



Second CITA Programme on Emission Testing at Periodic and Other Inspections

Programme Summary Report

Brussels, November 2002

Preface

This summary report briefly sets out the objectives, work undertaken and the main conclusions and recommendations of the five studies that made up the second CITA programme on emission testing at periodic and other inspections. The five studies were –

- (a) A working group to consider a 'best practice' procedure for measuring exhaust emissions from petrol vehicles;
- (b) A study on motorcycle exhaust emissions and noise;
- (c) A study on the use of OBD during periodic inspection;
- (d) A study on the influence of catalyst temperature on the effectiveness of periodic inspection;
- (e) A study to examine the feasibility of a large scale data gathering exercise.

The programme was funded by a grant of 50% from the EU Commission's Directorate General for Transport and Energy (DGTREN) and by contributions from participating organizations or their sponsors and from the European Garage Equipment Association, to whom particular thanks are due. In addition, all the other organizations that participated in co-ordinating meetings of CITA's working group on emissions (CITA WG1) and the individual studies contributed through the salary and travel costs of their representatives.

Although this programme was organised in the name of CITA, the conclusions and recommendations contained in this summary report and the individual study reports are a consensus of the views of the organizations that undertook each study. Neither this report nor its conclusions and recommendations have been formally adopted by the CITA Bureau Permanent nor by vote of the rest of the CITA membership and so they do not necessarily represent the views of CITA as a whole or of individual CITA members.

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1. Background and Reasons for the Programme

EU Directive 96/96/EC¹ specifies the tests that must be done during periodic inspection to measure the exhaust emission performance of road vehicles. Analysis of data obtained in 1999 during research sponsored by the Commission² showed that, if the test procedures could be made more effective, further significant reductions in the exhaust emissions from current technology vehicles (those without catalysts and with catalysts without closed loop control) could be realised. The research also concluded that, for vehicles with closed loop controlled catalysts or low emission diesel engines, the existing test procedures in the directive are either not very effective in identifying high polluting vehicles or fail significant numbers of vehicles that should be passed.

An amendment adopted in 1999 to directive 96/96/EC specified some improvements to the free acceleration test for diesel engines³. This was developed from a proposal by the International Motor Inspection Committee (CITA) using information from some research by AEA Technology⁴. In November 2000, a CITA working group, part funded by a grant from the EU Commission, reported on the possibility of introducing type specific emission limits as a way of improving the effectiveness of the current procedure for petrol engines⁵. The Commission has used the recommendations of this report as the basis for a proposal for a further amendment to directive 96/96/EC that is currently under discussion in the committee for the adaptation of directive 96/96/EC to technical progress (the 'TAC committee') .

However, these developments were not sufficient to address all the issues relating to future inspection of vehicles at periodic inspection for exhaust emissions. Further work needed to be done both to improve the current procedures and to specify new procedures that will adequately control the emissions from low emission vehicles. This second programme of work proposed by CITA was designed to contribute to filling in these gaps.

The Programme consisted of five studies –

- (a) A working group to consider a 'best practice' procedure for measuring exhaust emissions from petrol vehicles;
- (b) A study on motorcycle exhaust emissions and noise;
- (c) A study on the use of OBD during periodic inspection;
- (d) A study on the influence of catalyst temperature on the effectiveness of periodic inspection;
- (e) A study to examine the feasibility of a large scale data gathering exercise.

¹ Council directive 96/96/EC on the approximation of the laws of the Member States relating to roadworthiness tests for motor vehicles and their trailers.

² Joint Commission Services study "The inspection of in-use cars in order to attain minimum emissions of pollutants and optimum energy efficiency".

³ Commission directive 1999/52/EC OJ L142 p. 26

⁴ "Diesel smoke test procedures and meter specification", J.O.W.Norris, J.R.Donald, October 1997.

⁵ Report of the CITA Working Group on type specific emission limits, report number: CITA/1ERSP/S2/01, 16 November 2000

Sections 3 – 7 of this report give more details of the aims, the work done and the main results and conclusions of each separate study.

Section 8 of this report contains the overall conclusions of this programme and some key recommendations for future action.

Annex 1 lists the full titles, references and authors of all the separate study reports.

2. List of Participating Organizations

Study 1

The following organizations took part in the Working Group –

RWTÜV, Germany
UTAC, France
Bilprovningen, Sweden
EPA, Sweden
RDW, Netherlands
DEKRA, Germany
VdTÜV, Germany
EGEA (Robert Bosch GmbH)
EGEA (Sensors Europe GmbH)
CITA

Study 2

TNO, Netherlands (Study leader)
VdTÜV, Germany
TÜV Nord, Germany
DEKRA, Germany
Bilprovningen, Sweden
MTC, Sweden
EGEA (Grundig AG, now AVL Ditest)
CITA

Study 3

RWTÜV, Germany (Study leader)
VdTÜV, Germany
DEKRA, Germany
GOCA, Belgium
VI, Great Britain
UTAC, France
BIVV/IBSR, Belgium
VITO, Belgium (Cost/benefit evaluation)
EGEA
CITA

Study 4

AEA Technology plc, now EMSTec Ltd, Great Britain

Study 5

Laboratory of Applied Thermodynamics, Aristotle University Thessalonica, Greece

3. Study 1 - 'Best practice' procedure for petrol vehicles

3.1 Aim of the Study

Analysis of the data in the joint Commission services report ² suggested that, at least in theory, the following reductions in the exhaust emissions from current vehicles (without a catalyst or with only an oxidation catalyst) might be possible with improved inspection and maintenance regimes –

Carbon monoxide	16%
Nitrogen oxides	15%
Hydrocarbons	15%

In its first research study programme, CITA investigated the potential of using type specific emission values to realise some of these exhaust emission reductions. It seems likely that this development alone will not be sufficient to realise all the potential improvements.

Within the parameters of the basic test procedure, the scope for other improvements is limited. However, the specification of the test procedure in the directive is very rudimentary. Some member states have put considerable effort into developing more detailed procedures in order to ensure the test is properly controlled and as effective as possible. Those member states that started exhaust emission testing on cars and light vehicles more recently have not had the time and, in some cases, the resources to do this development. The aim of this work was to analyse all the procedures in use in the member states and to see whether a 'best practice' procedure could be synthesized, either as a recommendation to all member states or as the basis for further amendment to the procedures specified in the directive.

3.2 Summary of the work done

The work programme was in three stages. Firstly a special survey was done to gather information about the test procedures currently used by EU member states to test the emissions of non-catalyst equipped vehicles. Secondly, the replies were analysed to identify significant differences in procedures and to highlight issues that should be explored further. Finally a special group of emission experts from interested CITA members working under the general guidance of the CITA Exhaust Emissions Working Group met to consider the results of the survey, consider the significant issues arising from the analysis of the survey and to try to synthesize a 'best practice' procedure.

3.3 Conclusions and Recommendations

The working group reached the following conclusions –

1. Given the work involved and the uncertainty of the benefits, it was not now a cost/effective use of time to develop 'best practice' procedures to try to improve the effectiveness of the current test prescribed in directive 96/96/EC.
2. Future test procedures prescribed in the directives should be more closely specified to prevent significant divergence between the actual procedures developed in each member state.
3. The CITA Working Group on Emissions would be willing to assist in the development of proposals for future procedures.

4. The Commission should look at the provision on an EU wide basis of emission relevant information about the equipment fitted to vehicles in order to increase the effectiveness of the visual examination done as part of an emission test. The information for this database could be collected on a mandatory basis during type approval and it could be made available at the time of test by a variety of means, for instance via the internet or vehicle specific "smart cards".
5. The Commission should consider whether the directive should be amended to include requirements on the information to be given to vehicle owners following a periodic emission test.

4. Study 2 - Motorcycle exhaust emissions and noise

4.1 Aim of the study

Motorcycles are not within the scope of Directive 96/96/EC. The Commission's technical adaptation committee has discussed extending the scope to include them on a number of occasions, although such a change would have to be by a Council directive, not a Commission directive. To date, such an extension has always been opposed by a majority of member states, particularly those that had only just introduced, or were still in the process of introducing, periodic inspection of cars and light goods vehicles. However with increasing concern about the achievement of demanding air quality standards, attention is now being focused on all sources of exhaust emissions and how they might be controlled. In addition, concern is growing in a number of member states about noise from motorcycles. While the noise levels of new machines can be controlled via type approval, control on vehicles in-use is difficult without effective periodic inspection. Periodically the Commission re-raises the possibility of periodic inspection for this class of vehicle. To date the majority of member states have not been in favour.

However, if inspection of motorcycles is to be introduced, even if it is only in a limited number of member states on a voluntary basis or for limited items, it would be better if it was done on the basis of properly considered and developed harmonised test procedures and equipment standards. The first aim of this study was to get an insight into the basics of motorcycles testing in order to provide a reliable basis for road-worthiness testing of motorcycles. This basic information could then be used to setup the relevant required procedures and standards.

Before the majority of member states are likely to agree to the periodic inspection of motorcycles being added to directive 96/96/EC, they will want to be satisfied that there is a cost/benefit case for doing so. Another aim of this study was to see whether the experimental work could provide data from which reliable cost/benefit estimates could be made.

Critical components on motorcycles are required to be fitted with anti-tampering devices to stop unauthorised adjustments and alterations that would affect the level of exhaust emissions. There is currently little data on whether these measures are effective or not. A final aim of the study was to check the state of the anti-tampering devices on the motorcycles being tested and assess, if possible, the effectiveness of the current control arrangements.

4.2 Summary of the work done

In order to answer the questions raised, the following tasks were undertaken:

- (a) Investigation and definition of the topics involved, dealing with:
 - The critical motorcycle parameters (including anti-tampering devices) that should be examined and controlled during periodic inspection of motorcycles.
 - The critical inspection parameters that must be controlled during testing to ensure the quality, reliability and repeatability of the measurements.
 - Problems with current measuring instruments in relation to testing exhaust emissions and noise from motorcycles with both two- and four-stroke engines.
 - Evaluation of measuring instruments for exhaust emissions and noise adapted for use with motorcycle with both two- and four-stroke engines.

- (b) Definition of a basic measurement procedure that could be used for future roadworthiness testing, based on available information on how to test exhaust gas emissions and noise on vehicles.
- (c) Validation of the proposed procedure by defining and executing a programme of testing of motorcycles to measure the exhaust emissions and noise of vehicles in-use and to evaluate the correlation between static idle tests and type approval tests. The programme was conducted in three different countries to ensure a proper identification of any geographical factors. It included measurements of 105 types (both two- and four-stroke engines) spread over the 3 countries. The motorcycles chosen for testing were a representative sample of currently sold vehicles in-use in Europe. They were tested both 'as received' and, if the gaseous emission level was found to be above the applicable type approval limit, after maintenance.
- (d) Evaluation of the results and findings and the production of a proposal for an amendment to the road-worthiness directive.
- (e) A proposal for estimating of the cost-effectiveness of the proposed procedure.

The main elements of the study were carried out by the three main participating organisations working jointly on the initial evaluations and definition stages and in parallel for the testing and measurement phase. Members of the European Garage Equipment Association assisted with the development and supply of suitably modified measuring equipment.

4.3 Conclusions and Recommendations of Study

The study reached the following overall conclusions and recommendations –

- (a) Based on the validation programme, a protocol for roadworthiness testing involving elevated idle speed testing using standard passenger car testing equipment proved to be more or less adequate for establishing a motorcycle's emission performance in relation to its type approval set-up;
- (b) 25% and 80% respectively of the vehicles tested did not comply with the applicable type approval limits for gaseous (Type 1 driving test) and noise (in-motion) emissions. For the fleet as a whole, these figures will be underestimates as tampered vehicles were underrepresented (only 2% in ways that influenced exhaust emissions and 4% in ways that influenced noise emissions) because of the way the vehicles had to be obtained due to time limitations during the execution of the study;
- (c) In the light of the high percentage of vehicles found to be high emitters, a roadworthiness test of motorcycles seems to be justified, more especially when the non-representative nature of the test sample is taken into account;
- (d) Although the results obtained for exhaust emissions using the proposed procedure cannot be directly compared to the type approval limit values, a set of threshold cut-off values for different technology classes has been calculated on the basis that there should be not more than 5% errors of commission;
- (e) In order to simplify the final procedure, it is recommended that the possibility of establishing one common threshold value (at one or more idle speeds) for each component (CO and/or HC), should be investigated. This investigation could prove that measuring only one component against only one threshold value might be sufficient.

Because the proposed procedure is very much in line with parts of the type approval tests, a 4.5% threshold for CO at low idle speed could be applied for the time being;

- (f) Only very high noise emitters can be detected using the proposed noise test procedure because noise emissions during stationary idle tests do not correlate with in-motion noise levels and noise measurements are less reproducible than gaseous emission measurements. The procedure could be improved but this would significantly increase the complexity and cost of the test. Taking into account the requirement for less than 5% errors of commission, for the present, an excess noise limit of 10dB(A) added to the stationary test result at time of type approval could be applied;
- (g) It was not possible to be as conclusive about the application of the proposed test procedures in relation to future vehicles as vehicles with the latest technology were underrepresented in the study. Additional research should be carried out;
- (h) Although a procedure for calculating cost/effectiveness is proposed, estimations were not possible because no threshold levels have yet been established.

5. Study 3 - Use of OBD during periodic inspection

5.1 Aims of Study

Directive 98/69/EC specifies that petrol vehicles and diesel vehicles must be fitted with on-board diagnostic systems (OBD) from 2000 and 2003 respectively. The OBD systems are required to monitor critical functions of the engine and emission control system, store information about deviations and, if the deviations exceed certain levels, report this fact to the driver via a warning lamp. During maintenance, the on-board memory is interrogated to assist with fault diagnosis and fault rectification.

Given their function, it is essential to consider how OBD systems required by the directive could be used to enhance the effectiveness of periodic inspection. However, as they are designed primarily for driver information and for use during maintenance, it is first necessary to evaluate whether the information that can be obtained from them is useful at periodic inspection.

One aim of this study was to examine the ways in which relevant information could be obtained from OBD systems at periodic inspection and, as a result, make recommendations for equipment (scan tools) and future test procedures for vehicles fitted with OBD. Another aim was to examine the need to continue exhaust emission measurements and look at the cost-effectiveness of the procedures proposed for including examinations of OBD systems during periodic inspection.

As inter-active communication with on board systems will provide opportunities for solving future periodic inspection challenges, a further aim of the study was to evaluate the existing standards for OBD systems (ISO; SAE), the requirements of directive 98/69/EC and the different systems and solutions adopted by vehicle manufacturers. If necessary, recommendations for the amendment and improvement of the standards and the directive would be made to enhance the future usefulness of OBD systems at periodic inspection.

5.2 Summary of the work done

To enable the aims of the study to be met, the following work programme was performed –

- (a) Collect and evaluate information about the performance of generic scan tools to read out OBD information and data; assess their compliance with directive 98/96/EC and their suitability for use during the test phase of the project; recommend scan tools for use in the test phase.
- (b) Through contact with vehicle manufacturers and evaluation of type approval documents, collect and evaluate the information stored in OBD systems and determine which parameters might be useful during periodic inspection.
- (c) Collect and evaluate information on OBD standards world wide to see whether additional parameters which would yield useable information during periodic inspection should be added to directive 98/96/EC.
- (d) Define the vehicle test programme, including test to be done, test sequence, vehicle selection, faults to be simulated, data to be collected and any other relevant matter. Define the format for test data collection and transmission.
- (e) Undertake test programme. 6 organisations tested a total of 16 vehicles according to the defined test programme.

- (f) Evaluation of the test results and a synthesis of a proposal for how OBD could be evaluated during periodic inspection. The proposed procedure was discussed with both other CITA members not directly involved in the study and with representatives of the vehicle manufacturers.
- (g) Using the results obtained in the test phase, evaluate the cost/benefit of the proposed test procedure and the added benefit of continuing to test tailpipe emissions in addition examining OBD systems at periodic inspection.

5.3 Conclusions and Recommendations of Study

- (a) Although most of the vehicles investigated during the test phase supported the requirement to communicate with generic scan tools, there were problems with some vehicles.
- (b) Not all current OBD equipped and certified vehicles can ensure that important malfunctions that can cause the specified emission thresholds to be exceeded can be detected.
- (c) Generally OBD systems could detect electrical failures, but they were not always able to detect simulated aged components.
- (d) 50% of the vehicles with induced failures showed increased emissions beyond the threshold for the MIL without the MIL being activated.
- (e) OBD systems offer the potential to improve the effectiveness of periodic inspection but the current tailpipe test should be retained.
- (f) A practical procedure for assessing OBD has been developed. The additional time that this will take will be partially offset by simplifying the existing procedure and, in the case of some countries, e.g. Germany, entirely offset by removing the need for some additional inspection procedures.
- (g) A methodology for assessing the cost/benefit of the proposed procedures was developed but because there is a lack of information about the actual failure rate of OBD systems in use, realistic calculations are not yet possible.

6. Study 4 - Influence of catalyst temperature on effectiveness of periodic inspection

6.1 Aim of Study

Emissions from catalyst-fitted vehicles are dependent on catalyst temperature. In-service tests, whether idle-based or short cycle-based, do not involve a direct check on catalyst temperature. In the UK, for example, engine temperature is used as a proxy for catalyst temperature and this does not consistently avoid the experience of vehicles passing a second test carried out soon after a failed first test. Such events involve possibly avoidable cost to the vehicle owner and also have a detrimental effect on the credibility of the legislation with the public. The aim of this study was therefore to assess possible ways of eliminating anomalous test results due to catalyst light-off effects.

6.2 Summary of the work done

The review comprised:

- a brief introduction to the characteristics of operation of catalyst systems;
- a review of available information related to the effects of temperature on emissions and to potential indicators of catalyst system performance;
- a summary of reported studies and regulations related to the influence of catalyst light off in the context of the development and operation of I/M tests;
- analysis of relevant results from recent AEA Technology work on the evolution of cold start emissions and on the influence of preconditioning (on road or in test sequence) on the condition and performance of catalyst systems.

It was originally intended to carry out some limited experimental work but analysis of results of the work outlined above showed that this would not be likely to add significantly to the current state of knowledge.

6.3 Conclusions and Recommendations of the study

The main conclusions of the review were as follows:

- (a) Additional temperature measurements do not appear to have much potential as a means of assessing catalyst system condition prior to I/M tests. This is mainly because of the practical difficulties associated with intrusive measurements and of the complexities of the relationships between individual measurement parameters and the operation of specific emissions control systems.
- (b) There may be scope for providing more prescriptive guidance on preconditioning to both the tester and the vehicle owner, although this would be difficult to specify on the basis of the limited experimental data currently available.
- (c) There is a paucity of information available on the nature and magnitude of the normal ageing behaviour of catalyst-based emissions control systems.

7. Study 5 - Feasibility of a large scale data gathering exercise

7.1 Aims of the Study

There is currently little data on which to base the evaluation of policy options for lowering emissions from road vehicles through improved inspection and maintenance, such as the use of short cycle tests or the benefits of reducing or increasing the frequency of inspection.

A number of programmes have been undertaken to construct models that will predict the effect of various transport modes on future air quality. The quality of the outputs of these models is critically dependent on the emission factors for each group of vehicles. For road vehicles, the sample size that was used to determine the emission factors, particularly for newer vehicles, was small. This means that data is not particularly robust nor is it useful for evaluating inspection and maintenance policy options.

The aim of this study was to review current and planned emission data collection projects to see whether individually or collectively they will provide statistically reliable data which could be used to evaluate the benefits of policy options for emission testing. If they will not, the study will continue and examine the feasibility and value of a large-scale data collection exercise, perhaps measuring the exhaust emissions from vehicles coming for periodic inspection using a short cycle test on a chassis dynamometer in a number of different member states.

7.2 Summary of the work done

Three types of activities in the EU involving the collection of data on the result of emission testing were identified and evaluated:

- (a) Emission factor development and modelling programmes, such as MEET, Artemis and a large number of national programmes;
- (b) European and national I&M evaluation programmes, such as the Joint Commission Services (JCS) study on I&M, the German AU study, the UK Vehicle Inspectorate study etc; and
- (c) National I&M programmes, resulting in % failure rates and concentrations at low and high idle.

As it was concluded that none of the current projects would provide statistically valid data for the evaluation of policy options, the study continued and developed two options for a large scale data collection exercise. Both envisaged testing about 8000 vehicles. In one, 1000 vehicles would be tested over both type approval and loaded short cycles and an additional 7000 over only a transient loaded short cycle. In the other option, the full 8000 vehicles would be tested using only a transient loaded short cycle. The vehicles would be selected mainly in a random manner from those coming for periodic inspection. In both options, vehicles identified as 'failing' would be sent for maintenance and retested. The exercise would be repeated in the following year so that data on vehicle degradation could be captured. Inspection centres and laboratories related to I&M would participate in the exercise proposed.

7.3 Conclusions and Recommendations of Study

- (a) Existing data gathering projects do not provide statistically reliable data that could be used to evaluate the benefits of various policy options for emission testing during periodic inspection;

- (b) The three evaluation studies of the effectiveness of Directive 96/96/EC done so far come to significantly different results. The UK study found the current Directive to be very effective in identifying high emitters resulting in considerable high emission reductions. The German study claimed similar emission reductions though quotes some reservations regarding the possible effectiveness of an enhanced I&M scheme. In contrast, the JCS study concluded that the current Roadworthiness Directive is completely ineffective for the three way catalyst fleet. In addition, all the studies lacked statistical representivity. None of the existing projects evaluates emission performance degradation.
- (c) The proposed programme to test a statistically representative sample (4 000 petrol and 4 000 diesel vehicles, each vehicle to be tested, if possible, twice) would cost around 16 M€ including the testing programme, vehicle repair costs and data evaluation

8. Overall Programme Conclusions

The following main conclusions can be drawn from this programme –

Best practice

1. No effort should be made to improve emission test procedures in directive 96/96/EC for pre-OBD petrol cars as it would be unlikely to yield sufficient benefits to offset the time and effort required.
2. The practicability of collecting and distributing vehicle information needed at periodic inspection on a Europe-wide basis should be investigated.

Motorcycle emissions

3. It is both practical and necessary to extend directive 96/96/EC to include inspection of motorcycle noise and exhaust emissions, but further work is required.
4. Of the motorcycles tested within this programme, significant numbers of current vehicles did not comply with the applicable type approval limits.

OBD

5. An assessment of the OBD system together with a tailpipe test is the most effective procedure for periodic inspection of exhaust emissions.
6. Of the vehicles tested within this programme, significant numbers of current cars with OBD did not comply with the applicable type approval limits.
7. There is an urgent need for improved uniformity in the interpretation of the OBD type approval requirements.
8. The lessons learnt on petrol OBD must be applied to diesel OBD to prevent the same mistakes being repeated.

Feasibility of a large scale data collection exercise

9. A large scale exercise to gather more data about the emission performance of vehicles in use should be undertaken to provide a better basis for decision making on future emission inspection policy options.

General

10. The type approval directives for noise and emissions should take more account of the needs of in-use enforcement, particularly the requirements of periodic inspection.

Annex 1 – List of reports and authors

Study 1

'Best Practice' Procedure for Petrol Vehicles,
reference CITA/2ERSP/Study1, June 2002.

Study 2

Motorcycle Exhaust Emissions and Noise,
D.AM.M.Elst, N.L.J.Gense, R.Rijkeboer,
reference TNO Report 02.OR.VM.044.1/DE of 23 July 2002.

Study 3

- (a) *Use of OBD at Periodic Inspection, Interim Report of Test Phase,* reference CITA/2ERSP/Study3(interim), June 2002.
- (b) *Estimation of Costs and Benefits of Inspecting OBD Systems,*
E.Cornelis, L.De Nocker, L.Int Panis, I.De Vlieger,
reference VITO/IMS/R/...

Study 4

Influence of catalyst Temperature on Effectiveness of In-service Testing,
E.A.Feest, D.C.W.Buckley,
reference E&E/DDSE/02/022 Issue 1, October 2001.

Study 5

Feasibility Study for a Large Scale Data Gathering Exercise of the Emissions Produced by Vehicle In-use,
Z. Samaras, G.Mellios
reference LAT report 0210, 22 July 2002.