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Possible Approaches to Incorporating fine Particle Parameters into Vehicle type approval Legislation

POSSIBLE APPROACHES TO INCORPORATING FINE PARTICLE PARAMETERS INTO VEHICLE TYPE APPROVAL LEGISLATION.

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Introduction

At the last ETH Workshop (Paper no. 2) we reported on some European initiatives on nanoparticles in the vehicle emissions regulatory framework. One of these initiatives was a study commissioned by the CEC's DGXI, aimed at helping the EU formulate future regulations related to particulate emissions, in the context of health effects related to size ranges (slide 2). That study comprised information gathering and experimental phases (slide 3). The results of the information-gathering phase were reported last year. Since the last ETH Workshop the study has been completed and reported widely - including via the CEC's website (see: <http://europa.eu.int/comm/dg11/pollutants>). In this presentation we summarise the main findings of the study, present some of the key results and provide some additional information related to some of the issue involved.

Summary of information gathering phase

Slides 4 to 6 summarise the information gathered on health effects of particulate, and on the measurement of particulate. In this study the concept of thresholds on size ranges was used as a means of possibly simplifying the approach to regulatory standards, bearing in mind that in this field of application the moving away from a simple gravimetric parameter alone represents a major conceptual step. A threshold of 300nm was selected to demonstrate this concept on the basis of a compromise between typical emissions profiles and our understanding of particulate inhalation and deposition in humans. With no firm health data presently available to contradict this choice, 300nm was chosen because of its significance in particle deposition in the human lung. Generally, particles larger than 300nm will deposit in the upper airways due to impaction, whereas particles less than 300nm will deposit in the lower respiratory tract and alveoli due to diffusion (slide 5). However, the experimental programme was designed to demonstrate the principal of using any cut-off size, rather than this one in particular.

Experimental phase of DGXI study

The experimental programme was configured in the light of the findings of the information-gathering phase. The measurement approach focussed on both the number of ultrafines and the mass of 'course' particulate at sizes above and below 300nm. The experimental programme (slide 7) comprised an in depth investigation of key measurement variables on a single vehicle and then the application of a preferred measurement procedure on a range of vehicles representing different technologies and standards (slide 11).

Summary of main findings of DGXI study

For instrumentation (slide 6), the study found that existing concepts could form the basis of a method for number measurement, with a relatively simple CNC (plus diluter) providing equivalent total number data to the SMPS, except at high speeds (figure 9). At high speeds, the CNC measured higher levels of particle number than the SMPS, implying that there were significant emissions of particles below the lower size range of the SMPS (7nm in this case). Similarly, existing impactor concepts, appropriately optimised, could form the basis of a method for mass (slide 10).

Concerning sampling (slides 8 & 9), either CVS or raw sampling could be used although there remain some sampling issues to be clarified particularly for certain vehicle operating regimes. The SMPS results were relatively unaffected by the sampling conditions used, whereas the CNC results were affected by the high temperature and raw exhaust sampling systems. The high temperature sampling involved passing the sample through a furnace tube held at 600°C, to drive off any volatile component. The background levels by the CNC for these tests were higher than the sample measurements. In consequence this data has not been reported. During raw exhaust sampling, the CNC appears not to show the divergence from the SMPS data at high speeds (120kph). There were sampling issues at these high speeds, but this data could be used to imply that the high number of apparently sub-7nm particles measured in the dilution tunnel based tests may be artefacts of the dilution system. More work is needed to clarify the situation.

Correlations with various regulatory emissions parameters were made for the range of vehicle types studied but, whilst there were some indications of differences between older and current vehicle types, the sample was too small for firm conclusions to be drawn. Slides 12 and13 show the steady state flux measurements by both SMPS and (CNC +diluter) for the range of vehicles studied. Interestingly not all vehicles produced the high flux of apparently sub-7nm particles at high speed.

This being an initial study it understandably highlighted some issues requiring further investigation before definitive recommendations could be made (slide 20). In summary relatively simple approaches to either number or mass based regulations appear feasible using existing sampling and measurement concepts but further detailed study is required on certain critical areas before type approval protocols for example can be defined.

Experimental assessment of particulate measurement instrumentation

Report to CEC DGXI

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THE INNOVATION BUSINESS

Slide 1

Context

Information required to:

- help EU formulate future regulations
- related to particulate emissions
- from light duty vehicles
- taking account of health effects
- related to particle size ranges

Slide 2

Project scope

- gather information on health effects
- gather information on measurement methods
- propose trial measurement procedures
- make measurements on LD diesel vehicles
- propose changes in current measurement procedures for type approval testing
- report to the EU Commission Services

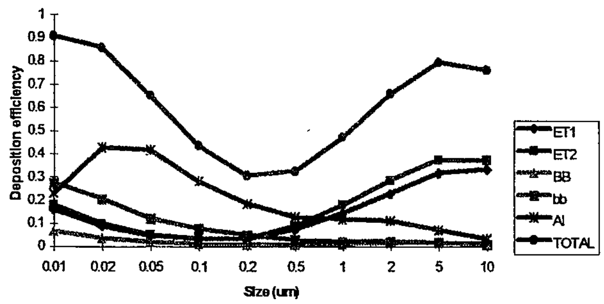
Slide 3

Literature findings - Health effects

- link between particulate exposure and health
- ultrafine may be most significant
- number, mass or both appropriate marker?
- unlikely to lead to new particle metric standards being implemented in time for 2005
- significant health-related and congestion costs attributed to urban road transport
- public and political opinion may require more rapid action on ultrafine particle abatement

Slide 4

Deposition Efficiency



Slide 5

Literature findings - Measurement

- combination of methods probably required
- measure number of ultrafines and mass of 'coarse'
- simplify measurements - explore 300nm split (lung deposition mechanisms and emissions profiles)
- investigate using CNC (+diluter) and impactor
- consider dilution & sampling
- SMPS benchmark (number)

Slide 6

Experimental programme

In depth study on latest technology vehicle

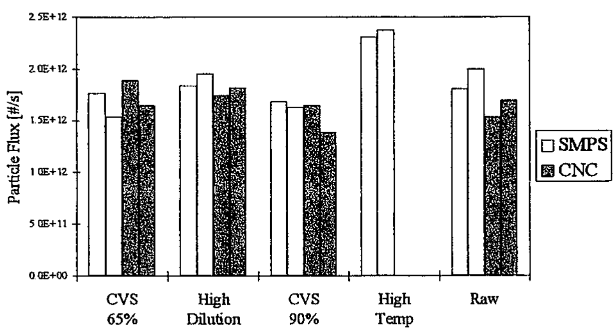
- diesel DI VW Golf
- sampling (raw to high dilution, temperature)
- test cycles (steady state, transient, FAS)
- for repeatability, stability and correlation

Measurements on representative vehicle classes

- IDI (to 88/436/EEC & 94/12/EC)
- DI (to 94/12/EC)

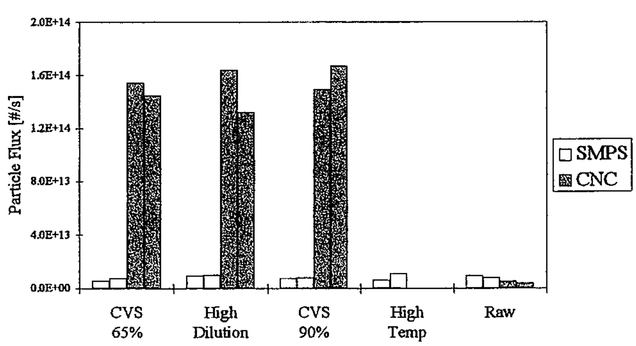
Slide 7

Effect of instrumentation and sampling at low speed (50kph)



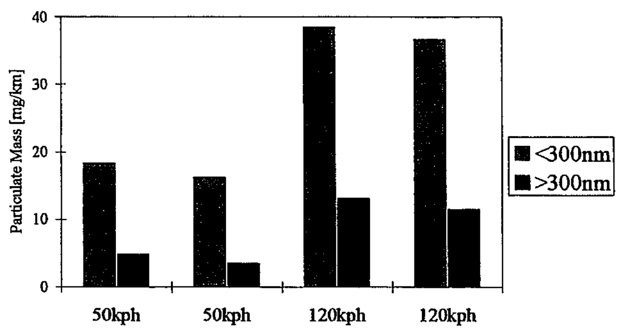
Slide 8

Effect of instrumentation and sampling at high speed (120kph)



Slide 9

Anderson Mass Measurements



Slide serial no 10

Slide 10

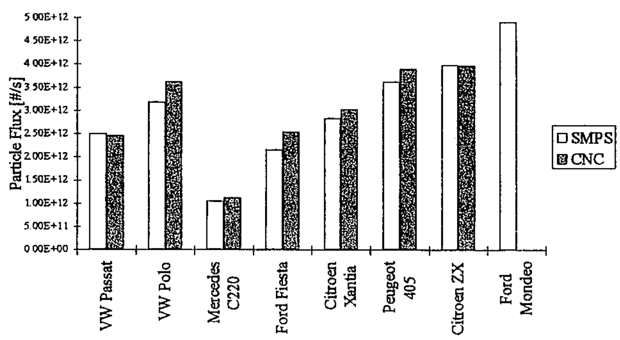
Vehicle technologies and standards

VW Passat TDi 1.9	4244km	DI	94/12/EC
VW Polo DL 1.9	5723km	"	"
Mercedes C220 2.2	52294km	IDI	"
Ford Fiesta 1.8	18613km	"	"
Citroen Xantia 1.9	8555km	"	"
Peugeot 405 TD 1.9	194848km	"	88/436/EEC
Citroen ZX 1.9	202220km	"	"
Ford Mondeo 1.8	166451km	"	"

Slide serial no 11

Slide 11

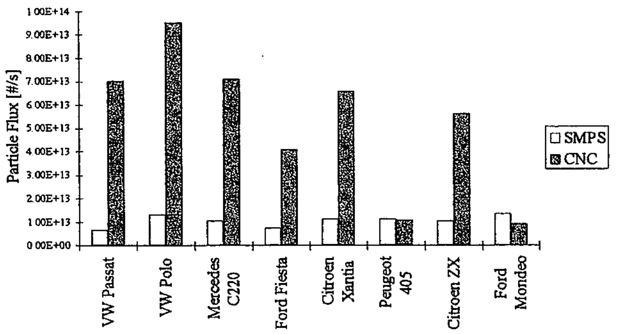
Influence of technology level on low speed particle number flux



Slide serial no 12

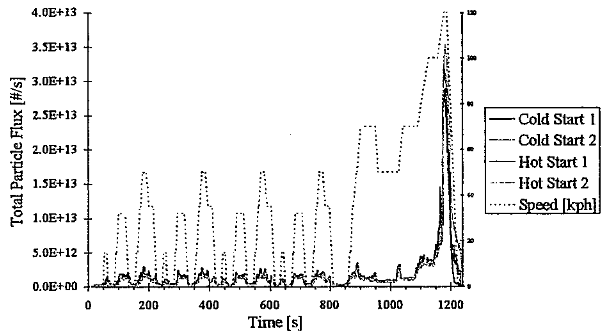
Slide 12

Influence of technology level on high speed particle number flux



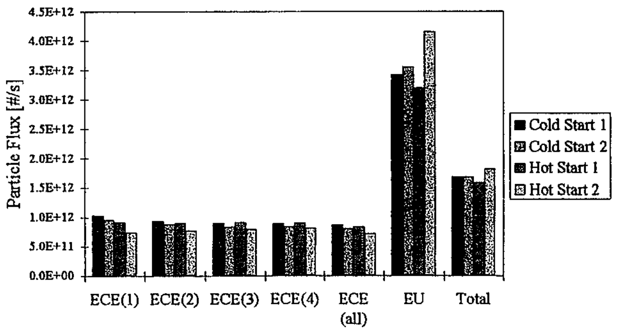
Slide 13

Particle Number Flux over NEDC



Slide 14

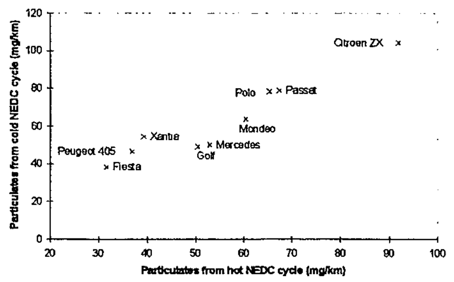
Average Particle Number Flux over NEDC



Slide 15

Cold start and hot start NEDC comparisons for regulatory PM

Relationship between cold and hot NEDC cycle particulate emissions



Slide 16

Results - Instrumentation

Existing instrument concepts could form basis for specification

- CNC (+diluter) could be basis for number measurements
- improved and simple two-stage impactor design needed for mass discrimination
- smoke obscuration might be a useful indicator of mass

Slide 17

Results - Sampling and test cycles

Sampling
- standard CVS can be retained for Type Approval
- in-service testing could be on raw exhaust
- care needed in tunnel design and flow measurement

Test cycles
- no need to change from NEDC
- no evidence for usefulness of FAS

Slide 18

Results - Vehicles and technologies

- factor of five variation in total mass and particle flux at steady state (no obvious link with technology)
- little variation in number under NEDC
- older technology vehicles perhaps produce fewer ultrafines at high speed

But sample too small to draw general conclusions on technologies

Slide serial no 19

Slide 19

Conclusions

- until health position is clarified, measure:
  - total particle number
  - particle mass above and below 300nm
- a CNC + diluter can measure total particle number
- an improved impacter can be used to measure size segregated particle mass
- standard CVS sampling conditions can be used (though more work on sub 7nm particle source)
- no reason to change from standard cold start NEDC

Slide serial no 20

Slide 20

Outstanding issues

- further health data
- measurement uncertainties at nanometre level
- sampling issues
- composition issues
- assess performance of industry wide CVS systems
- much more data needed before limits (and cut-offs) can be proposed (all fuels and technologies)
- assess technical/ economic implications of meeting both fine particulate and other pollutant regs.

Slide serial no 21

Slide 21