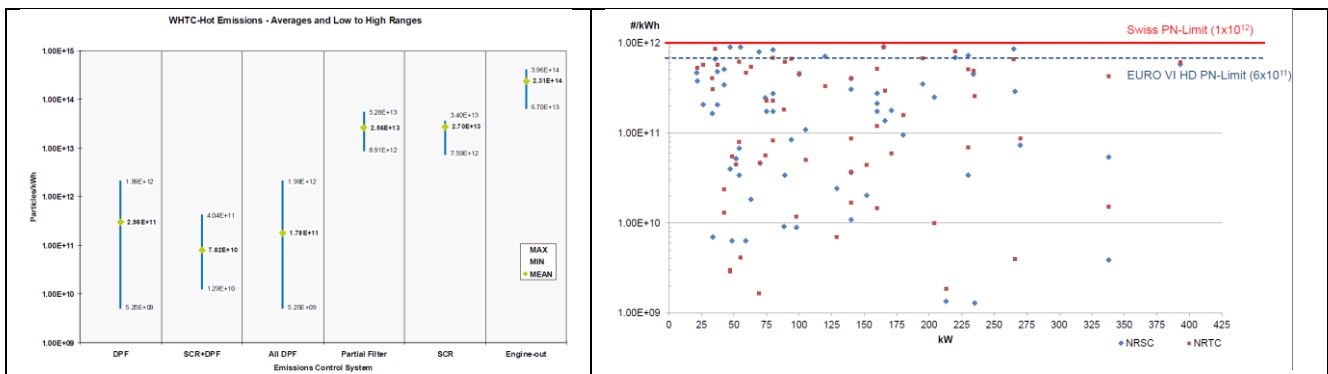
Particle Number limit (Recital 15.)	Particle Number limit (Article 12.)
<ul style="list-style-type: none"> In order to achieve these environmental objectives, it is appropriate to indicate that the particle number limits are likely to reflect the highest levels of performance currently obtained with particle filters by using the best available technology. 	<ul style="list-style-type: none"> 1. After the completion of the relevant parts of the PMP of the UN/ECE, conducted under the auspices of the World Forum for Harmonisation of Vehicle Regulations, the Commission shall, without lowering the level of environmental protection within the Community: <ul style="list-style-type: none"> (a) introduce as an additional control upon emissions of particulate matter particle number based limit values set at a level appropriate to the technologies actually being used at that time to meet the particulate mass limit; (b) adopt a measurement procedure for particle number.

- 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. 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

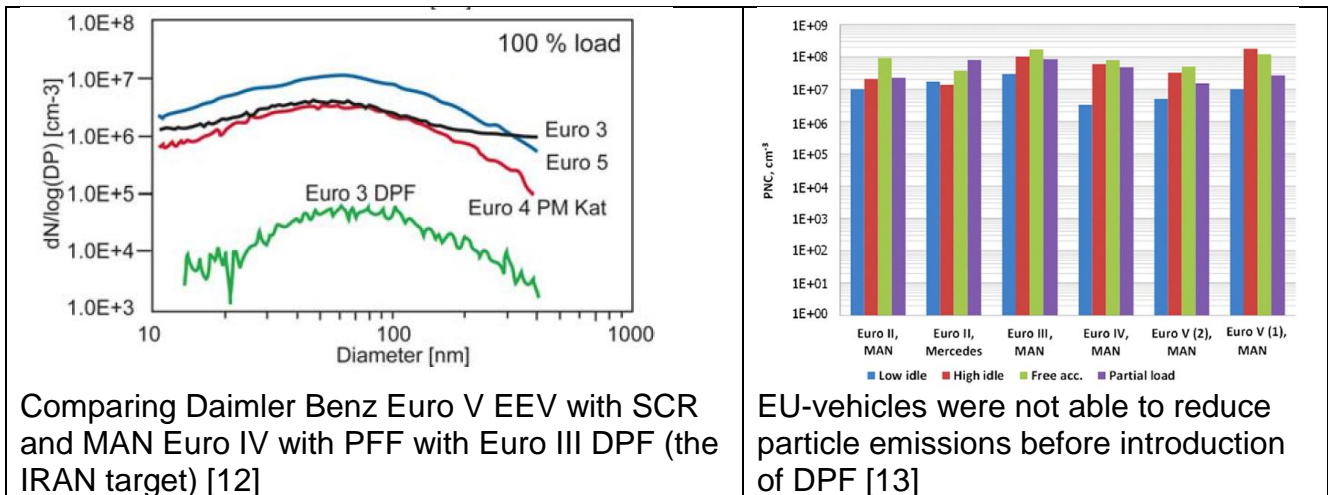
- for the introduction of PN in addition of PM
- for the definition of the PN limit value of 6×10^{11} particle/kWh which could be reduced in further steps by a factor of ten - **this defines DPF**
- for **replacement of EEV by Euro VI** – EEV can no longer be offered on the EU-market since 2014
- for 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.VERTE-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]

4. 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 NO_x concentrations are emitted. This can lead to NO_x-emissions, which are several times higher than even today's engines NO_x emissions [15]. The risk for higher NO_x in cities instead of lower NO_x 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.

5. 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

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Acronyms:

BAT	Best Available Technology
EEV	Enhanced environmentally friendly – an outdated European emission definition
EU	European Union
DOC	Diesel Oxidation 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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