

# Automotive Particle Emissions: an update of regulatory Euro 6/VI and UNECE developments

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The presentation should provide an update on ongoing and imminent regulatory developments in relation to particle-related emission legislation. It should be noted that its main purpose is not to present "final" regulations but to initiate discussions among participants about the regulatory relevance of several particle-emission related issues and possible technical approaches. The following topics should be addressed in particular:

1. Particle number limits & DPF regeneration (diesel, Euro VI and 6). Euro 6 legislation currently does not mandate the consideration of regeneration events for the measurement of particle numbers, for Euro VI such consideration is under discussion. How could DPF regeneration be better reflected in type approval particle measurements, e.g. via ki-factors?
2. Particle number limits for positive ignition engines (Euro 6). Euro 6 legislation shall provide particle number limits for petrol engines, the values of which should be defined until end of 2011. A study by the JRC is currently on the way, issues to be considered are real particle number emissions of PI engines as well as available techniques for emission reduction and related costs.
3. UNECE WLTP GTR. Currently a new light duty test cycle is being developed by the World Light duty Test Procedure (WLTP) group for a future global technical regulation (GTR) under the 1998 UNECE agreement. In this respect also the related measurement procedures should be internationally harmonised, which also offers an opportunity to revise the particle number measurement procedures with respect to new scientific evidence.
4. DPF retrofit systems for heavy duty engines. A GRPE sub-group for the development of a new Regulation for HD DPF retrofit systems under the 1958 UNECE agreement has been established. The objectives and timeline of this work will be discussed, including certain technical aspects to be considered (e.g. filtration efficiency, impact on NO<sub>2</sub> emissions) and whether it should be combined with similar initiatives in the field of non-road mobile machinery.



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# Topics

- **Particle number limits (diesel)**
- **Particle number limits for positive ignition engines (Euro 6)**
- **UNECE WLTP : particle number measurements**
- **UNECE Regulation: Retrofit exhaust gas after-treatment systems**

# EU Emission Legislation: overview

**'Euro' emissions standards - introduced progressively since the 1990's:**

Light duty: - Euro 4 (2005 - 2007)

- Euro 5 (2009 - 2012)

- Euro 6 (2014 - 2016)

Heavy duty: - Euro IV (2005 - 2006)

- Euro V (2008 - 2009)

- Euro VI (2013 - 2014)

Motorbikes: - Euro 3 (2003 - 2006)

# EU Emission Legislation: snapshot

## **Split level approach:**

- Co-decision regulation – adopted by European Parliament & Council
- Technical implementing regulation – to be adopted by Commission with Committee

## **Euro 5/6 (light duty):**

- Co-decision Regulation 715/2007/EC + implementing Regulation 692/2008/EC => to be updated for Euro 6

## **Euro VI (heavy duty):**

- Co-decision Regulation 595/2009/EC + implementing Regulation still to be finalised

# Euro 6/VI, compression ignition: particle emissions

## Euro 6 (light duty):

➤ Particle mass emissions  $PM \leq 4,5 \text{ mg/km}$

➤ Particle number emissions  $PN \leq 6,0 \cdot 10^{11} / \text{km}$

⇒ On the NEDC according to new PMP measurement procedure of UNECE Regulation 83.05 Annex 4a.

⇒ DPF regeneration currently is not considered for particle number emissions !

## Euro VI (heavy duty):

➤ Particle mass emissions  $PM \leq 10 \text{ mg/kWh}$

➤ Particle number emissions  $PN \leq 8,0 \cdot 10^{11} \text{ km (WHSC)}$

$PN \leq 6,0 \cdot 10^{11} \text{ km (WHTC)}$

⇒ On WHSC/WHTC according to new PMP measurement procedure, still to be validated at UNECE (until end of 2010).

⇒ DPF regeneration should be included for particle number emissions. How? Ki-factors?

# Euro 6/VI, positive ignition: particle emissions

## Euro 6 (light duty)

- Particle mass emissions:  $PM \leq 4,5 \text{ mg/km}$   
(only PI direct injection)
- Particle number emissions: tbd  
(all PI vehicles)

## Euro VI (heavy duty)

- Particle mass emissions:  $PM \leq 10 \text{ mg/kWh}$
- Particle number emissions: tbd

# Euro 6/VI, positive ignition: particle emissions

PI particle number emissions, study by the JRC (for light & heavy duty):

- Typical engine out
- Particle size distribution, extension of PN measurement procedure
- (Chemical composition & specific health effects)
- Particle abatement technologies for PI vehicles/engines: availability, costs, ...

Possible regulatory results:

Scientific evidence	Regulation
Engine out PN emissions “very low” for PI	No PN limits, no measurements
Engine out PN emissions for PI “around” CI emission limits, high costs for abatement technology	“Slightly” higher PN emission limits for PI than for CI
<b>Engine out PN emissions for PI “typically above” CI emission limits, no specific health effects for PI emissions</b>	<b>PN emission limits the same for PI and CI</b>
Severe specific health effects for PI particle emissions	PN emission limits for PI below CI emission limits



# Euro 6/VI, positive ignition: particle emissions

## PI particle number emissions, study by the JRC (for light & heavy duty):

- Due by end of 2010, discussion in MVEG, Commission proposal
- Preliminary results:
  - Engine out PN emissions for PIDI significantly higher than CI emission limit
  - Shift towards smaller particles (=> PMP lower cutoff still appropriate?)
  - However: contribution of particles with sizes below 23 nm “limited”
  - PN abatement technologies (wall flow filters) technically available

## Preliminary consequences:

- PN emission limits the same for PIDI and CI
- Revision of PN measurement procedure: lower cutoff for particle size (?) ...
- PN emission limits for PI port injection?

## Open question:

- Specific health effects of PI particle emissions?

# Euro 6/VI: particle emissions & OBD

## **Euro 5 CI:**

- Monitoring only for “total DPF failures”
- OBD threshold limit (OTL) for PM: 50 mg/km

## **Euro 6, VI CI:**

- Objective: monitoring also for “partial DPF failures”
- “Harmonisation” with CARB/EPA requirements

## **Euro 6 CI (to be defined in legislation by end 2010):**

- Proposed (2008/C1808 of 19/07/2008) PM-OTL: 9 mg/km

## **Euro VI CI (still being discussed):**

- Until 2016: PM-OTL = 40 mg/kWh
- From 2016: PM-OTL = 25 mg/kWh
- Exemption for “early Euro VI” to use performance monitoring against +/- 50% loss of backpressure instead => not very efficient but need to strike balance between technical feasibility & environmental benefit

# Euro 6/VI: particle emissions & OBD

## **Open regulatory issues:**

- OBD monitoring also against PN-OTLs? If yes: which multiplication factor above the emission limit?
- OBD monitoring of PN emissions of positive ignition engines?

## **Soot sensor:**

- Several technical concepts
- Availability
- Performance (accuracy, durability, ...)
- Costs
- PN sensors?

## **DPF backpressure monitoring (mainly light duty):**

- Improvements possible to identify e.g. a 50% loss of filtration efficiency?

# UNECE WLTP

## World Light duty Test Procedure (WLTP)

- Development of a Global Technical Regulation (GTR) for light duty test procedures under the 1998 UNECE agreement
- Duration: 2008 to 2022
- First phase: 2008 - 2013, development of a globally harmonised test cycle

## WLTP, state of play:

- Sub-group WLTP-DHC: design of the new driving pattern. Currently: driving data collection and analysis
- Sub-group WLTP-DTP: definition of test procedures. 5 specific working groups:
  - **PN/PM measurements**
  - New pollutant measurements: NO<sub>2</sub>, NH<sub>3</sub>, VOC,...
  - Lab procedures, general
  - Electric / hybrid vehicle specific issues
  - Reference fuels

# UNECE WLTP : particle number measurements

**Should PN measurements be part of the WLTP process?**

- EU (Member States, Commission): yes
  - Strong US scepticism (but US left the WLTP process recently)
  - Indifference of other contracting parties and industry
- ⇒ PN measurements will be “optional” in GTR &  
⇒ existing procedures to be revised and updated

**Possible issues:**

- Lower particle size cutoff
- Volatile vs. non-volatile particles
- New particle formation processes and reflection in measurement

# Retrofit exhaust gas after-treatment systems

## Why retrofits?

- Reduction of existing fleet's emission essential for air quality objectives
- Financial incentives: tax benefits, road toll reductions, direct payments,...

“Harmonisation” of retrofits:

- Which pollutants should be reduced by retrofits?
- For which vehicles, i.e. light, heavy duty vehicles, NRMM?
- Which emission levels to be addressed (e.g. Euro II, III to Euro IV, V; Euro IV, V to Euro VI etc.)

Conclusions from stakeholders consultation in early 2009:

- Basically all pollutants to be covered, but priority on particles (due to current technical availability of retrofits)
  - Focus on heavy duty since cost/benefit of light duty retrofits questionable
  - Harmonisation of “low level” retrofits (e.g. Euro II, III to Euro IV, V) would be desirable now, but is not likely to be relevant anymore in 2 - 3 years
- ⇒ Focus on harmonisation of retrofits achieving Euro VI emission levels
- ⇒ Particle reduction retrofits to be treated first

# Retrofit exhaust gas after-treatment systems

## **“Harmonisation” of “Euro VI” retrofits:**

- Development of UNECE “Retrofit” Regulation under the 1958 Agreement
- Link financial incentives to be granted by Member States to UNECE “Retrofit” Regulation according to Article 10(2) of 595/2009/EC (Euro VI)

## **UNECE “Retrofit” Regulation objectives, agreed by WP.29:**

- Scope: all exhaust gas after-treatment system retrofits for heavy duty vehicles and NRMM, includes installation requirements
- First step: retrofits for reducing particle emissions to the Euro VI levels (or stage IIIB for NRMM)
- Second step: retrofits reducing NO<sub>x</sub> emissions
- In principle “technology neutral”
- Consideration of different qualification schemes, e.g. retrofit system oriented requiring minimum filtration efficiencies (e.g. CH-DE VERT) or engine oriented (e.g. German Anlage XXVII)

## **Additional technical issues (for retrofits reducing particle emissions):**

- Secondary pollutant emissions due to catalytic activity (toxic HC, NO<sub>2</sub>)
- Durability
- Backpressure & fuel consumption



# Thank you!

# Thank you for your attention!

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