

PROGRAMME OVERVIEW:
GRPE PARTICLE MEASUREMENT PROGRAMME (PMP)

Transmitted by the Expert from the United Kingdom.

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1. INTRODUCTION

Current medical evidence indicates that particle emissions, measured as PM10, are associated with increased mortality. However, a growing number of medical experts consider that nanometer size particles, that may be insignificant to the total mass of particulates, may be more significant in terms of health effects. New engine/vehicle technologies offer levels of particulate emission control that are considered to be approaching the effective measurement limits of the current legislative systems. It is therefore necessary to consider the development of new systems of particulate measurement that can be recommended for adoption into international regulations governing these emissions.

The GRPE Particulate Measurement Programme (PMP) is a collaborative programme operating under the auspices of the UNECE WP29/GRPE Group. Its focus is on the development of a new approach to the measurement of particles in vehicle exhaust emissions, which may be used to replace or to complement the existing regulated mass based system. PMP is open to contributions from governments, industry and NGOs who are members of the GRPE. Each contributor to the programme will undertake and fund their own research and deliver the results in accordance with the schedule of the two-year programme. Interim and final results of the national research programmes will be shared with all members of the programme, to enable the development of a PMP consensus report.

2. AIM

The aim of PMP is to recommend to the regulatory authorities a new particulate assessment and measurement system for application during type approval testing of light-duty vehicles and heavy-duty engines for particulate emissions. This recommended system would permit the development of new emission standards, which would, in turn, promote the adoption of new emission reduction technologies. In this context “system” comprises a description of the test procedures, sampling equipment and measurement instrumentation. The system will enable accurate and repeatable measurement of particles present in the exhaust stream and at stringency levels below those currently set down in legislation. The output will be draft text for use as a proposal that may replace or supplement the current systems set out in UNECE Regulations 83 and 49.

To assist in the setting of future limit values for light-duty vehicles and heavy-duty engines, the programme will provide data on the emissions of particles from engines employing a range of advanced technologies, and in particular from different diesel particle filters (DPF), measured using the new PMP recommended test system.

3. ORGANISATION

A Steering Group with representatives from Governments that are actively contributing to the programme will be the main decision making body. Its current membership comprises representatives from Germany, France, the Netherlands, Sweden and the United Kingdom. A representative of the United Kingdom chairs the group.

The Steering Group will meet regularly throughout the course of the programme. To ensure that GRPE members who are not part of the steering group are kept informed of progress, two meetings will be held each year in conjunction with the GRPE in Geneva.

4. PROGRAMME

Based on an initial literature study the programme will be divided into the following elements:

- Phase I - development of candidate systems
- Phase II - testing programme and validation of systems
- Phase III - characterisation of advanced technology

The programme will keep a watching brief of emerging evidence on the health effects of particulate emission to ensure the relevance of the output of the programme.

5. TRANSPARENCY

Contractors/researchers contributing to PMP will be expected to maintain regular contact with their counterparts in other organisations/countries through bilateral discussions. The research will be undertaken in an open and transparent manner to ensure good collaboration and rapid progress.

6. TIMESCALE

The programme began in March 2001 and will end in March 2003. It is intended to:

- transmit a formal proposal for a test system(s) to the UNECE in October 2002 for discussion at the January 2003 meeting of GRPE
- deliver preliminary data on emission levels from advanced technology to the UNECE in December 2002 for discussion at GRPE
- deliver final data on emission levels from advanced technology to the UNECE in March 2003 for discussion at GRPE.

The attached Gantt chart shows the programme's milestones.

7. HEALTH EFFECTS

The metric used to measure particle emissions in vehicle emission control legislation should be either directly or indirectly related to the effects on air quality and human health. Current opinion suggests that particle size and number may be important criteria with respect to health effects. However, there remains uncertainty as to the best metric to use and therefore it is important that those involved in this programme are aware of emerging evidence on the health effects so as to ensure it's the programme's relevance in future years. Therefore, an ongoing

activity of this programme will be to keep a watching brief on emerging evidence on the health effects of particles, specifically those relevant to automotive exhaust emissions.

Output: All members are expected to bring to the Steering Group's attention significant new developments that may influence the direction of PMP.

8. LITERATURE STUDY

Literature reviews reporting studies on the health effects and assessing instrumentation, analytical methodologies and the future of particle measurements will be undertaken under several national programmes. PMP will evaluate these national reviews, summarise them and make recommendations for the development of the test system.

Output: A PMP report summarising the main conclusions and recommendations of the national literature studies.

9. PHASE I: DEVELOPMENT OF CANDIDATE SYSTEMS

9.1 Background

9.1.1 Aim

The aim is to develop new systems for the measurement of particles emitted from the exhaust of motor vehicles/engines. The development will consider all potentially relevant measuring instruments including prototype equipment. Phase I will also recommend generic evaluation criteria to enable the selection of suitable candidates for Phase II of the programme.

9.1.2 Scope

The national programmes will develop one or more potential test systems applicable to light-duty vehicles and heavy-duty engines. Although the immediate interest is focused on diesel vehicles/engines the system(s) must be capable of measuring particles from both compression and spark ignition engines at the low emission levels expected from the technologies anticipated for the market place around 2008/2010. The programme will consider the effect of fuel and lubricants on the performance of the system and make recommendations accordingly.

9.1.3 Particle Measurement Metric

The relative importance of particle mass, size, number, surface area, and chemical composition on human health is yet to be decided. Current evidence suggests that there is a clear association between mortality and PM₁₀, whilst some experts consider that nanometer size particles may also be important.

Researchers in different fields have adopted a variety of terms to describe different types of particles in vehicle exhausts. Many current definitions are not precise. The smallest particles in the nanometer size range are often referred to as the nucleation mode particles and are mainly condensed volatile materials. In PMP these will be known as non-carbonaceous nano-particles. The larger particles, often referred to as the accumulation mode particles, are mainly solid, predominantly carbonaceous material. These will be known as the carbonaceous ultrafine particles. The cut-off point between the two types of particle is around 40 to 50 nm.

The main focus of PMP will be on particles in the nanometre/ultrafine range. However, the methodology developed must be capable of responding to new health effects evidence.

Preference will be given to candidate systems that can:

- Measure more than one metric (e.g. mass and/or number & size) relatively easily;
- Measure particles using a system that adequately reflects the characteristics of vehicle particles witnessed in the appropriate exhaust stream;
- Avoid the creation of artefacts or at least minimise the possibility of such artefacts.

The objective of this programme is to develop a new test system(s) that allows the development of new emission standards that will, in turn, drive the adoption of advanced vehicle technology. This *may* mean concentrating on the measurement of carbonaceous particles as this is felt to offer the best repeatability and reproducibility. However, in this case the programme will also assess the impact of advanced technologies on the emissions of non-carbonaceous particles. Similarly particle size *may* be the most appropriate parameter for future regulatory control; these views should be developed during Phase I and an appropriate measurement size parameter defined.

9.1.4 Test Cycles

It is considered that transient test cycles offer the best repeatability when measuring particle emission and it is therefore likely that the test system will use the existing legislative transient test cycles. However there is a proposal for the global harmonisation of the heavy-duty driving cycle (the World Heavy-duty Driving Cycle - WHDC). Therefore it is important that any test system developed can be readily adapted to this cycle when it is concluded.

9.2 Develop candidate test systems

The candidate test systems must be appropriate to measure particle emissions at levels significantly below those required by regulations for 2005.

A number of issues that can affect the reproducibility of results will have to be addressed. These may include, but are not limited to:

- Preconditioning of vehicles/engines;
- Preconditioning of the dilution tunnel;
- Design of sample probes;
- Tunnel losses;
- Temperature and humidity;
- Avoidance of artefacts;
- Scrubbing the dilution air;
- Dilution and residence times;
- Fuel and lubrication oil components (esp. Sulphur).

9.3 Devise interim level instrumentation

Currently only laboratory quality instruments exist for the measurement of particle size distribution (i.e. the number of particles in different size categories) and there is a lack of reliable calibration standards.

Progress in the adaptation of existing instrument technology to meet the requirements of type approval testing should be an important component of the work within national programmes. These requirements include good:

- Accuracy;
- Repeatability;
- Reproducibility;
- Durability;

As well as:

- Reasonable price;
- Ease of calibration;
- Potential for market availability within [5] years;
- Practicality and ease of handling for type approval purposes.

During this phase it will be important to begin discussions with scientific instrument manufacturers to identify candidate instruments that can be developed as viable commercial products. In addition, for prototype equipment, calibration standards need to be developed for each particle metric/size range measured, and therefore discussion with appropriate suppliers of calibration standards should also begin.

9.4 Outputs

At the end of Phase 1 the following will be produced:

National Programmes

- Detailed description of the operation and performance of each candidate system with data to support its main elements;
- The operating specification of the instrumentation for each candidate test system, with data on the particle metric it measures, its accuracy and precision;
- Draft evaluation criteria for evaluating the merits of candidate systems.

PMP

- Consolidated report on candidate test systems with agreed generic evaluation criteria.

10. PHASE II: TESTING AND VALIDATION OF SYSTEMS

10.1 Introduction

The details of Phase II will be developed when the number and type of candidate test systems is clear. It will be necessary to involve a number of stakeholders at this stage, including the instrument manufacturers and vehicle/engine manufacturers.

10.2 Aim

The aims of Phase II are to evaluate the agreed candidate systems and select the best system(s) to recommend for future legislative use. This will be undertaken in the most cost-effective means available.

10.3 Evaluate competing systems

There will be an initial screening of the candidate systems against the Phase I evaluation criteria. The PMP Steering Group will select the minimum number of candidate systems for further testing to evaluate their performance under the typical testing conditions of different facilities. The best elements of different systems may be used to produce a composite system that will then be tested.

10.4 Evaluate accuracy, repeatability and reproducibility

PMP participating governments will consider the funding of the validation of one or more candidate systems within their own national programmes. The exact nature of this validation will be defined towards the end of Phase I. However, it is likely to take the form of round robin tests with the same vehicle/engine being tested using the same candidate system at several laboratories.

10.5 Report and recommendations for new systems

Each PMP member will report the results of their evaluation of the candidate systems in an agreed format and make recommendations for the final test system. The PMP Steering Group will assess the national evaluation results and agree a recommended system for light-duty vehicles and for heavy-duty engines.

10.6 Outputs

PMP will produce a report detailing the recommended test systems for light-duty vehicles and heavy-duty engines in a format that can be readily adapted by legislators. This will be submitted to the UNECE in October 2002 as a formal document for discussion at GRPE in January 2003.

11.0 PHASE III: CHARACTERISATION OF ADVANCED TECHNOLOGY

11.1 Aim

The aim of Phase III is to provide data on the particulate emission of different advanced technologies when measured by the recommended test system(s). The focus will be on diesel vehicles/engines fitted with DPF or equivalent emission control technologies. Light-duty vehicle evaluation will include direct injection spark ignition engines.

11.2 Establish benchmark emission values for current vehicles with advanced emission control technologies

Cooperation with industry will be sought to identify engine and after-treatment technologies likely to be available on production vehicles from 2005/2008 and beyond. Common design features of emission control systems, (e.g. the use of the same substrate in DPFs), will be identified to minimise the number of different technologies requiring testing. Testing will be undertaken by the national programmes, using the PMP recommended test system(s). These programmes will report to an agreed format.

11.3 Outputs

PMP will produce data indicating the emission levels of the technologies tested. A preliminary set of data will be submitted to the UNECE in December 2002 and a final one in March 2003.

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