COMMISSION OF THE EUROPEAN COMMUNITIES

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Proposal for a

EUROPEAN PARLIAMENT AND COUNCIL DIRECTIVE

on the approximation of the laws of the Member States relating to the measures to be taken against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery

(presented by the Commission)

SUMMARY

of the Proposal for a Directive of the Council and the European Parliament on the approximation of the laws of the Member States relating to the measures to be taken against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery

A. Content

The proposal concerns the establishment of an approval process for engines installed in non-road mobile machinery e.g. excavators, fork lift trucks, or motor graders. The approval criteria are based upon the emissions of atmospheric pollutants such as particulate matters, oxides of nitrogen, hydrocarbons, and carbonmonoxide. As emission standards for "on-road" vehicles becoming increasingly severe the relative contribution from non-road vehicles is rising. It is therefore cost effective in terms of tonne of pollution abated to address this hitherto uncontrolled source.

The proposal foresees progressively more rigorous emission standards to be introduced in two stages; Stage 1 being from June 1997 to December 1998 and Stage 2 being phased in between January 2001 and December 2003. This relatively long phasing-in of the emission standards will allow the industry the necessary time to adjust to the new regulations.

The approval procedures which are foreseen are based on those which currently exist under EU legislation for "on-road" vehicles and engines. However, the proposed administrative approval procedures have been reduced by the introduction of a self-certification by manufacturers in respect of the production meeting the required deadlines, and by a type-approval scheme, that allows the formation of engine families. Administrative control is limited to the evaluation of the manufacturers' reports, spot checks of the conformity of production, and the numbering of the engines.

Given the compliance of all engines concerned, for Stage II it is estimated that emissions from non-road vehicles will be reduced by up to 67% for particulate matters, 29% for hydrocarbons and 42% for oxides of nitrogen.

B. Requested Decision

In accordance with the 5th Environmental Action Programme[1] in particular the control of emissions of nitrogen dioxide, particulate matters, and with regard to the prevention of tropospheric ozone formation, the emissions of the ozone precursors nitrogenoxides and hydrocarbons must be reduced. The environmental damage caused by acidification also requires reductions inter alia of the emission of nitrogenoxides and hydrocarbons. The proposed Directive appears to be an appropriate means complying with these requirements.

The Commission is requested:

- to approve the proposal of the Directive;
- to present the proposal to the Council, the European Parliament and the Economic and Social Committee.

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(1) **Council Resolution of 1 February 1993, OJC 138, 17.05.1993, p.1**

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E X P L A N A T O R Y   M E M O R A N D U M

CONCERNING THE PROPOSAL

FOR A PARLIAMENT AND COUNCIL DIRECTIVE

RELATED TO

THE MEASURES TO BE TAKEN AGAINST THE EMISSION

OF GASEOUS AND PARTICULATE POLLUTANTS FROM

INTERNAL COMBUSTION ENGINES TO BE INSTALLED IN

NON-ROAD MOBILE MACHINERY

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EXPLANATORY MEMORANDUM

1. *Introduction*

Road traffic has long been recognized as major source of certain atmospheric pollutants e.g. nitrogen oxides (NOx), sulphur dioxides (SO_2), hydrocarbons (HC) and particulate matters (PT). Recent investigations carried out for the Commission demonstrate quite clearly that emissions from mobile machinery operating mostly off-road are also significant.

The Commission therefore considers it appropriate as part of its overall strategy to reduce emissions of certain atmospheric pollutants, to introduce cost effective measures to reduce emissions from non-road mobile machinery.

The present proposal concerns inter alia the establishment of emission standards and type-approval procedures for certain categories of engines for mobile machinery used off-road but excluding agricultural and forestry tractors. For regulatory purposes these latter types of vehicles are assimilated to road vehicles and as such fall within the scope of existing EU legislation.

While specific emission standards for agricultural and forestry tractors have not yet been established it is the Commissions intention to put forward such a proposal in a parallel initiative to the present text.

2. ***What are the objectives of the action envisaged in connection with the obligations which the Community has?***

2.1 Reference to the Fifth Action Programme

Sustainable development, the major theme of the Fifth Action Programme, requires the definition and implementation of a policy for continued economic and social development without detriment to the environment and natural resources, on which the quality of continued human activity and further development depend. Industry and transport are among the five target sectors listed in the Community's Fifth Action Programme[1]; and one of the three pillars on which action should be based is Community-standards.

The engines which will be subject to regulation are used mainly in machinery applications for industrial activities including specific transport processes. Within this framework, the proposed Directive aims at reducing emissions of carbon monoxide (CO), nitrogen oxides

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(1) OJ No C 138, 17.05.1993, p.1

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(NO_x), hydrocarbons (HC), and diesel particulates (PT) from non-road mobile machinery.

Hydrocarbons and nitrogen oxides belong to the group of target substances mentioned under the 'Themes and Targets of the Programme', sub-chapter 5.2, due to their contribution to the generation of photochemical oxidants and, as far as NOx is concerned, to acidification. In respect of emission reduction carbon monoxide is currently not specifically targeted in the 5th Programme, but it can be considered as an indicator for the efficient use of energy in combustion processes. It is a classical air pollutant affecting human health and it also acts indirectly as greenhouse gas. Diesel particulates and their associated compounds like some polycyclic aromatic hydrocarbons (PAH) are considered as mutagenic, and in some countries even as potentially carcinogenic, although conclusive evidence is still lacking. CO and PAH are mentioned in the recently proposed Directive on air quality as target substances COM(94)109 [1] for which ambient air quality objectives shall be proposed as soon as possible and not later than 31.12.1999.

2.2 Scientific basis

Despite recent improvements in relation to certain atmospheric pollutants such as sulphur dioxide, ambient air quality in Europe continues to give rise to concern. In many cities and regions threshold values for specific pollutants continue to be exceeded while in other localities the margin of security between measured and threshold values continues to be eroded. Furthermore, recent scientific evidence is tending to lead to a downward revision of threshold values. In this context the continued abatement of atmospheric pollutants is an urgent objective.

Nitrogen oxides are harmful to human health. The guide value laid down in Directive 85/203 [2] on air quality standards for nitrogen dioxide is breached frequently, the limit value laid down in the same Directive is breached in some cases. WHO estimates that about 8% of the European population is exposed to levels above its guideline value of 150 $\mu g/m^3$ in 24 hours/day. All these excesses occur in urban areas. Emissions of nitrogen oxides contribute to the acidification of the environment. Currently critical loads defined to protect ecosystems are breached in large areas of the European Union.

Nitrogen oxides and hydrocarbons undergo chemical reactions in the atmosphere within relatively short time intervals, which cause a number of indirect effects, in particular, due to the formation of

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(1) OJ No C 216, 06.08.1994, p.4

(2) OJ No L 87, 27.03.1985, p.1

[redacted]

photochemical oxidants and their main constituent, ozone (O_3). Ozone in elevated air concentrations can impair human health and can damage forests, vegetation and crops, reducing the latter's yield. Ozone is also a potent greenhouse gas. Ozone formation occurs in episodes at local, as well at regional level. In such episodes, precursors and photochemical oxidants transported over long distances are involved.

In this respect, it should be recalled that the ozone thresholds laid down in Annex I of the Council Directive 92/72/EEC[3] on air pollution by ozone are frequently exceeded within the European Community. The Directive entered into force in March 1994. Accordingly during the Summer of 1994 for only the months of June and July, from Member States, approximately 3500 exceedances of the "Information to the Public Threshold (180 $\mu g/m^3$)" were registered.

A summary of the human health and environmental effects of NOx (or nitrogen), O_3, and HC, is given in the table below:

Critical Threshold	**Receptor**	**Effect**
Critical Loads:		
acidity N	forest soils, surface waters	acidification
nutrient N	forest soils, surface waters	eutrophication
Critical Levels:		
[NO_2]	crops, forests, materials	direct effects
[NO_2], [O_3]	human health	direct effects
[O_3]	crops, forests,	direct effects
Critical Photochemical Precursor Levels:		
[NOx], [HC]	crops, forests, human health	Leads to excess of critical [O_3] levels

Diesel particulates and many compounds associated with their emissions are harmful or mutagenic. Exposure to these pollutants occurs mainly in certain urban areas. Some of the PAH associated with diesel particulates fall under the group of persistent organic compounds which are target substances for European-wide emission reduction measures under the UN-ECE Convention on Long-Range

(3) OJ No L 297, 13.10.1992, p.1

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Carbon monoxide is directly harmful to human health. It combines with the haemoglobin in human blood thereby reducing the amount of oxygen available to the cells.

Since all these pollutants are transported across international boundaries, affecting the quality of the environment in neighbouring States, coordinated international action is necessary. To reduce the transboundary fluxes is a long term goal which requires, inter alia, significant reductions of the emissions within the Union.

2.3 Environmental objectives to be achieved

The proposed Directive forms a part of the implementation of the Fifth Action Programme. It also forms a part of a strategy for an overall reduction of emissions of volatile organic compound and nitrogen oxides in the European Union. The political drive by the Commission in this area stems from the Community's accession to the UN-ECE protocol on NOx reduction and the proposed accession to the protocol on VOC reduction. In this light the Commission committed itself in March 1991 at the 1477th Environmental Council meeting, to continue examining the question of pollution from diesel engines in agriculture, forestry and industry. An additional impetus was given when the Commission in June 1993 was asked by a Memorandum of four Member States (Denmark, Germany, The Netherlands and The United Kingdom) to proceed with the preparation of the present Directive.

According to CORINAIR-figures, the 1990 man-made emission of CO, NOx, and non-methane HCs in the Union are estimated to be as follows:

NOx	13,000 kilotons
HC	13,000 kilotons
CO	48,000 kilotons

Union-wide figures for anthropogenic particulate emissions are not available.

The contribution to these man-made emissions from the total sector 'non-road vehicles and machinery', which covers both gasoline and compression ignition (C.I.) internal combustion engines used in agriculture, forestry, industry, households, or on trains and non-seagoing ships, is as follows:

NOx	15%
HC	9%
CO	10%

For reasons explained in section 1 the proposed Directive does not cover agricultural or forestry tractors. Furthermore, the proposal is directed at C.I. engines (e.g. diesel) for non-road mobile machinery only. This is because total NOx and particulate (PT) emissions from machinery powered by diesel engines are

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machinery powered by diesel engines are significantly higher than those from machinery powered by gasoline engines (in terms of total fuel consumption of all engines the ratio diesel/gasoline amounts approximately to 10 : 1). Thus the potential for effectively reducing emissions is higher by regulating diesel engines. In respect of NOx and PT it should be mentioned that these are classic emissions from diesel engines. However, it is not to be excluded that at a future date the scope of the Directive may be extended to include gasoline engines in particular in respect of HC and CO emissions. With regard to this aspect studies still have to be carried out relating to the possible emission performance of these engines. Therefore they are not subject to regulation in the present proposal.

Taking into account the above precision regarding the scope, the present proposal covers non-road machinery engines the emissions from which account for the following percentages of total anthropogenic emissions of the various pollutants:

NOx	7%
HC	1%
CO	0.5%

While these amounts do not seem to be so significant but it must be kept in mind that e.g. this 7% NOx represents a quantity which is as high as nearly **37%** of all diesel engine emissions from road traffic sources [1990 EU Road Traffic Emissions of NOx from Diesel Engines: 2300 kt; Total of all sectors covered by the proposed Directive: 855 kt] ([4]). A ratio of similar significance (**33%**) can be stated for PT emissions [1990 Road Traffic: 300 kt; Total of all sectors covered by the proposed Directive: 100 kt][4]. Thus the effectiveness of the proposed Directive will be high in respect of the latter two pollutants. Mostly for reasons of consistency with already existing legislation on mobile sources a threshold has been imposed also for HC and CO emissions. With regard to these pollutants the effectiveness will be modest as state of the art diesel engines show already a good emission performance and the emitted total amount therefore is rather low. On the other hand these requirements will in individual cases prevent the possible use of design which unnecessarily exceeds the given framework of modern technology.

As these non-road mobile machinery engines until now have not been subject to any emission requirement the potential for cost effective improvement appears to be higher than that of road vehicle engines. The latter will be subject to a third stage of requirements after the year 1999. The technology needed for this step will be more sophisticated and therefore more expensive than that to be used for the adaptation of the "non-road engines" to their "Stage II" of

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(4) "The Estimation of the Emissions of 'Other Mobile Sources and Machinery' Subparts - 'Off-Road Vehicles and Machines', 'Railways', and 'Inland Waterways' in the European Union. (Final Report September 1994, prepared for the European Commission, Andrias/Samaras/Zierock).

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onwards.

Given the compliance of all engines concerned the measures proposed are estimated to reduce emissions from the sectors covered by this proposal by approximately:

	Stage I	*Stage II*		**corresponds to**
NOx	**23%**	**42%**	**=**	**-197/360 [kt]**
HC	**11%**	**29%**	**=**	**-13/34 [kt]**
PT	**27%**	**67%**	**=**	**-26/65 [kt]**

as compared with the uncontrolled case. Excepting specific situations, CO-emissions will not be reduced because they are already now at a very low level. Therefore, the limits set in the Directive mainly aim at officially standardising this level.

3 *Does the action envisaged fall within the exclusive competence of the Community or is it a competence shared with Member States?*

3.1 *Choice and justification of the legal basis*

The legal basis of the proposed Directive is article 100A of the EEC Treaty for the following reasons:

- the introduction of technical standards concerning the emission performance of non-road mobile machinery engines will have a profund effect upon the functioning of the market. To ensure harmonizedmarket conditions and to avoid the creation of technical barriers to trade it is essential that community provisions are based upon Article 100 A of the Treaty;

- the engines concerned are produced in large numbers and are sold to different machine manufacturers in different countries; thus the harmonization of the requirements for emission performance is the most appropriate means to achieve the targeted environmental goal; this is particularly true as the necessary measures to ensure compliance are costly; as the engines concerned have been recently identified as a considerable source of air pollution, a lack of Community legislation would provoke individual legislation, which thus would cause a cost multiplication for production in compliance with different requirements within the internal market;

- to provide a fair perspective in respect of industrial competition also the time-scale for the application of the requirements will be provided to ensure consistency within the internal market;

- comparable current legislation on similar products is also based on Article 100a, such as the Directives relating to measures to be taken against the emission of gaseous and particulate

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pollutants from diesel engines for use in vehicles (88/77 and 91/542).

Therefore the Community has exclusive competence for this area.

4 Is a uniform regulation necessary or would a directive giving general objectives be sufficient in the case that the execution would be done by Member States and what modalities for action are at the disposal of the Community?

4.1 Justification of the instrument chosen

A Directive has been chosen as the most appropriate method of achieving the necessary harmonisation. It will enable a broad legislative framework to be established at Community level with flexibility left to the Member States in the implementation of the measures, for example, to take account of local conditions. This is particularly true as the proposed Directive foresees flexibility for Member States in respect of measures for registration and control.

4.2 Justification of the specification

The proposal follows similar principles to those laid down in other Directives that deal with emission abatement from mobile sources, namely road vehicles and engines for road vehicles (70/220/EEC, 88/77/EEC). This allows the inclusion of a reference which avoids double testing and certification of engines which are appropriate also for non-road applications.

For the case where there is only a general objective, further orientation would have to be sought from appropriate national and international standards. This would cause the use of a wide-branched pattern of procedures and requirements including diverse options for the applicants. In general there is no motivation for the manufacturers of such engines for product liability reasons to develop products which are as clean as possible. They must not fear environmental accidents which occur during usage of their products which could cause considerable cost implications, as for example in the case of the proof of neglected security standards. Currently it is not possible to produce evidence of environmental damage caused by one specific engine type as there are thousands and thousands of other mobile sources. Thus for cost and competitiveness reasons only the weakest standard options would be taken for the certification of the compliance with the general objective.

It is therefore appropriate that a clear system of refusal or acceptance is established for the certification of the engines in respect of their emission performance to enable a high level of protection for man and the environment to be realised.

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5 Costs, benefits and effectiveness

5.1 Advantages and costs of the proposal

It is estimated that e.g. a 30% reduction of ozone precursors (NOx, HC) would result - in and around industrial and populated regions over areas of 100 x 100 km up to 1000 x 1000 km - in a reduction of about 15% of ozone peak concentrations[5], which would have beneficial consequences on human health and the environment. The reduction of NOx emissions will reduce the stress put on the environment due to acidification. Moreover, the reduction of emissions of noxious substances, like NO2, CO and diesel particulates(PT), will contribute to the improvement of public health.

The total annual costs for technically up-grading the engines are estimated to be in the range of 31 million ECU for Stage I and 125 million ECU for Stage II. This would result in an increase in selling prices of about 1% to 3% for Stage I and 3% to 8% for Stage II [4]. Finally, the average quotient of estimated costs for technical improvement of the engines to comply with the proposed requirements, and of the estimated amount of the sum of pollutants abated (NOx,PT and HC), has been calculated to be around 1400 ECU/t for stage I, and 2600 ECU/t for stage II. These figures are within the ranges already known from other emission reduction measures taken for mobile and stationary sources[4].

In respect of necessary investments in the production-line it is estimated that these are marginal for the following reasons:

Stage I would come into force between 07/1997 and 01/1999, and compliance would only necessitate the non-usage of obsolete engine technology, i.e. some engine types would have to be replaced by new models. These changes could in any case have been pending due to competition forces. Stage II would come into force between 01/2001 and 01/2004, thus allowing industry time to plan the coinciding of application dates for new emission performance with pending engine model changes. Thus additional costs only would arise if in single cases the investment had to be made earlier than foreseen by the original depreciation calculation. And even then the investment does not appear to be excessive. Most of the technical changes can be made by adaptation of existing tools and the integration of more sophisticated components (e.g. turbochargers, injection pumps, injection nozzles) which are available on the market.

In addition to these costs, those necessary for additional research and development work and for related facilities must also be taken into account.
All in all, these additional costs will differ from manufacturer to

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(5) Evaluation of the POCP-concept on a European scale (POCP= Photochemical Ozone Creation Potential). TNO-report April 1993.

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manufacturer depending on the infrastructure which he already has available.

For example if a manufacturer is used to produce engines for "on-road" purposes, then emission measurement hardware, know-how and operational facilities for the preparation of certification applications, are already there. Another manufacturer, not yet experienced with emission type-approval may be required to invest some capital in measuring facilities and in some additional personnel costs.

Given that it is not possible to distinguish these costs between the different manufacturers concerned and clearly attribute them to the proposed Directive, and that additional employment also has beneficial aspects, these additional costs were not included in the evaluation.

6 *Subsidiarity*

6.1 Need

Since the engines coming within the scope of the regulation are products for which free trade within the Union needs to be guaranteed, Union-wide action needs to be taken in order to avoid any distortions of the market. Therefore, the proposed Directive is fully in line with the principle of subsidiarity.

6.2 Proportionality

The principle of proportionality has been taken into account as the reduction of emissions achieved will be significant, and as the potential price increase due to additional emission performance required will be very small; given that the additional costs in respect of the improved engine design are in general in the range of a few per cent([4]) of the price of an engine. As the production costs for engines in general increase according to the increase in power output, the proposed progressive strengthening of the emission limit values related to the power output of engines also result in a relatively similar increase in costs per engine.

Taking into account that the costs for the engines in general are only a small fraction of the total costs of the final machinery, the impact of the additional investment on the prices of the completed machines is estimated to be marginal. Therefore, it is expected that the proposal as such will not have any negative, but will rather have additional positive repercussions on the generation of new businesses in the sectors concerned.

Although it is already obvious by the small percentage calculated for the price increase of the engines concerned given the total cost figures above, the significance of the market sector should be mentioned separately. The total amount of the retail prices of the engines currently estimated to operate within the EU which will be covered by the proposed Directive can be calculated to be

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$1,84 \times 10^{10}$ ECU. Given the average engine lifetime of 9.3 years per engine the yearly value of the market amounts to:

1978 MECU (1,978,000,000 ECU)

The certification charges to be paid for the local administration may be different between the Member States. In any case this payment will raise the funds necessary for additional manpower. In comparison with total costs this is only a marginal contribution.

7 *Results of consultations with affected partners*

In 1993 consultation began in the form of expert meetings with Member States Representatives and Industry Associations, using a discussion paper (draft proposal) presented from the Commission and distributed to all parties concerned. In total, three formal meetings were convened by the Commission. In addition, many informal meetings with industrial associations have been arranged in order to exchange views on the proposal.

The proposal has evolved during the course of these discussions. The major changes that have been made include: greater clarification of the scope of the Directive and extension of the application to smaller engines, including the addition of a number of exemptions, introduction of a sales time limit as an additional control parameter, more detailed definition of the emission limit values for individual power classes, details concerning the definition of test procedures and the marking of the engines.

In general a favourable response by the Experts of the Member States to the draft proposal as developed by thé Commission has been noted.

The Industry Representatives from EUROMOT, CEMA and CECE expressed concerns mainly with regard to:

- the burden of the foreseen administrative procedures,
- too stringent limit values,
- too strict time scale.

According to the discussions far reaching changes of the original draft have been integrated in respect of the marking requirements for the certified engines and exemptions for the use of end-of-series engines after enforcement of the standards.

As far as possible the positions of the Industry Associations have also been taken into account with regard to the administrative procedures laid down, the proposed limit values of stage II and the timetable for the implementation. With regard to the emission standards which are proposed, certain assumptions have been made concerning the technical performance of diesel engines. While certain of these assumptions have been challenged by some industry representatives as being overly optimistic, the industry organizations were unwilling for reasons of confidentiality to

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satisfactorily substantiate their position through the use of technical data.

Additional data inputted by the Swedish Environmental Protection Agency, from industry sales literature, and general literature, in addition the available data from officially certified on-road engines, have been taken into account for the preparation of a sound evaluation document[6]. The conclusion shows that:

- the proposed requirements which reflect a balance based on the comments received by the government representatives, are more lenient than the emission limits which have to be met by **on**-road diesel engines from 1996 onwards;

- the technology necessary for compliance is available and does not need to be invented.

Also the time frame foreseen up to the year 2003/2005 for total application should leave sufficient margin for the preparation.

These conditions will compensate for the disadvantages which non-road mobile machinery engines are subject to in their applications.

With regard to the criticized administrative burden, it should be noted that almost all of the procedures foreseen are in harmony with the pattern in force for the type approval of on-road engines defined in Directive 88/77/EEC[7], as last amended by Directive 91/542/EEC[8], in conjunction with Directive 70/156/EEC[9], as last amended by Directive 93/81/EEC[10]. The industry affected by these Directives in force meets the administrative requirements without any difficulties. Thus the concerns expressed may have their source mostly with those companies whose products have not yet been subject to any type approval.

8 Description of the legislative situation in Member States (and OECD)

For the non-road mobile machinery engines covered by the proposed Directive, there are currently no emission limitations in force in any Member State. In Italy, the requirements on smoke emissions for agricultural tractors are also applied to completed non-road mobile machinery. Thus the engine manufacturers are in this case only indirectly affected.

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(6) Emission Limits of Non-Road Mobile Machinery Engines, G.Cornetti 31/08/1994

(7) OJ No L 36, 09.02.1988, p.33

(8) OJ No L 295, 25.10.1991, p.1

(9) OJ No L 42, 23.02.1970, p.1.

(10) OJ No L 264, 23.10.1993, p.49

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In June 1994, the United States of America published a new rule[11] which, to a large extent, covers the same sector of application as this proposed Directive. The title of the US rule is:

"Determination of Significance for Nonroad Sources and Emission Standards for New Nonroad Compression-Ignition Engines at or above 37 kW".

As a result of cooperation between the Commission services and the US Environmental Protection Agency (EPA) during the preparation of both the new US Rule and the proposed Directive, the emission standards foreseen in the US and in the present proposal are now largely compatible. This became possible after an agreement was made in several areas, including the formula for the definition of the engine power output.

Thus, with regard to the requirements of Stage I, an extensive alignment of the requirements in terms of measuring procedures and limit values has been realized. Both the European and the US industry have confirmed that this compatibility of emission legislation on mobile sources covering this worldwide market is very important. With regard to a Stage II, in contrast with this proposal, the US are now not ready to correspondingly introduce a next phase into their rule. However, the US has begun the Stage II development program and have an air quality need for a rapid implementation. The Commission will continue to strive for co-ordination with the US with regard to future amendments of both EC and US legislation.

In parallel, this Proposal is in line with an UN/ECE Draft Regulation on emissions from agricultural tractors, which was recently proposed for adoption under the framework of the UN/ECE "1958 Agreement". This regulatory document covers some of the same kind of engines as this Directive Proposal, and is based on the same test procedure and has the same limit values but does not provide as yet for a Stage II requirement.

9 *Explanation of the provisions of the proposal*

9.1 The Scope of the Directive (Article 1)

The scope of the proposal has been designed to fill a gap in emission legislation. As declared in paragraph 1.3, a considerable amount of NOx- and particulate emissions is produced by those sources which have as yet not been regulated. The proposed measures will not eliminate the negative environmental impacts, but will provide for a distinct improvement.

The proposal does apply to those sources which have been determined to be the most important polluters in respect of the noxious substances mentioned above, by a study[4] prepared for the

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(11) US EPA, 40 CFR Parts 9 and 89

[redacted]

Commission.

The structure of the proposal has been designed for an easy extension of the scope with regard to sources which have been determined to be significant contributors of other pollutants. As, in advance of such an extension additional measurements and investigations have to be carried out, this cannot be included now but must be integrated by a future amendment. Correspondingly this intention has been indicated in the last recital of the introductory considerations.

9.2 Definitions (Article 2)

The definitions of the various terms are aligned as closely as possible to the current definitions used for EC legislation[6] [7] [8] [9] concerning type approval of road vehicles, components or separate technical units.

9.3 Application for type-approval (Article 3)

This Article unifies the form of the application to be sent to the type-approval authority of the Member State chosen by the applicant for the final certification. As there is a need in certain cases for the type-approval authorities of the different Member States to inform each other even about technical details of the certifications, this exchange of information is most effective if the same scheme and structure of the documents is maintained by all parties concerned.

For specific technical reasons the selection scheme, laid down in Annex I of the proposal, for the determination of the parent engine which can be tested as being representative for several other similar engine types, could, in special cases, be insufficiently comprehensive. These technical reasons could be interactions of the parameters used for the determination, or influences of other variable features not yet known. In respect of the aforementioned the applicant has certain possibilities to influence the determination of the parent engine to be tested. To insure a serious determination of worst cases, this Article provides convenient control instruments to the authorities. This control can be done either by carrying out tests of alternative parent engines, or of an additional engine of the family, on the basis of spot checks. It is important to retain these decisions at the level of the type-approval authorities and not to delegate them to the technical services. They would be forced by competition to decide mostly in the interest of the applying manufacturers.

In order to avoid a possible abuse of the system by some applicants playing on different interpretations by type-approval authorities of different Member States, and as a result causing distortions to the whole approval system: It is necessary to restrict the application per certification to only one unique type-approval authority.

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9.4 The type-approval process (Article 4)

Most of the described organization scheme coincides in a general sense with that used for current EC legislation as mentioned above. Additionally the informing of the Commission with type-approval data at regular intervals has been insured by integrating a corresponding commitment for the national type-approval authorities. This will guide evaluations of the state of the art of technology, and future measures for improving the environment.

The reference to the Annexes which are given as a model outlining the necessary data and documents to be compiled, will ensure equitable requirements independent from the place where the application is made, and will facilitate the exchange of information between the different type-approval authorities, in addition ensuring that all information will be gathered and documented for the indubitable determination of:

- the engine manufacturer(s);
- the type(s) of the engines covered by the certificate;
- use restrictions;
- the technical service(s) involved;
- and the emission performance.

Additionally the national type-approval authorities have been committed to cooperate in respect of information exchange which may be necessary for administrative and control reasons.

9.5 Amendments to approvals (Article 5)

Hereby the Member States are committed to provide a proper maintenance of the certifications in respect of possible changes which could appear to become necessary. In order to provide consistency in the documentation it is indispensable that applications for amendments or extensions to a type-approval must in all cases be addressed to the authority of that Member State which granted the original approval.

9.6 Declaration of conformity (Article 6)

The marking of the engine according to the described requirements clarifies the manufacturer's confirmation for compliance with the corresponding type-approval certificate. If the engines are subject to particular restrictions in their use, the single information document, e.g. provided for one single manufacturer of machinery for a series of engines to be delivered, must list the relevant engine identification numbers. This must be so in order to avoid information failures due to possible amendments of type-approvals which could be applicable for different engines of the same type but with different production dates.

The provisions of the proposed Directive surrender the compliance control of the engines at the relevant production dates to the

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manufacturers. The responsible type-approval authority is committed to monitor the proper implementation but only indirect control measures are available. An official registration of single units after sale or at entry into use, has not been foreseen. Thus it seems to be necessary that the manufacturers provide the authorities regularly with detailed information regarding types and identification numbers of engines produced in compliance with the type-approval certificate(s) granted. This is of particular importance if the manufacturer would later claim for exemptions for end-of-series engines according to Article 11. This would allow the sale of engine types after the sales time limit. In this case evidence must be available, e.g. that the numbers of engines notified for the exemption procedure have been produced before the relevant application date 2 years earlier, or that the numbers of the exempted engines must not exceed a certain percentage of the numbers of the same engine type sold or used during the entire previous year. The verification and control of these conditions would be very difficult if the responsible authority was not regularly provided with the statistical data in accordance with this Article.

Also these data seem to be indispensable for indirect control measures with regard to compliance of the non-exempted products from application dates onwards where requirements may have changed. For example verification of that engines which are in compliance with an obsolete stage of legislation and which are found by the authority during a "Conformity of Production Assessment" according to Article 12 in context with Article 8(3), had been produced before the relevant application date. On the other hand a control should also be possible on such occasions if engines reported as produced before the relevant application date really have been produced. Where the authority concerned will prepare and carry out these controls by use of the data regularly received according to the provisions of this Article, the applicants' possibilities for concealing possible infringements would be much less than in the case of information received only on particular request close to, or even not until, the date of the assessment.

In the current era of modern electronic data processing it is understood that gathering, maintaining and regular reporting of the relevant data should not be an administrative and bureaucratic burden on the Industry.

However, the responsible authority may of its own discretion use other measures such as only occasional disclosure of Industry data bases at "Conformity of Production Assessments", provided that they thus can ensure the same level of effective control. This would spare Industry from regular reporting but would require the obligatory maintenance and availability of the industry data bases for the expected lifetime of the engines, i.e. 30 years. Additional provisions should be included in such an alternative control scheme which would ensure availability of information also in cases where single manufacturers cease to do business, perhaps even situated in third countries.

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The provisions laid down in paragraph four of the Article shall facilitate for the authority the preparation and the execution of "Conformity of Production Assessments". The required declaration of intent does not obligate the manufacturers to observe it later in all details, but the degree of compliance, verified during assessments by the authority, could influence the planning of the sequence of future assessments.

9.7 Acceptance of equivalent approvals (Article 7)

Current investigations which have been carried out in respect of evaluation of the level of emission performance required for type-approval of non-road engines, in comparison with on-road diesel engine performance, have shown that these levels in some cases are of similar severity, but in most other cases for on-road type-approval even more stringent limits must be met. Thus without causing negative environmental impacts, but maybe in special cases providing some simplification for Industry, it is proposed to accept type-approvals according to 88/77/EEC as last amended, as being equivalent to this proposed Directive. Related to the former Directive, the Council already has confirmed the equivalence of the corresponding UN/ECE Regulation listed in Annex 1. Therefore also this Regulation is proposed to be accepted as equivalent.

9.8 Registration and sale (Article 8)

Hereby it is ensured that engines which are covered by the scope of the proposed Directive and which are correspondingly approved in respect of their emission performance must be permitted to be sold and used in the Member States. Additionally it is stipulated that these engines must not be subject to any other national emission requirement.

The Member States are committed to maintain the necessary control measures; and the manufacturers to provide all information needed also with regard to purchasers of the engines. Where engines were delivered to middlemen belonging to the distribution system of the manufacturer also the middlemen are committed to report on demand. This shall enable the authority to verify on a spot check basis the control of engines notified as really having been produced.

If manufacturer as holder of a type-approval certificate do not comply with their obligations, the authority is entitled to withdraw the corresponding approval. This may increase the motivation for utmost compliance with the requirements.

9.9 Application dates (Article 9)

This Article sets four different kinds of application dates. The first regulates the obligation for Member States to recognize and accept applications, and to grant EC type-approvals.

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The second sets a threshold from which onwards prospective national emission type approval must be replaced. Non-compliance with additional national requirements in respect of emission performance are no longer permissible to be used as justification for the refusal of a national type approval of a completed machine. More stringent requirements which have to be met for the granting of particular national or EC certificates, e.g. for the use of engines in closed rooms or mines explicitly, shall not be affected by the provisions of this Directive proposal.

The third introduces a second more stringent step (Stage II) in respect of the performance level at type approval. The other conditions remain unchanged.

The fourth corresponds to a limitation of sales and use of new engines in non-compliance with the requirements that applied earlier for the type approval. The date of limitation is related to the production date of the engine, e.g. engines produced in the past before the built date limit, benefit from a two years later deadline.

Although this Directive proposal in general is addressed to engines only, within this Article reference has been made also to the mobile machinery within which these engines are foreseen to be used. By this means the engine manufacturers in some Member States would be protected from being indirectly concerned by additional emission (smoke) requirements which are addressed to the completed machinery. Current requirements on smoke performance which apply to agricultural tractors and on-road vehicles are obsolete. Given its obligatory application to non-road engines, this would only increase the administrative burden on Industry, but would not be beneficial for the environment. By means of this Directive proposal ambitious particulate emission values will be placed which will provide for sufficient smoke performance.

Once corresponding reviews of the current smoke legislation have been completed, it may be worthwhile to integrate this scheme also into non-road mobile machinery legislation. This then could be useful in context with a future provision for in-use performance control.

The different application dates addressed to the obligatory type-approval of Stage I and II and to the sale/use of new engines have been staggered in relation to different ranges of power output of these engines (powerbands). For Stage I three powerbands are covered. With Stage II an additional powerband has been integrated. The complication resulting in the need to introduce staggering is caused by the state of the art of technology. For bigger engines with high power output sophisticated technical solutions, which have been developed for the already regulated on-road engines, can be easily adapted. Therefore the implementation of emission requirements is possible at an earlier stage for bigger engines than for engines within a lower power band. For those of the up-to-now unregulated engines more lead time is necessary for the adaptation.

This approach is fully in alignment with the provisions laid down in the parallel legislation (USA)/Draft legislation (UN/ECE), which was previously mentioned at point 8 and therefore contributes to the up-to-now unique worldwide harmonization.

9.10 Economic instruments (Article 10)

In order to encourage the early introduction of advanced emission technology, it is proposed that Member States be allowed to use economic instruments such as granting tax incentives. However, a balance has to be achieved between, on the one hand, the desire to introduce the new, less polluting technologies as soon as possible, and, on the other, the necessity to avoid the fragmentation of the market due to the introduction of a diversity of different fiscal incentives. In order to achieve this equilibrium fiscal incentives could only be considered as condition that they are:

- non-discriminatory;
- limited in time;
- of a value less than the additional cost of the advanced technology; and
- applied to engines able to satisfy future European standards, agreed by the Council and the Parliament, ahead of time (i.e. before the standards become mandatory).

Finally, it should be noted that Member States are required to inform the Commission of any plans to introduce tax incentives in sufficient time to enable the Commission to submit comments.

9.11 Exemptions and alternative procedures (Article 11)

The exemption for engines used only by the armed forces has been made in alignment with other Community Legislation dealing with on-road engines and vehicles. It is understandable that for such specific cases the particular performance required from an engine can not be subordinated to environmental targets. Fortunately these engines currently do not operate very frequently and therefore their contribution to the total amount of emissions is estimated to be negligible[4].

The normal rule of business is that excess stocking of engines should be avoided, as it represents dead capital. However, given extraordinary technical or economic reasons, it may happen that production for stocking is used to bridge gaps before critical decisions e.g. redundancies, cessation of business, are taken. If then at the same time the requirements on emission performance of the engine change due to the passing of a deadline, this may justify the granting of exemptions from the obligations normally foreseen.

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To avoid abuse of this possibility for derogation which could otherwise cause distortion of competition, the granting of, and the application for, exemptions require some conditional criteria and must be proceeded according to certain control parameters as follows:

Conditional Criteria	**Control Parameter**	**Justification of control measures**
Emergency situation	Application before entry into force of the time limit	Possibility for the Authority to verify the reasons for, and the existence of, the engines in stock within the EC
Engines concerned were produced before the time limit	List as defined in Article 6(3) of those engines still in stock; Application <u>only</u> to original type-approval Authority	Possibility for the Authority to verify the engines as being produced according to the time limit; Avoidance of complicated control conditions due to necessary exchange of data
Engines concerned must have been already stored within the EC	Application as above	Evidence for planning of sales within EC
Restriction to 10% of the same type of engine sold one year previously	List as defined in Article 6(3) in context with the declaration of the previous year	Coherence with existing EC-legislation([9]), ([10]) related to "on-road" vehicles/engines
Informing of the Authorities of the other Member States and of the Commission	Notification	Avoidance of distortion of the internal market by means of transparency
Issuing of special certificate of conformity	n.a.	Evidence of granted exemptions necessary in the case of conformity controls

The scheme introduced for certification and sale normally allows the selling of engines produced according to a certain stage of requirements valid at the date of production. Once the deadline for the next stage has been reached, the production of engine types and families from this time on must be carried out according to the new

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requirements, but the sale of the "old stage engines" is still permitted during two additional years. This is the point at which the type-approval loses its validity. Thus it is considered to be sufficient that the exemption procedure as described above provides a sales limit which is prolonged for one further year. In summary this means that the stock should have been sold three years at the latest after cessation of production.

9.12 Conformity of production arrangements (Article 12)

Hereby the general prerequisite has been defined that type-approval certifications can only be granted to manufacturers that have provided sufficient arrangements for ensuring "Conformity of Production" (COP) of their products, once these engines were confirmed to be in compliance with the requirements by a type-approval procedure. Additionally a commitment is made that the responsible Member State in respect of the type-approval must continuously survey the arrangements in order that the COP procedures remain efficient.

9.13 Non-conformity with the approved type or family (Article 13)

This Article defines the failures to conform to the approved type, and the kinds of corrective actions to be taken in such cases by the responsible Member State. For transparency reasons also the approval Authorities of the other Member States shall be informed. In the case of obvious non-compliance of certain engines also non- responsible Member States may ask the responsible State for verification.

Also a co-operation procedure has been laid down which shall allow the settling of possible differences of opinion between Member States in respect of conformity of certified engines.

These procedures will on the one hand provide sufficient control possibilities for Member States even in the case that the certification has been released by an Authority of another Member State, and on the other hand the Member States will be encouraged to provide good laboratory practice for the tests which will be carried out on their own behalf. Thus mutual recognition of certifications will be ensured.

9.14 Notification of decisions and remedies available (Article 14)

Hereby, in accordance with parallel legislation, the procedure is described as to how in the case of negative decisions taken on the basis of this proposed Directive, must be notified to the parties concerned.

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9.15 Adaptation des annexes/Procédures du comité (article 15/16)

Conformément avec les procédures standards, il est prévu que la Commission, assistée par le Comité institué par la Directive 96/.../CE[1], soit habilitée à adopter les annexes de la présente directive au progrès technique. Ces déterminations sont compatibles avec celles prévues par la législation existante, par exemple les directives concernant la réception des véhicules à moteur. En outre, il est prévu que les valeurs limites d'émission ne peuvent être pas modifiées par ce comité mais qu'elles ne peuvent l'être que par une directive du Parlement et du Conseil.

In accordance with standard procedures it is foreseen that the Commission assisted by the Committee established under Directive 96/.../EC[2] will be empowered to adapt the Annexes of the present Directive to technical progress. These provisions are compatible with those foreseen by existing legislation, e.g. the Directives concerning type-approval of motor vehicles. Additionally the restriction has been laid down that changes of the required emission limit-values are exempted from the responsibility of this Committee, and thus can only be amended by a Parliament and Council Directive.

A. Approval Authorities and Technical Services (Article 17)

In order to provide tests according to the provisions of this proposed Directive which are carried out in compliance with the rules of good laboratory practice, reference is made to the rules laid down in the corresponding EC Directives dealing with type-approval and emissions from "on-road" engines([7]),([8]),([9]),([10]). Thus, if the type-approval Authority delegates tasks to be carried out on its behalf to Technical Services, these Services must have been notified to the Commission and they must satisfy the harmonized standards on the operation of testing laboratories (EN 45000).

B. Coming into force and Address (Articles 18, 19 and 20)

These Articles contain standard provisions.

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1 Proposition soumise par la Commission concernant l'évaluation et la gestion de la qualité de l'air ambiant - COM (94) 109 final, 94/0106 (SYN), JO C 216, 06.08.1994, p.4

2 Proposal submitted by the Commission on ambient air quality assessment and management-COM (94) 109 final, 94/0106(SYN), OJ No C 216, 06.08.1994, p.4

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C. Annexes I - X

Annex I: Gives a specification of the scope in detail, explains definitions and abbreviations, defines requirements on engine marking, emission performance (limit-) values, parameters for the demarcation of the parent engine of a family, and outlines in detail specifications for COP assessments.

Annex II: Outlines a form according to which the applicant should complete related to the engine(s) to be certified.

Annex III: Describes the test procedure which is to be used. It derives in its crucial provisions from the recently finalized draft ISO 8178 Standard.

Annex IV: Specifies the technical characteristics of the reference fuel to be used for approval tests, and to verify COP.

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[2] Proposal submitted by the Commission on ambient air quality assessment and management-COM (94) 109 final, 94/0106(SYN), OJ No C 216, 06.08.1994, p.4

Annex V: Specifies analytical and sampling systems.

Annex VI: Outlines a form according to that an EC Type-Approval Certificate should be issued by the responsible Authority

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THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 100a thereof,

Having regard to the proposal from the Commission[1],

Having regard to the Opinion of the Economic and Social Committee[2],

Acting in accordance with the procedure laid down in Article 189b of the Treaty,

Whereas measures should be adopted within the framework of the internal market; whereas the internal market comprises an area without internal frontiers in which the free movement of goods, persons, services and capital is ensured;

Whereas the 5th environmental action programme[3] recognizes as a fundamental principle that all persons should be effectively protected against recognized health risks from air pollution and that this requires in particular the control of emissions of nitrogen dioxide (NO_2), particulates (PT) - black smoke, and other pollutants such as carbon monoxide (CO); whereas with regard to the prevention of tropospheric ozone (O_3) formation and its associated health and environmental impact, the emissions of the precursors nitrogenoxides (NOx) and hydrocarbons (HC) must be reduced; whereas the environmental damage caused by acidification will also require reductions inter alia on the emission of NOx and HC;

Whereas the European Community signed the UN-ECE protocol on VOC reduction in April 1992 and adhered to the protocol on NOx reduction in December 1993 (accession), both of which are related to the 1979 Convention on Long-range Transboundary Air Pollution which was approved in July 1982; whereas the Commission committed itself in March 1991 at the 1477th Environmental Council meeting, to continue examining the question of pollution from diesel engines in agriculture, forestry and industry; whereas the Commission in June 1993 was asked by a Memorandum of four Member States to proceed with the preparation of this Directive;

Whereas the objective of reducing the level of pollutant emissions from non-road mobile machinery engines and the establishment and operation of the internal market for engines and machinery cannot be sufficiently achieved by individual Member States, and can therefore be better achieved by the

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(1) OJC ..., ..., p. ...

(2) OJC ..., ..., p. ...

(3) Council Resolution of 1 February 1993, OJC 138, 17.05.1993, p.1

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approximation of the laws of the Member States relating to measures to be taken against air pollution by engines to be installed in non-road mobile machinery;

Whereas Article 100a (3) of the Treaty inter alia requires a high level of protection for health and the environment;

Whereas legislation concerning the control of emissions from these engines is currently lacking both at the level of the Community and in most of the Member States;

Whereas recent investigations[(1)] undertaken by the Commission show that the emissions from non-road mobile machinery engines constitute a significant proportion of the total manmade emissions of certain noxious atmospheric pollutants; whereas the category of compression ignition engines which will be regulated by the current proposal is responsible for a considerable share of air pollution by NOx and PT, in particular when it is compared with that coming from the road transport sector;

Whereas a significant body of legislation exists at the level of the European Community governing emission requirements for road vehicles and for diesel engines of heavy road vehicles (e.g. Directive 88/77[(2)] as last amended by Directive 91/542[(3)] and Directive 70/220[(4)] as last amended by Directive 94/12[(5)]);

Whereas emissions from non-road mobile machinery operating on the ground equipped with compression ignition engines, and in particular the emissions of NOx and PT, constitute a primary cause of concern; whereas these sources should be regulated in the first instance, it is appropriate to retain the option to subsequently extend the scope of the Directive to include the control of emissions from other non-road mobile machinery engines and which are used in other appliances, e.g. equipped with gasoline engines;

Whereas every effort should be made to reduce input of these pollutants into the environment in the most cost effective way;

Whereas, in addition, the control of these emissions and the

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(1) Final Report September 1994, not published in the OJ

(2) OJL 36, 09.02.1988, p.33

(3) OJL 295, 25.10.1991, p.1

(4) OJ No L 76, 6.4.1970, p.1

(5) OJ No L 100, 19.4.1994, p. 42

[redacted]

establishment of emission standards for this source of atmospheric pollution, represents a cost-effective option when compared to the tightening of control for other sources of these pollutants;

Whereas the financial impact of the Directive is limited and the time table for the implementation of the more stringent requirements of Stage II is generous;

Whereas in respect of certification procedures the type approval approach has been taken which as a European method has stood the test of time for approvals of road vehicles and their components; whereas as a new element the approval of a parent engine on behalf of a group of engines (engine family) built using similar components according to similar construction principles, has been introduced;

Whereas the engines produced in compliance with the requirements will have to be accordingly marked and notified to the approval authorities; whereas in order to keep administrative burdens low no direct control by the authority of the engine production dates relevant for strengthened requirements has been foreseen; whereas this freedom for the manufacturers requires them to facilitate the preparation of spot checks by the authority and to make available relevant production planning information at regular intervals; whereas absolute compliance with notification made in accordance with this procedure is not obligatory but a high degree of compliance would facilitate the approval authorities' planning of assessments and contribute to a relationship of increased trust between manufacturers and type approval authorities;

Whereas approvals granted in accordance with Directive 88/77/EEC as last amended and with UN/ECE Regulation 49 Series 02, as listed in Annex IV, Appendix II of Directive 92/53/EEC[1] are recognized as equivalent to those required by this Directive;

Whereas engines which are in compliance with the requirements and covered by the scope must be permitted to be sold and used in the Member States; whereas these engines must not be subject to any other national emission requirement; whereas the Member State granting approvals will take the necessary control measures;

Whereas, in laying down the new test procedures and limit values, it is necessary to take into account the specific usage patterns of these types of engines;

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(1) OJ No L 225, 10.08.1992, p.1

Whereas the work undertaken by the Commission in that sphere has shown that the Community engine industry has had available for some time, or is currently perfecting, technologies which allow a considerable improvement in terms of emission performance;

Whereas it is appropriate to introduce these new standards according to the proven principle of a two stage approach; whereas the enforcement of the second stage for full efficiency in real use requires the meeting of certain framework conditions in relation to the availability of low-sulphur gas oil for engines of this category of non-road mobile machinery in all Member States;

Whereas for engines with higher power output the achievement of substantial emission reduction seems to be easier, as existing technology that has been developed for engines of road vehicles can be used; whereas taking this into account a staggered implementation of the requirements has been foreseen, beginning with the highest of three powerbands for Stage I; whereas this principle has been retained for Stage II with the exception of a new fourth powerband not covered by Stage I;

Whereas for this now regulated sector of non-road mobile machinery applications which is the most important one besides agricultural tractors if compared with emissions coming from road transport, a considerable reduction of emissions can be expected by the implementation of this Directive; whereas, given the compliance of all engines concerned, for Stage I the calculated emission reductions would be in the range of 23% for NOx, 11% for HC and 27% for PT, and in Stage II in the range of 67% for PT, 29% for HC and 42% for NOx; whereas due to the in general very good performance of diesel engines in respect to CO and HC emissions the margins for improvements in respect of the total amount emitted is very small; whereas a considerable reduction of the CO and HC emissions may be achievable with the envisaged amendment of this Directive with regard to the enlargement of the scope to gasoline powered engines;

Whereas, in order to encourage the early introduction of advanced emission technology a provision has been made for the use of economic instruments;

Whereas, in order to make provision for the case of extraordinary technical or economic circumstances procedures have been integrated which could exempt manufacturers from the obligations related to the Directive;

Whereas, in order to ensure "Conformity of Production" (COP) once an approval shall be granted for an engine, the manufacturers will be required to provide corresponding arrangements; whereas provisions have been made for the case of discovered non-

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conformity which lay down information procedures, corrective actions and a co-operation procedure which shall allow the settling of possible differences of opinion between Member States in respect of conformity of certified engines;

Whereas the technical provisions must be supplemented and as necessary adapted to technical progress; whereas to this end, provision should be made for the establishment of a "Committee for Adaptation to Technical Progress" in order to adapt the Annexes of the Directive;

Whereas provisions have been made in order to ensure testing of the engines in compliance with the rules of good laboratory practice,

HAVE ADOPTED THIS DIRECTIVE:

[redacted]

[redacted]

Article 1

Scope

This Directive shall apply to engines to be installed in non-road mobile machinery with the exception of:

- vehicles intended for the use of passenger- or goods-transport on the road as defined by Directive 70/156/EEC[1], as last amended by Directive 93/81/EEC[2], and by Directive 92/61[3];

- agricultural tractors as defined by Directive 74/150/EEC[4], as last amended by Directive 88/287/EEC[5];

- those machinery not covered due to the definition in section 1 of Annex I of this Directive.

Article 2

Definitions

For the purposes of this Directive:

- *"non-road mobile machinery"* means any mobile machine or vehicle with or without body work, powered by an internal combustion engine.

- *"type-approval"* means the procedure whereby a Member State certifies that an internal combustion engine type, may be on behalf of an engine family with regard to the level of emission of gaseous and particulate pollutants by the engine(s), satisfies the relevant technical requirements of this Directive.

- *"engine type"* means a category of engines which do not differ in such essential engine characteristics as defined in paragraphs 1 to 4 of Annex II, Appendix 1 to this Directive;

- *"engine family"* means a manufacturer's grouping of engines which, through their design, are expected to have similar exhaust emission characteristics and each engine of this group complies with the requirements of this Directive and may be subject to the measures described in Article 12 with regard to the results of the approval of its parent engine;

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(1) OJ No L 42, 23.02.1970,p.1.

(2) OJ No L 264, 23.10.1993, p.49

(3) OJ No L225, 10.08.1992, p.72

(4) OJ No L 84, 28.03.1974, p.10

(5) OJ No L 126, 20.05.1988, p.52(to be replaced by the pending amending proposal once adopted by the Council and the Parliament)

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- *"parent engine"* means an engine selected from an engine family in such a way that it complies with the requirements set out in section 6 and 7 of Annex I of this Directive;

- *"manufacturer"* means the person or body who is responsible to the approval authority for all aspects of the type-approval process and for ensuring conformity of production. It Is not essential that the person or body is directly involved in all stages of the construction of the engine.

- *"approval authority"* means the competent authority of a Member State which is responsible for all aspects of type-approval of an engine or of an engine family, to issue and to withdraw approval certificates, to serve as the contact point with the approval authorities of the other Member States and which is responsible for verifying the manufacturer's conformity of production arrangements;

- *"technical service"* means the organisation or body that has been appointed as a testing laboratory to carry out tests or inspections on behalf of the approval authority of a Member State. This function may also be carried out by the approval authority itself;

- *"information document"* means the document set out in Annex II to this Directive that prescribes the information to be supplied by an applicant;

- *"information folder"* means the total folder or file of data, drawings, photographs, etc. supplied by the applicant to the technical service or the approval authority as prescribed in the information document;

- *"information package"* means the information folder plus any test reports or other documents that the technical service or the approval authority has added to the information folder in the course of carrying out their functions;

- *"index to the information package"* means the document in which is listed the contents of the information package suitably numbered or otherwise marked to clearly identify all pages.

Article 3

Application for type-approval

(1) Application for engine- or engine family type-approval shall be submitted by the manufacturer to the approval authority of a Member State. An application shall be accompanied by an information folder, the contents of which are given in the information document in Annex II of this Directive.

(2) If the approval authority determines that, with regard to the selected parent engine, the submitted application does not fully represent the engine family described in Annex II, Appendix

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2, an alternative and, if necessary, an additional parent engine which is determined by the approval authority shall be provided for approval according to paragraph (1).

(3) No application in respect of one type of engine or engine family may be submitted to more than one Member State. A separate application shall be submitted for each type (family) to be approved.

Article 4

The type-approval process

(1) Each Member State shall grant type-approval to all engine types or engine families which conform to the particulars in the information folder and which meet the requirements of this Directive.

(2) Each Member State shall complete all applicable sections of the type-approval certificate (the model is described in Annex VI to this Directive) for each type of engine or engine family which it approves and shall compile or verify the contents of the index to the information package. Approval certificates shall be numbered in accordance with the method described in Annex VII. The completed approval certificate and its attachments shall be delivered to the applicant.

(3) Where the engine to be approved fulfils its function or offers a specific feature only in conjunction with other parts of the non-road mobile machinery and for this reason compliance with one or more requirements can be verified only when the engine to be approved operates in conjunction with other machinery parts, whether real or simulated, the scope of the type-approval of the engine(s) must be restricted accordingly. The type-approval certificate for an engine type or engine family shall then include any restrictions on its use and shall indicate any conditions for fitting it.

(4) The approval authority of each Member State shall send monthly to the approval authorities of the other Member States a list (containing the particulars shown in Annex VIII) of the engine (family) type approvals it has granted, refused to grant or withdrawn during that month; in addition, on receiving an application from the approval authority of another Member State, it shall send forthwith a copy of the engine (family) type-approval certificate with/without information package for each type of engine (family) which it has approved or refused to approve or withdrawn and/or the list of engines produced according to type approvals granted, as described in Article 6 (3), containing the particulars shown in Annex IX and/or a copy of the declaration described in Article 6 (4).

(5) The approval authority of each Member State shall yearly, or in addition on receiving a corresponding application, send the Commission a copy of the data sheet as shown in Annex X related to the engines approved since the last notification was made.

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Article 5

Amendments to approvals

(1) The Member State which has granted type-approval must take the necessary measures to ensure that it is informed of any change in the particulars appearing in the information package.

(2) The application for the amendment or extension of a type-approval shall be submitted exclusively to the Member State which granted the original type-approval.

(3) If particulars appearing in the information package have changed, the approval authority of the Member State in question shall :

- issue revised page(s) of the information package as necessary, marking each revised page to show clearly the nature of the change and the date of re-issue. On any occasion when revised pages are issued the index to the information package (which is attached to the approval certificate) shall also be amended to show the latest dates of revised pages; and

- issue a revised approval certificate (denoted by an extension number) if any information on it (excluding its attachments) has changed or if the standards of the Directive have changed since the date currently on the approval. The revised certificate shall show clearly the reason for revision and the date of re-issue.

If the approval authority of the Member State in question finds that an amendment to an information package warrants fresh tests or checks it shall inform the manufacturer thereof and issue the documents mentioned above only after the conduct of successful fresh tests or checks.

Article 6

Declaration of conformity

(1) The manufacturer shall affix to each unit manufactured in conformity with the approved type the markings as defined in Annex I, section 3 of this Directive, including the type-approval number.

(2) Where the type-approval certificate, in accordance with the provisions of Article 4(3) includes restrictions on its use, the manufacturer shall deliver with each unit manufactured detailed information on these restrictions and shall indicate any conditions for fitting it. Where a series of engine types is delivered to one single manufacturer of machinery, it is sufficient that he will be provided with only one such information document - at the latest on the delivery date of the first engine - which additionally lists the relevant engine identification numbers.

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(3) The manufacturer shall send on demand to the responsible approval authority within 45 days after the end of each calendar year, and without delay after each application date when the requirements of this Directive change, and immediately following each additional date the authority may stipulate, a list which contains the range of identification numbers for each engine type produced in accordance with the requirements of this Directive since the last reporting was made, or since the requirements of this Directive were first applicable. Where not clarified by the engine coding system this list must specify correlations of the identification numbers to the corresponding engine types or engine families and to the type-approval numbers. Additionally this list must contain particular information if the manufacturer completely ceases to produce an engine type or family approved. Where this list is not required to be regularly sent to the responsible approval authority, the manufacturer must maintain these records for a minimum period of 30 years.

(4) The manufacturer shall send to the responsible approval authority within 45 days after the end of each calender year and at each application date, a declaration defining the engine types and engine families together with the relevant engine identification codes for those engines he intends to produce from this date on.

Article 7

Acceptance of equivalent approvals

(1) The Parliament and the Council acting by a qualified majority on a proposal from the Commission may acknowledge the equivalence between the conditions and provisions for type-approval of engines by the present Directive and the procedures established by international regulations or regulations of third countries, in the framework of multilateral or bilateral agreements between the Community and third countries.

(2) The equivalence of the international Regulation listed in Part 1 of Annex I, footnote (1) with Directive 88/77/EEC[1] as last amended by Directive 91/542/EEC[2] shall be recognized. The approval authorities of the Member States shall accept approvals according to such regulations and, where applicable the pertaining approval marks, in lieu of the corresponding approvals and/or approval marks according to the Directive.

Article 8

Registration and sale

(1) Each Member State shall only permit the sale or entry into service of engines covered by the scope of this Directive if they were produced in accordance with the requirements of this Direc-

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(1) OJ No L 36, 09.02.1988, p.33

(2) OJ No L 295, 25.10.1991, p.1

[redacted]

[redacted]

tive.

(2) A Member State granting a type-approval shall take the necessary measures in relation to that approval to register and control, if need be in cooperation with the approval authorities of the other Member States, the identification numbers of those engines produced in conformity with the community requirements.

(3) The control of the identification numbers may be additional subject in conjunction with the measures with regard to the control of conformity of production as described in Article 12.

(4) With regard to measures of control of the identification numbers the manufacturer shall without delay give on demand to the responsible approval authority all the information needed related to the direct purchasers together with the identification numbers of the engines reported as produced in accordance with the provisions of paragraph (3) of Article 6. Also he shall commit his middlemen to that. Where engines are sold to a manufacturer of machinery further information is not required.

(5) If on stipulation of the approval authority the manufacturer is not able to verify the requirements as specified in Article 6 particularly in conjunction with paragraph (4) of this Article, the approval granted in respect of the corresponding engine type or family pursuant to this Directive may be withdrawn. Then the information procedure shall be carried out as described in Article 13 (4).

Article 9

Application dates

(1) Acceptance of Type-Approvals
From 31 December 1996 no Member State may, on grounds relating to the gaseous and particulate pollutants emitted from an engine:

- refuse to grant national type-approval for a type of non-road mobile machinery propelled by an engine, or
- prohibit the registration, sale, entry into service or use of such new machinery propelled by an engine, or
- refuse to grant EC type-approval for an engine type and to issue the document as described in Annex VI of this Directive, or to grant national type approval for an engine type, or
- prohibit the sale or use according to the definitions of this Directive of new engines,

for which the requirements of this Directive and its Annexes are satisfied.

(2) Type-Approvals Stage I (Engine Categories A/B/C)
Member States shall refuse national type-approval with regard to emissions, for engine types and for non-road mobile machinery

[redacted]

propelled by an engine:

- **A:** from 31 March 1997 for engines of a power output: $130\ KW \leq P \leq 560\ KW$,
- **B:** from 30 June 1997 for engines of a power output: $75\ KW \leq P < 130\ KW$,
- **C:** from 31 December 1997 for engines of a power output: $37\ KW \leq P < 75\ KW$,

if they fail to meet the requirements specified in this Directive and its Annexes and where the emissions of gaseous and particulate pollutants from the engine do not comply with the limit values as set out in the table in section 4.2.1. of Annex I to this Directive. Additional requirements with regard to emissions shall not be imposed.

(3) Type-Approvals Stage II (Engine Categories: D, E (was A at Stage I), F (was B at Stage I), G (was C at Stage I))
Member States shall refuse to grant EC type-approval with regard to emissions, for an engine type and to issue the document as described in Annex VI of this Directive, and shall refuse type-approval with regard to emissions, for non-road mobile machinery propelled by an engine:

- **D:** from 31 December 1999 for engines of a power output: $18\ KW \leq P < 37\ KW$,
- **E** (= A II): from 31 December 2000 for engines of a power output: $130\ KW \leq P \leq 560\ KW$,
- **F** (= B II): from 31 December 2001 for engines of a power output: $75\ KW \leq P < 130\ KW$,
- **G** (= C II): from 31 December 2002 for engines of a power output: $37\ KW \leq P < 75\ KW$,

if they fail to meet the requirements specified in this Directive and its Annexes and where the emissions of gaseous and particulate pollutants from the engine do not comply with the limit values as set out in the table in section 4.2.3. of Annex I to this Directive. Additional requirements with regard to emissions shall not be imposed.

(4) Required Compliance of the Engines
With the exception of machinery and engines intended for export to third countries, Member States shall only permit the registration, sale, entry into service and use of new non-road mobile machinery propelled by an engine and the sale or use of new engines if the engine is approved in compliance with one of the categories as defined in paragraph(2) and (3). The following time table shall apply. In the case of engines produced before the stated application date the requirement for the relevant approval shall be delayed up to the date in brackets. The permission granted for Stage I-engines shall be terminated with effect from

[redacted]

the mandatory application of Stage II:

Application of Stage I

- category "A" from 30 June 1997 [31 December 1998],
- category "B" from 31 December 1997 [31 December 1999],
- category "C" from 31 December 1998 [31 December 2000],

Application of Stage II

- category "D" from 31 December 2000 [31 December 2002],
- category "E" from 31 December 2001 [31 December 2003],
- category "F" from 31 December 2002 [31 December 2004],
- category "G" from 31 December 2003 [31 December 2005],

Additional requirements with regard to emissions shall not be imposed.

Article 10

Economic instruments

Member States may make provision for tax incentives only in respect of engines which comply with the requirements of this Directive. Such incentives shall comply with the provisions of the Treaty and satisfy the following conditions:

- they shall apply to all new engines offered for sale on the market of a Member State which comply in advance with the requirements of this Directive,
- they shall be terminated with effect from the mandatory application of the emission values laid down in Article 9(4) for newly produced engines,
- for each type of engine, they shall be for an amount lower than the additional cost of the technical solutions introduced to ensure compliance values set and of their installation on the engine.

The Commission shall be informed in sufficient time of plans to institute or change the tax incentives referred to in the first paragraph, so that it can submit its observations.

Article 11

Exemptions and alternative procedures

(1) The requirements of Article 8(1) do not apply to:

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[redacted]

- engines produced directly or indirectly on behalf of and for use only by the armed services,

- engines approved in accordance with paragraph 2.

(2) Each Member State may, at the request of the manufacturer, exempt end-of-series engines which are still in stock, or stocks of non-road mobile machinery in respect of their engines, from the sales or use time limit of Article 9(4) of this Directive in accordance with the following conditions:

- The manufacturer must submit a request to the competent authorities of that Member State which approved the corresponding type(s)/family(ies) of engines, before the entry into force of the time limit(s);

- The application of the manufacturer must include a list as defined in Article 6(3) of those new engines which remain unsold or used within the time limit(s);

- The request must specify the technical and/or economic reasons on which it is based;

- The engines must conform to a type or family for which the type approval is no longer valid, but which have been produced according to the time limit(s). In general this procedure also applies to engines covered by this Directive for the first time, except with regard to the expired type approval;

- The engines must have been physically stored within the territory of the European Community within the time limit(s);

- The maximum number of new engines of one or more types sold or used in each Member State by the application of this exemption must not exceed 10% of the new engines of all types concerned sold or used in that Member State during the previous year;

- If the request is accepted by the Member State, the latter must, within one month, send the competent authorities of the other Member States particulars of, and reasons for, the exemptions granted to the manufacturer;

- The Member State granting exemptions according to this Article shall be responsible for ensuring that the manufacturer complies with all corresponding obligations;

- The competent authority shall release for each engine in question a certificate of conformity on which a special entry has been made. If applicable a consolidated document that contains all engine identification numbers in question may be used;

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- Member States shall each year send the Commission a list of exemptions granted specifying the reasons.

This option shall be limited to a period of 12 months as from the date on which the engines for the first time were subject to the sales or use time limit.

Article 12

Conformity of production arrangements

(1) The Member State granting a type-approval shall take the necessary measures to verify, with regard to the specifications laid down in section 5 of Annex I, if need be in cooperation with the approval authorities of the other Member States, that adequate arrangements have been made to ensure effective control of the conformity of production before it grants type-approval.

(2) The Member State which has granted a type-approval shall take the necessary measures to verify, with regard to the specifications laid down in section 5 of Annex I, if need be in cooperation with the approval authorities of the other Member States, that the arrangements referred to in paragraph 1 continue to be adequate and that each production engine bearing an EC type-approval number pursuant to this Directive continues to conform to the description as given in the approval certificate and its Annexes for the approved engine type or family.

Article 13

Non-conformity with the approved type or family

(1) There shall be failure to conform to the approved type where deviations from the particulars in the type-approval certificate and/or the information package are found to exist and where these deviations have not been authorized under Article 5(3), by the Member State which granted the type-approval.

(2) If a Member State which has granted type-approval finds that engines accompanied by a certificate of conformity or bearing an approval mark do not conform to the type or family it has approved, it shall take the necessary measures to ensure that the engines, in production again conform to the approved type. The approval authorities of that Member State shall advise those of the other Member States of the measures taken which may, where necessary, extend to withdrawal of type-approval.

(3) If a Member State demonstrates that engines bearing an EC type-approval number do not conform to the approved type or family it may request the Member State which granted the type-approval to verify that engines in production conform to the approved type or family. Such action shall be taken within six months of the date of the request.

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(4) The approval authorities of the Member States shall inform each other within one month of any withdrawal of type-approval and of the reasons for such measure.

(5) If the Member State which granted type-approval disputes the failure to conform notified to it, the Member States concerned shall endeavour to settle the dispute. The Commission shall be kept informed and shall, where necessary, hold appropriate consultations for the purpose of reaching a settlement.

Article 14

Notification of decisions and remedies available

All decisions taken pursuant to the provisions adopted in implementation of this Directive and refusing or withdrawing type-approval, or refusing registration or prohibiting sale, shall state in detail the reasons on which they are based. Any decision shall be notified to the party concerned who shall, at the same time, be informed of the remedies available to him under the laws in force in the Member States and of the time limits allowed for the exercise of such remedies.

Article 15

Adaptation to technical Progress

(1) Any amendments which are necessary in order to adapt the Annexes to this Directive with exemption of the requirements specified in Annex I, Section 4.2.1 and 4.2.3, to take account of technical progress shall be adopted by the Commission assisted by the Committee established in accordance with Article ( ) of Council Directive 96/.../EC[1] and in accordance with the procedure laid down in Article 16 of the present Directive.

Article 16

Committee procedures

(1) The representative of the Commission shall submit to the Committee a draft of the measures to be taken. The Committee shall deliver its opinion on the draft within a time-limit which the Chairman may lay down according to the urgency of the matter, if necessary by taking a vote.

(2) The opinion shall be recorded in the minutes; in addition, each Member State shall have the right to ask to have its position recorded in the minutes.

(3) The Commission shall take the utmost account of the opinion

(1) Proposal submitted by the Commission on ambient air quality assessment and management-COM (94) 109 final, 94/0106(SYN), OJ No C 216, 06.08.1994, p.4

[redacted]

delivered by the Committee. It shall inform the Committee of the manner in which its opinion has been taken into account.

Article 17

Approval authorities and technical services

The Member States shall notify to the Commission and to the other Member States the names and addresses of the approval authorities and technical services that are responsible for the purposes of this Directive. The notified services must satisfy the requirements as laid down in Article(14) of Directive 92/53/EEC[1] amending Directive 70/156/EEC.

Article 18

Coming into force

(1) Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive not later than 01 July 1996.

When Member States adopt these measures, they shall contain a reference to this Directive or shall be accompanied by such reference on the occasion of their official publication. The methods of making such a reference shall be laid down by Member States.

(2) Member States shall communicate to the Commission the texts of the provisions of national law which they adopt in the field governed by this Directive.

Article 19

This Directive shall enter into force on the twentieth day following that of its publication in the Official Journal of the European Communities.

Article 20

Address

This Directive is addressed to the Member States.

Done at Brussels,

For the European Parliament
The President

For the Council
The President

(1) OJ No L 225, 10.08.1992, p.1

[redacted]

LIST OF ANNEXES

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ANNEX I

SPECIFICATION OF SCOPE, DEFINITIONS AND ABBREVIATIONS, ENGINE MARKINGS, REQUIREMENTS AND TESTS, SPECIFICATION OF CONFORMITY OF PRODUCTION ASSESSMENTS AND PARAMETERS FOR THE DEFINITION OF THE ENGINE FAMILY

1 SCOPE

This Directive applies to the emission of gaseous and particulate pollutants from engines , used to propel non-road mobile machinery as defined in Article 2, and portable industrial equipment, additionally :

A: intended and suited, to move, or to be moved on the ground, with or without road, and with a C.I. engine having an installed net power in accordance with 2.(2.4) that is higher than 18 KW but not more than 560 KW[1] and that is operated under intermittent speed rather than a single constant speed

Criteria for engines to be covered under this definition include but are not limited to:

- Industrial drilling rigs, compressors etc.,
- Construction equipment including wheel loaders, bulldozers, crawler tractors, crawler loaders, truck-type loaders, off-highway trucks, hydraulic excavators etc.,
- Agricultural equipment, rotary tillers,
- Forestry equipment,
- Self propelled agricultural vehicles (except tractors as defined in Article 1)
- Material handling equipment,
- Fork lift trucks,
- Road maintenance equipment (motor graders, road rollers, asphalt finishers),
- Snow plough equipment,
- Airport supporting equipment,
- Aerial lifts,
- Mobile cranes.

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(1) Engines for which has been granted type-approval under the conditions of Directive 88/77/EEC as last amended shall be exempted from the requirements of this Directive. In this context a certificate of compliance that is valid up to 30 September 1996 with regard to the requirements of Directive 88/77/EEC shall be sufficient for Stage I of this Directive. The certificates validity for new engines shall be terminated with effect of the mandatory application of Stage II. An approval granted in accordance with Regulation 49 of the Economic Commission for Europe, Series of amendments 02, Corrigenda 1/2 shall be deemed to be equivalent to an approval granted in accordance with Directive 88/77/EEC as last amended.

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This Directive is not applicable for the following applications:

B: ship

C: locomotive

D: aircraft

2 DEFINITIONS AND ABBREVIATIONS

For the purpose of this Directive,

2.1 "Compression ignition (C.I.) engine" means an engine which works on the compression-ignition principle (e.g. diesel engine);

2.2 "Gaseous pollutants" means carbon monoxide, hydrocarbons (assuming a ratio of $C_1H_{1.85}$) and oxides of nitrogen, the last named being expressed in nitrogen dioxide (NO_2) equivalent;

2.3 "Particulate pollutants" means any material collected on a specified filter medium after diluting C.I. engine exhaust gas with clean filtered air so that the temperature does not exceeded 325 K (52°C);

2.4 "Net power" means the power in "EEC kW" obtained on the test bench at the end of the crankshaft, or its equivalent, measured in accordance with the EEC method of measuring the power of internal combustion engines for road vehicles as set out in Directive 80/1269/EEC[1], as last amended by Directive 89/491/EEC[2], except that the power of the engine cooling fan is excluded and the test conditions and reference fuel specified in this Directive are adhered to;

2.5 "Rated speed" means the maximum full load speed allowed by the governor as specified by the manufacturer;

2.6 "Per cent load" means the fraction of the maximum available torque at an engine speed;

2.7 "Maximum torque speed" means the engine speed at which the maximum torque is obtained from the engine, as specified by the manufacturer;

2.8 "Intermediate speed" means that engine speed which meets one of the following requirements:

- For engines which are designed to operate over a speed range on a full load torque curve, the intermediate speed shall be the declared maximum torque speed if it occurs between 60% and 75% of rated speed;

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(1) OJ No L 375, 31.12.1980, p.46

(2) OJ No L 238, 15.08.1989, p.43

[redacted]

- If the declared maximum torque speed is less than 60% of rated speed, then the intermediate speed shall be 60% of the rated speed;

- If the declared maximum torque speed is greater than 75% of the rated speed then the intermediate speed shall be 75% of rated speed.

2.9 Symbols and Abbreviations

2.9.1 Symbols for test parameters

Symbol	Unit	Term
A_p	m^2	Cross sectional area of the isokinetic sampling probe.
A_T	m^2	Cross sectional area of the exhaust pipe.
aver		Weighted average values for:
	m^3/h	volume flow;
	kg/h	mass flow;
C1	-	Carbon 1 equivalent hydrocarbon.
conc	ppm Vol%	Concentration (with suffix of the component nominating).
$conc_c$	ppm Vol%	Background corrected concentration.
$conc_d$	ppm Vol%	Concentration of dilution air.
DF	-	Dilution factor.
f_a	-	Laboratory atmospheric factor.
F_{FH}	-	Fuel specific factor used for the calculations of wet concentrations from dry concentrations hydrogen to carbon ratio.
G_{AIRW}	kg/h	Intake air mass flow rate on wet basis.
G_{AIRD}	kg/h	Intake air mass flow rate on dry basis.

[redacted]

G_{DILW}	kg/h	Dilution air mass flow rate on wet basis.
G_{EDFW}	kg/h	Equivalent diluted exhaust gas mass flow rate on wet basis.
G_{EXHW}	kg/h	Exhaust gas mass flow rate on wet basis.
G_{FUEL}	kg/h	Fuel mass flow rate.
G_{TOTW}	kg/h	Diluted exhaust gas mass flow rate on wet basis.
H_{REF}	g/kg	Reference value of absolute humidity 10,71 g/kg for calculation of NO_x and particulate humidity correction factors.
H_a	g/kg	Absolute humidity of the intake air.
H_d	g/kg	Absolute humidity of the dilution air.
i	-	Subscript denoting an individual mode.
K_H	-	Humidity correction factor for NO_x.
K_p	-	Humidity correction factor for particulate.
$K_{W,a}$	-	Dry to wet correction factor for the intake air.
$K_{W,d}$	-	Dry to wet correction factor for the dilution air.
$K_{W,e}$	-	Dry to wet correction factor for the diluted exhaust gas.
$K_{W,r}$	-	Dry to wet correction factor for the raw exhaust gas.
L	%	Percent torque related to the maximum torque for the test speed.

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mass	g/h	subscript denoting emissions mass flow rate.
M_{DIL}	kg	Mass of the dilution air sample passed through the particulate sampling filters.
M_{SAM}	kg	Mass of the diluted exhaust sample passed through the particulate sampling filters.
M_d	mg	Particulate sample mass of the dilution air collected.
M_f	mg	Particulate sample mass collected.
p_a	kPa	Saturation vapour pressure of the engine intake air (ISO 3046 p_{sy} = PSY test ambient).
p_B	kPa	Total barometric pressure (ISO 3046: P_x = PX Site ambient total pressure; P_y = PY Test ambient total pressure).
p_d	kPa	Saturation vapour pressure of the dilution air.
p_s	kPa	Dry atmospheric pressure.
P	kW	Power, brake uncorrected.
P_{AE}	kW	Declared total power absorbed by auxiliaries fitted for the test which are not required by paragraph 2.4. of this Annex.
P_M	kW	Maximum measured power at the test speed under test conditions (see Annex VI, Appendix 1).

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P_m	kW	Power measured at the different test modes.
q	-	Dilution ratio.
r	-	Ratio of cross sectional areas of isokinetic probe and exhaust pipe.
R_a	%	Relative humidity of the intake air.
R_d	%	Relative humidity of the dilution air.
R_f	-	FID response factor.
S	kW	Dynamometer setting.
T_a	K	Absolute temperature of the intake air.
T_D	K	Absolute dewpoint temperature.
T_{ref}	K	Reference temperature (of combustion air: 298K).
V_{AIRD}	m^3/h	Intake air volume flow rate on dry basis.
V_{AIRW}	m^3/h	Intake air volume flow rate on wet basis.
V_{DIL}	m^3	Volume of the dilution air sample passed through the particulate sample filters.
V_{DILW}	m^3/h	Dilution air volume flow rate on wet basis.
V_{EDFW}	m^3/h	Equivalent diluted exhaust gas volume flow rate on wet basis.
V_{EXHD}	m^3/h	Exhaust gas volume flow rate on dry basis.
V_{EXHW}	m^3/h	Exhaust gas volume flowrate on wet basis.
V_{SAM}	m^3	Volume of sample through particulate sampling filters.

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V_{TOTW}	m^3/h	Diluted exhaust gas volume flow rate on wet basis.
WF	-	Weighting factor.
WF_E	-	Effective weighting factor.

2.9.2 Symbols for the Chemical Components

CO	Carbon monoxide.
CO_2	Carbon dioxide.
HC	Hydrocarbons.
NO_x	Oxides of nitrogen.
NO	Nitric Oxide.
NO_2	Nitrogen Dioxide.
O_2	Oxygen.
C_2H_6	Ethane.
PT	Particulate.
DOP	Di-octylphthalate.
CH_4	Methane.
C_3H_8	Propane.
H_2O	Water.
PTFE	Polytetrafluoroethylene

2.9.3 Abbreviations

FID	Flame ionization detector.
HFID	Heated flame ionization detector.
NDIR	Non-dispersive infrared analyzer.
CLD	Chemiluminescent detector.
HCLD	Heated chemiluminescent detector.
PDP	Positive displacement pump.
CFV	Critical flow venturi.

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3 **ENGINE MARKINGS**

3.1 The engine approved as a technical unit must bear:

3.1.1 the trademark or trade name of the manufacturer of the engine;

3.1.2 the engine type, engine family (if applicable), and a unique engine identification number;

3.1.3 the EC type-approval number as described in Annex VII.

3.2 These marks must be durable for the useful life of the engine and must be clearly legible and indelible. If labels or plates are used, they must be attached in such a manner that in addition the fixing is durable for the useful life of the engine, and the labels/plates cannot be removed without destroying or defacing them.

3.3 The marking must be secured to an engine part necessary for normal engine operation and not normally requiring replacement during engine life.

It must be located so as to be readily visible to the average person after the engine is installed in the equipment. Where covers eventually have to be dismantled this requirement is considered to be satisfied if this is easily possible without the use of tools.

Where the fulfillment of this requirement is uncertain, it is considered to be met by the use of a supplementary marking containing at least the unique engine identification number together with the trademark, trade name or logo of the manufacturer. This supplementary marking must be located either on, or adjacent to, a major component not normally requiring replacement during the life of the engine, which is easily accessible for routine servicing without the use of tools, or it must be affixed at a considerable distance from the original marking onto the engine's crankcase. Both the original and the (if applicable) supplementary marking must be readily visible to the average person after the engine has been completed with all auxilaries necessary for engine operation. The previous dismantling of eventual covers as defined above is permissible. The supplementary marking must be done directly on the engine's surface by the use of a durable method like imprinting or affixed with a label/plate that meets the requirements of point 3.2 above.

3.4 The coding of the engines in context with the identification numbers must be such that it allows for the indubitable determination of the sequence of production.

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3.5 Before leaving the production line the engines must bear all markings.

3.6 The exact location of the engine markings shall be declared in Annex VI, Section 1.

4 SPECIFICATIONS AND TESTS

4.1 <u>General</u>

The components liable to affect the emission of gaseous and particulate pollutants shall be so designed, constructed and assembled as to enable the engine, in normal use, despite the vibrations to which it may be subjected, to comply with the provisions of this Directive.

The technical measures taken by the manufacturer must be such as to ensure that the mentioned emissions are effectively limited, pursuant to this Directive, throughout the normal life of the engine and under normal conditions of use. These provisions are deemed to be met if the provisions of sections 4.2.1., 4.2.3. and 5.3.2.1. are respectively complied with.

If a catalytic converter and/or a particulates trap is used the manufacturer must prove by durability tests, which he himself may carry out in accordance with good engineering practice, and by corresponding records, that these aftertreatment devices can be expected to function properly for the lifetime of the engine. The records must be produced in compliance with the requirements of section 5.2 and in particular with 5.2.3 . A corresponding warranty must be guaranteed to the costumer. Systematic replacement of the device after a certain running time of the engine, is permissible. Any adjustment, repair, disassembly, cleaning, or replacement of engine components or systems which is performed on a periodic basis to prevent malfunction of the engine in context with the aftertreatment device, shall only be done to the extent that is technologically necessary to assure proper functioning of the emission control system. Accordingly scheduled maintenance requirements must be included in the customer's manual, and be covered by the warranty provisions mentioned above, and be approved before an approval is granted. The corresponding extract from the manual with respect to maintenance/replacements of the treatment device(s), and to the warranty conditions, must be included in the information document as set out in annex II to this Directive.

4.2 <u>Specifications concerning the emissions of pollutants</u>

The gaseous and particulate components emitted by the engine submitted for testing shall be measured by the

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methods described in Annex V.

Other systems or analyzers may be accepted if they yield equivalent results to the following reference systems:

- for gaseous emissions measured in the raw exhaust, the system shown in Figure 2 of Annex V;

- for gaseous emissions measured in the dilute exhaust of a full flow dilution system, the system shown in Figure 3 of Annex V;

- for particulate emissions, the full flow dilution system, operating either with a separate filter for each mode or with the single filter method, shown in Figure 13 of Annex V.

The determination of system equivalency shall be based upon a seven test cycle (or larger) correlation study between the system under consideration and one or more of the above reference systems.

The equivalency criterion is defined as a ± 5% agreement of the averages of the weighted cycle emissions values. The cycle to be used shall be that given in Annex III, paragraph 3.6.1.

For introduction of a new system into the Directive the determination of equivalency shall be based upon the calculation of repeatability and reproducibility, as described in ISO 5725.

4.2.1 The emissions of the carbon monoxide, the emissions of hydrocarbons, the emissions of the oxides of nitrogen and the emissions of particulates obtained shall for **Stage I** not exceed the amount shown in the table below:

Net Power (P) (kW)	Carbon Monoxide (CO) (g/kWh)	Hydrocarbons (HC) (g/kWh)	Oxides of Nitrogen (NO_x) (g/kWh)	Particulates (PT) (g/kWh)
$130 \leq P < 560$	5,0	1,3	9,2	0,54
$75 \leq P < 130$	5,0	1,3	9,2	0,70
$37 \leq P < 75$	6,5	1,3	9,2	0,85

4.2.2 The emission limits given in paragraph 4.2.1. are engine-out limits and shall be achieved before any exhaust after-treatment device.

[redacted]

4.2.3 The emissions of the carbon monoxide, the emissions of hydrocarbons, the emissions of the oxides of nitrogen and the emissions of particulates obtained shall for **Stage II** not exceed the amount shown in the table below:

Net Power (P) (kW)	Carbon Monoxide (CO) (g/kWh)	Hydrocarbons (HC) (g/kWh)	Oxides of Nitrogen (NO_x) (g/kWh)	Particulates (PT) (g/kWh)
130 ≤ P < 560	3,5	1,0	7,0	0,2
75 ≤ P < 130	5,0	1,0	7,0	0,3
37 ≤ P < 75	5,0	1,3	8,0	0,4
18 ≤ P < 37	5,5	1,5	8,5	0,8

4.2.4 Where, as defined according to section 6 in conjunction with Annex II, Appendix 2, one engine family covers more than one power band, the emission values of the parent engine (type approval) and of all engine types within the same family (COP) must meet the more stringent requirements of the higher power band. The applicant has the free choice to restrict the definition of engine families to single power bands, and to correspondingly apply for certification.

4.3 Installation on the mobile machinery

The engine installation on the mobile machinery shall comply with the restrictions set out in the scope of the type-approval. Additionally the following characteristics in respect to the approval of the engine always must be met:

4.3.1 Intake depression shall not exceed that specified for the approved engine in Annex II, Appendix 1 or 3 respectively.

4.3.2 Exhaust back pressure shall not exceed that specified for the approved engine in Annex II, Appendix 1 or 3 respectively.

5 SPECIFICATION OF CONFORMITY OF PRODUCTION ASSESSMENTS

5.1 With regard to the verification of the existence of satifactory arrangements and procedures for ensuring effective control of production conformity before granting type-approval, the approval authority must also accept the manufacturer's registration to harmonized standard EN 29002 (whose scope covers the engines concerned) or an equivalent accreditation standard as satisfying the requirements. The manufacturer must provide details of the registration and undertake to inform the approval authority of any revisions to its validity or scope. In order to verify that the requirements of paragraph 4.2 are continuously met, suitable controls of the production shall be carried out.

5.2 The holder of the approval shall in particular:

5.2.1 ensure existence of procedures for the effective control of the quality of the product;

5.2.2 have access to the control equipment necessary for checking the conformity to each approved type;

5.2.3 ensure that data of test results are recorded and that annexed documents shall remain available for a period to be determined in accordance with the approval authority;

5.2.4 analyses the results of each type of test, in order to verify and ensure the stability of the engine characteristics, making allowance for variations in the industrial production process;

5.2.5 ensure that any sampling of engines or components giving evidence of non-conformity with the type of test considered shall give rise to another sampling and another test. All the necessary steps shall be taken to re-establish the conformity of the corresponding production.

5.3 The competent authority which has granted approval may at any time verify the conformity control methods applicable to each production unit.

5.3.1 In every inspection, the test books and production survey record shall be presented to the visiting inspector.

5.3.2 When the quality level appears unsatisfactory or when it seems necessary to verify the validity of the data presented in application of paragraph 4.2, the following procedure is adopted:

5.3.2.1 An engine is taken from the series and subjected to the test described in Annex III. The emissions of the carbon monoxide, the emissions of the hydrocarbons, the emissions of the oxides of nitrogen and the emissions of particulates obtained shall not exceed the amounts shown in the table in paragraph 4.2.1, subject to the requirements of paragraph 4.2.2, or those shown in the table in paragraph 4.2.3 respectively.

5.3.2.2 If the engine taken from the series does not satisfy

[redacted]

the requirements of paragraph 5.3.2.1 the manufacturer may ask for measurements to be performed on a sample of engines of the same specification taken from the series and including the engine originally taken. The manufacturer shall determine the size n of the sample in agreement with the technical service. Engines other than the engine originally taken shall be subjected to a test. The arithmetical mean $(\bar{x})$ of the results obtained with the sample shall then be determined for each pollutant. The production of the series shall then be deemed to confirm if the following condition is met:

$$\boxed{\bar{x} + k \cdot S_t \leq L} \; (^1)$$

where:

L is the limit value laid down in paragraph 4.2.1./4.2.3. for each pollutant considered;

k is a statistical factor depending on n and given in the following table:

n	2	3	4	5	6	7	8	9	10
k	0.973	0.613	0.489	0.421	0.376	0.342	0.317	0.296	0.279

n	11	12	13	14	15	16	17	18	19
k	0.265	0.253	0.242	0.233	0.224	0.216	0.210	0.203	0.198

$$\text{if } n \geq 20, \qquad k = \frac{0.860}{\sqrt{n}}$$

5.3.3 The approval authority or the technical service responsible for verifying the conformity of production shall carry out tests on engines which have been run-in partially or completely, according to the manufacturer's specifications.

5.3.4 The normal frequency of inspections authorized by the competent authority shall be 1 per year. If the requirements of paragraph 5.3.2 are not met, the competent authority shall ensure that all necessary steps are taken to re-establish the conformity of production as rapidly as possible.

---

(1) $S_t^2 = \sum \frac{(x - \bar{x})^2}{n-1}$ where x is any one of the individual results obtained with the sample n

[redacted]

[redacted]

6 PARAMETERS DEFINING THE ENGINE FAMILY

The engine family may be defined by basic design parameters which must be common to engines within the family. In some cases there may be interaction of parameters. These effects must also be taken into consideration to ensure that only engines with similar exhaust emission characteristics are included within an engine family.

In order that engines may be considered to belong to the same engine family, the following list of basic parameters must be common:

6.1 Combustion cycle:

- 2 cycle
- 4 cycle

6.2 Cooling medium:

- air
- water
- oil

6.3 Individual cylinder displacement:

- engines to be within a total spread of 15%.
- number of cylinders for engines with after-treatment device

6.4 Method of air aspiration:

- naturally aspirated
- pressure charged

6.5 Combustion chamber type/design:

- pre-chamber
- swirl chamber
- open chamber

6.6 Valve and porting - configuration, size and number:

- cylinder head
- cylinder wall
- crankcase

6.7 Fuel system:

- pump-line-injector
- in-line pump
- distributor pump
- single element
- unit injector

[redacted]

[redacted]

6.8 Miscellaneous features:

- exhaust gas recirculation
- water injection/emulsion
- air injection
- charge cooling system

6.9 Exhaust after-treatment

- oxidation catalyst
- reduction catalyst
- thermal reactor
- particulates trap

7 CHOICE OF THE PARENT ENGINE

7.1 The parent engine of the family shall be selected using the primary criteria of the highest fuel delivery per stroke at the declared maximum torque speed. In the event that two or more engines share this primary criteria, the parent engine shall be selected using the secondary criteria of highest fuel delivery per stroke at rated speed. Under certain circumstances, the approval authority may conclude that the worst case emission rate of the family can best be characterised by testing a second engine. Thus, the approval authority may select an additional engine for test based upon features which indicate that it may have the highest emission levels of the engines within that family.

7.2 If engines within the family incorporate other variable features which could be considered to affect exhaust emissions, these features must also be identified and taken into account in the selection of the parent engine.

[redacted]

[redacted]

ANNEX II

INFORMATION DOCUMENT No...

relating to EEC type-approval and referring to measures to be taken against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery

(Directive 95/.../EEC as last amended by Directive ../.../EEC)

Parent- [1]
Engine type:..

0. **General**

0.1. Make (name of undertaking):..

0.2. Type and commercial description of the parent- and (if applicable) of the family engine(s)[1]:..

0.3. Manufacturer's type coding as marked on the engine(s)[1]:..

0.4. Specification of machinery to be propelled by the engine [2]:......................................

0.5. Name and address of manufacturer:..

Name and address of manufacturer's authorized representative (if any):.................

....

0.6. Location, coding and method of affixing of the engine identification number :.....

....

0.7. Location and method of affixing of the EEC approval mark :...............................

....

0.8 Address(es) of assembly plant(s) :..

---

(1) Delete as appropriate

(2) As defined in Annex I, section 1 (e.g.: "A")

[redacted]

[redacted]

Attachments

1.1. Essential characteristics of the parent engine(s) (see Appendix 1)

1.2. Essential characteristics of the engine family (see Appendix 2)

1.3. Essential characteristics of engine types within the family (see Appendix 3)

2. Characteristics of engine-related parts of the mobile machinery (if applicable)

3. Photographs of the parent engine

4. List further attachments if any

Date, File

[redacted]

Appendix 1

ESSENTIAL CHARACTERISTICS OF THE (PARENT) ENGINE ([1])

1. <u>Description of engine</u>

1.1. Manufacturer: . . . .

1.2. Manufacturer's engine code: . . . .

1.3. Cycle: four stroke / two stroke ([2])

1.4. Bore: . . . . mm

1.5. Stroke: . . . . mm

1.6. Number and layout of cylinders: . . . .

1.7. Engine capacity: . . . . cm^3

1.8. Rated speed: . . . .

1.9. Maximum torque speed: . . . .

1.10. Volumetric compression ratio ([3]): . . . .

1.11. Combustion system description: . . . .

1.12. Drawing(s) of combustion chamber and piston crown . . . .

1.13. Minimum cross sectional area of inlet and outlet ports: . . . .

1.14. <u>Cooling system</u>

1.14.1. <u>Liquid</u>

1.14.1.1. Nature of liquid: . . . .

1.14.1.2. Circulating pump(s): yes/no ([2])

---

(1) For the case of several parent engines to be submitted for each of them

(2) Strike out what does not apply

(3) Specify the tolerance

[redacted]

1.14.1.3. Characteristics or make(s) and type(s) (if applicable): …

1.14.1.4. Drive ratio(s) (if applicable): …

1.14.2. <u>Air</u>

1.14.2.1. Blower: yes/no ([1])

1.14.2.2. Characteristics or make(s) and type(s) (if applicable): …

1.14.2.3. Drive ratio(s) (if applicable): …

1.15. <u>Temperature permitted by the manufacturer</u>

1.15.1. Liquid cooling: Maximum temperature at outlet: … K

1.15.2. Air cooling: Reference point: …

Maximum temperature at reference point: … K

1.15.3. Maximum charge air outlet temperature of the inlet intercooler (if applicable): … K

1.15.4. Maximum exhaust temperature at the point in the exhaust pipe(s) adjacent to the outer flange(s) of the exhaust manifold(s): … K

1.15.5. Lubricant temperature: min: … K
max: … K

1.16. Pressure charger: yes/no [(1)]

1.16.1. Make: …

1.16.2. Type: …

1.16.3. Description of the system (e.g. max charge pressure, waste-gate, if applicable): …

1.16.4. Intercooler: yes/no [(1)]

1.17. Intake system: Maximum allowable intake depression at rated engine speed and at 100% load: … kPa

1.18. Exhaust system: Maximum allowable exhaust backpressure at rated engine speed and at 100% load: … kPa

2. <u>Additional anti-pollution devices</u> (if any, and if not covered by another heading)
- Description and/or diagram(s): …

([1]) Strike out what does not apply.

[redacted]

3. Fuel feed

3.1. Feed pump

Pressure (1) or characteristic diagram: .... kPa

3.2. Injection system

3.2.1. Pump

3.2.1.1. Make(s): ....

3.2.1.2. Type(s): ....

3.2.1.3. Delivery: ....and.........mm^3 (1) per stroke or cycle at full injection at pump speed of: .... rpm (rated) and ....rpm (max. torque) respectively, or characteristic diagram.

Mention the method used: On engine/on pump bench (2) ....

3.2.1.4. Injection advance

3.2.1.4.1. Injection advance curve (1) : ....

3.2.1.4.2. Timing (1) : ....

3.2.2. Injection piping

3.2.2.1. Length: .... mm

3.2.2.2. Internal diameter: .... mm

3.2.3. Injector(s)

3.2.3.1. Make(s): ....

3.2.3.2. Type(s): ....

3.2.3.3. Opening pressure (1) or characteristic diagram: .... kPa

3.2.4. Governor

3.2.4.1. Make(s): ....

3.2.4.2. Type(s): ....

---

(1) Specify the tolerance.

(2) Strike out what does not apply.

[redacted]

3.2.4.3. Speed at which cut-off starts under full load [1]: .... rpm

3.2.4.4. Maximum no-load speed ([1]) : .... rpm

3.2.4.5. Idling speed [1] : .... rpm

3.3. Cold Start System

3.3.1. Make(s): ....

3.3.2. Type(s): ....

3.3.3. Description: ....

4. Valve timing

4.1. Maximum lift and angles of opening and closing in relation to dead centres or equivalent data: ....

4.2. Reference and/or setting ranges ([2])

([1]) Specify the tolerance.

([2]) Strike out what does not apply.

[redacted]

[redacted]

Appendix 2

ESSENTIAL CHARACTERISTICS OF THE ENGINE FAMILY

1. Common parameters [1] :

1.1. Combustion cycle: . . . .

1.2. Cooling medium: . . . .

1.3. Method of air aspiration: . . . .

1.4. Combustion chamber type/design: . . . .

1.5. Valve and porting - configuration, size and number:

1.6. Fuel system: . . . .

1.7. Engine management systems:

Proof of identity pursuant to drawing number(s):

- charge cooling system: . . . .
- exhaust gas recirculation [2]: . . . .
- water injection/emulsion [2]: . . . .
- air injection [2]: . . . .

1.8. Exhaust after-treatment system [2]: . . . .

Proof of identical (or lowest for the parent engine) ratio: system capacity / fuel delivery per stroke, pursuant to diagram number(s) : . . . .

---

[1] To be completed in conjunction with the specifications given in section 6 and 7 of Annex I

[2] If not applicable mark n.a.

[redacted]

[redacted]

2. **ENGINE FAMILY LISTING**

2.1. Name of Engine family : ....

2.2. Specification of engines within this family:

Engine Type					**Parent Engine** (1)
No. of cylinders					
Rated Speed (rpm)					
Fuel delivery per stroke (mm^3)					
Rated Net Power (kW)					
Maximum Torque Speed (rpm)					
Fuel delivery per stroke (mm^3)					
Maximum Torque (Nm)					
Low Idle Speed (rpm)					
Cylinder displacement (in % of parent engine)					100

(1) For full details see Appendix 1

[redacted]

[redacted]

Appendix 3

ESSENTIAL CHARACTERISTICS OF ENGINE TYPE WITHIN THE FAMILY ([1])

1. <u>Description of engine</u>

1.1. Manufacturer: . . . .

1.2. Manufacturer's engine code: . . . .

1.3. Cycle: four stroke / two stroke ([2])

1.4. Bore: . . . . mm

1.5. Stroke: . . . . mm

1.6. Number and layout of cylinders: . . . .

1.7. Engine capacity: . . . . cm^3

1.8. Rated speed: . . . .

1.9. Maximum torque speed: . . . .

1.10. Volumetric compression ratio ([3]): . . . .

1.11. Combustion system description: . . . .

1.12. Drawing(s) of combustion chamber and piston crown . . . .

1.13. Minimum cross sectional area of inlet and outlet ports: . . . .

1.14. <u>Cooling system</u>

1.14.1. <u>Liquid</u>

1.14.1.1. Nature of liquid: . . . .

1.14.1.2. Circulating pump(s): yes/no ([2])

([1]) To be submitted for each engine of the family

([2]) Strike out what does not apply

([3]) Specify the tolerance

[redacted]

[redacted]

1.14.1.3. Characteristics or make(s) and type(s) (if applicable): . . . .

1.14.1.4. Drive ratio(s) (if applicable): . . . .

1.14.2. <u>Air</u>

1.14.2.1. Blower: yes/no (1)

1.14.2.2. Characteristics or make(s) and type(s) (if applicable): . . . .

1.14.2.3. Drive ratio(s) (if applicable): . . . .

1.15. <u>Temperature permitted by the manufacturer</u>

1.15.1. Liquid cooling: Maximum temperature at outlet: . . . . K

1.15.2. Air cooling: Reference point: . . . .

Maximum temperature at reference point: . . . . K

1.15.3. Maximum charge air outlet temperature of the inlet intercooler (if applicable): . . . . K

1.15.4. Maximum exhaust temperature at the point in the exhaust pipe(s) adjacent to the outer flange(s) of the exhaust manifold(s): . . . . K

1.15.5. Lubricant temperature: min: . . . . K
max: . . . . K

1.16. Pressure charger: yes/no (1)

1.16.1. Make: . . . .

1.16.2. Type: . . . .

1.16.3. Description of the system (e.g. max charge pressure, waste-gate, if applicable): . . . .

1.16.4. Intercooler: yes/no (1)

1.17. Intake system: Maximum allowable intake depression at rated engine speed and at 100% load: . . . . kPa

1.18. Exhaust system: Maximum allowable exhaust backpressure at rated engine speed and at 100% load: . . . . kPa

---

(1) Strike out what does not apply.

[redacted]

[redacted]

2. Additional anti-pollution devices (if any, and if not covered by another heading)
- Description and/or diagram(s): . . . .

3. Fuel feed

3.1. Feed pump

Pressure ([1]) or characteristic diagram: . . . . kPa

3.2. Injection system

3.2.1. Pump

3.2.1.1. Make(s): . . . .

3.2.1.2. Type(s): . . . .

3.2.1.3. Delivery: ....and........mm^3 [(1)] per stroke or cycle at full injection at pump speed of: .... rpm (rated) and...........rpm (max. torque) respectively, or characteristic diagram.

Mention the method used: On engine/on pump bench ([2]) . . . .

3.2.1.4. Injection advance

3.2.1.4.1. Injection advance curve [(1)] : . . . .

3.2.1.4.2. Timing [(1)] : . . . .

3.2.2. Injection piping

3.2.2.1. Length: . . . . mm

3.2.2.2. Internal diameter: . . . . mm

3.2.3. Injector(s)

3.2.3.1. Make(s): . . . .

3.2.3.2. Type(s): . . . .

3.2.3.3. Opening pressure [(1)] or characteristic diagram: . . . . kPa

---

([1]) Specify the tolerance.

([2]) Strike out what does not apply.

[redacted]

[redacted]

3.2.4. Governor

3.2.4.1. Make(s): . . . .

3.2.4.2. Type(s): . . . .

3.2.4.3. Speed at which cut-off starts under full load (1): . . . . rpm

3.2.4.4. Maximum no-load speed (1) : . . . . rpm

3.2.4.5. Idling speed (1) : . . . . rpm

3.3. Cold Start System

3.3.1. Make(s): . . . .

3.3.2. Type(s): . . . .

3.3.3. Description: . . . .

4. Valve timing

4.1. Maximum lift and angles of opening and closing in relation to dead centres or equivalent data: . . . .

4.2. Reference and/or setting ranges (2)

---

(1) Specify the tolerance.

(2) Strike out what does not apply.

[redacted]

ANNEX III

TEST PROCEDURE

1. **Introduction**

1.1. This Annex describes the method of determining emissions of gaseous and particulate pollutants from the engines to be tested.

1.2. The test shall be carried out with the engine mounted on a test bench and connected to a dynamometer.

2. **Test Conditions**

2.1. General Requirements

All volumes and volumetric flow rates shall be related to 273K (0°C) and 101.3 kPa.

2.2. Engine Test Conditions

2.2.1. The absolute temperature T_a of the engine intake air expressed in Kelvin, and the dry atmospheric pressure p_s, expressed in kPa, shall be measured, and the parameter f_a shall be determined according to the following provisions:

Naturally aspirated and mechanically supercharged engines:

$$f_a = \left(\frac{99}{p_s}\right) \left(\frac{T}{298}\right)^{0.7}$$

Turbocharged engine with or without cooling of the intake air:

$$f_a = \left(\frac{99}{p_s}\right)^{0.7} \times \left(\frac{T}{298}\right)^{1.5}$$

2.2.2. Test Validity

For a test to be recognised as valid, the parameter f_a shall be such that:

$$0.98 \leq f_a \leq 1.02$$

2.2.3. Engines with Charge Air Cooling

The temperature of the cooling medium and the temperature of the charge air have to be recorded.

[redacted]

2.3. Engine Air Inlet System

The test engine shall be equipped with an air inlet system presenting an air inlet restriction at the upper limit specified by the manufacturer for a clean air cleaner at the engine operating conditions as specified by the manufacturer which result in maximum air flow.

A test shop system may be used, provided it duplicates actual engine operating conditions.

2.4. Engine Exhaust System

The test engine shall be equipped with an exhaust system presenting an exhaust back pressure at the upper limit specified by the manufacturer for the engine operating conditions which result in maximum declared power.

2.5. Cooling System

An engine cooling system with sufficient capacity to maintain the engine at normal operating temperatures prescribed by the manufacturer.

2.6. Lubricating Oil

Specifications of the lubricating oil used for the test shall be recorded and presented with the results of the test.

2.7. Test Fuel

The fuel shall be the reference fuel specified in Annex IV.

The cetane number and the sulphur content of the reference fuel used for test shall be recorded at paragraph 5.1. of Annex II, Appendix 1.

The fuel temperature at the injection pump inlet shall be 306-316 K (33-43°C).

2.8. Determination of dynamometer settings

The settings of inlet restriction and exhaust pipe backpressure shall be adjusted to the manufacturer's upper limits, in accordance with paragraphs 2.3. and 2.4.

The maximum torque values at the specified test speeds shall be determined by experimentation in order to calculate the torque values for the specified test modes. For engines which are not designed to operate over a speed range on a full load torque curve, the maximum torque at the test speeds shall be declared by the manufacturer.

The engine setting for each test mode shall be calculated using the formula:

$$S = \left((P_M + P_{AE}) \times \frac{L}{100} \right) - P_{AE}$$

[redacted]

If the ratio,

$$\frac{P_{AE}}{P_M} \geq 0.03$$

the value of P_{AE} may be verified by the technical authority granting type approval.

3. **Test Run**

3.1. Preparation of the Sampling Filters

At least one hour before the test, each filter (pair) shall be placed in a closed, but unsealed petri dish and placed in a weighing chamber for stabilisation. At the end of the stabilisation period, each filter (pair) shall be weighed and the tare weight shall be recorded. The filter (pair) shall then be stored in a closed petri dish or filter holder until needed for testing. If the filter (pair) is not used within eight hours of its removal from the weighing chamber, it must be re-weighed before use.

3.2. Installation of the Measuring Equipment

The instrumentation and sample probes shall be installed as required. When using a full flow dilution system for exhaust gas dilution, the tailpipe shall be connected to the system.

3.3. Starting the Dilution System and Engine

The dilution system and the engine shall be started and warmed up until all temperatures and pressures have stabilised at full lcad and rated speed (paragraph 3.6.2).

3.4. Adjustment of the Dilution Ratio

The particulate sampling system shall be started and running on bypass for the single filter method (optional for the multiple filter method). The particulate background level of the dilution air may be determined by passing dilution air through the particulate filters. If filtered dilution air is used, one measurement may be done at any time prior to, during, or after the test. If the dilution air is not filtered, measurements at a minimum of three points, after the starting, before the stopping, and at a point near the middle of the cycle, are required, and the values averaged.

The dilution air shall be set to obtain a maximum filter face temperature of 325 K (52°C) or less at each mode. The total dilution ratio shall not be less than four.

For the single filter method, the sample mass flow rate through the filter shall be maintained at a constant proportion of the dilute exhaust mass flow rate for

[redacted]

full flow systems for all modes. This mass ratio shall be within ±5%, except for the first 10 seconds of each mode for systems without bypass capability. For partial flow dilution systems with single filter method, the mass flow rate through the filter shall be constant within ±5% during each mode, except for the first 10 seconds of each mode for systems without bypass capability.

For CO_2 or NO_x concentration controlled systems, the CO_2 or NO_x content of the dilution air must be measured at the beginning and at the end of each test. The pre and post test background CO_2 or NO_x concentration measurements of the dilution air must be within 100 ppm or 5 ppm of each other, respectively.

When using a dilute exhaust gas analysis system, the relevant background concentrations shall be determined by sampling dilution air into a sampling bag over the complete test sequence.

Continuous (non bag) background concentration may be taken at the minimum of three points, at the beginning at the end, and a point near the middle of the cycle and averaged. At the manufacturers request background measurements may be omitted.

3.5. <u>Checking the Analyzers</u>

The emission analyzers shall be set at zero and spanned.

3.6. <u>Test Cycle</u>

3.6.1. Specification A of machinery according to Annex I, Section 1:

3.6.1.1. The following 8-mode cycle([1]) shall be followed in dynamometer operation on the test engine:

Mode Number	Engine Speed	Percent Load	Weighting Factor
1	Rated	100	0.15
2	Rated	75	0.15
3	Rated	50	0.15
4	Rated	10	0.1
5	Intermediate	100	0.1
6	Intermediate	75	0.1
7	Intermediate	50	0.1
8	Idle	-	0.15

3.6.2. <u>Conditioning of the Engine</u>

Warming up of the engine and the system shall be at maximum speed and

(1) Identical with C1 cycle of the draft ISO 8178-4 Standard

[redacted]

[redacted]

torque in order to stabilise the engine parameters according to the recommendations of the manufacturer.

Note:

The conditioning period should also prevent the influence of deposits from a former test in the exhaust system. There is also a required period of stabilisation between test points which has been included to minimise point to point influences.

3.6.3. Test Sequence

The test sequence shall be started. The test shall be performed in the order of the mode numbers as set out above for the test cycle.

During each mode of the test cycle after the initial transition period, the specified speed shall be held to within ±1% of rated speed or $\pm 3 min^{-1}$ whichever is greater except for low idle which shall be within the tolerances declared by the manufacturer. The specified torque shall be held so that the average over the period during which the measurements are being taken is within ±2% of the maximum torque at the test speed.

For each measuring point a minimum time of ten minutes is necessary. If for the testing of an engine longer sampling times are required for reasons of obtaining sufficient particulate mass on the measuring filter the test mode period can be extended as necessary.

The mode length shall be recorded and reported.

The gaseous exhaust emission concentration values shall be measured and recorded during the last three minutes of the mode.

The particulate sampling and the gaseous emission measurement should not commence before engine stabilisation, as defined by the manufacturer has been achieved and their completion must be coincident .

The fuel temperature shall be measured at the inlet to the fuel injection pump or as specified by the manufacturer, and the location of measurement recorded.

3.6.4. Analyzer Response

The output of the analyzers shall be recorded on a strip chart recorder or measured with an equivalent data acquisition system with the exhaust gas flowing through the analyzers at least during the last three minutes of each mode. If bag sampling is applied for the diluted CO and CO_2 measurement (see Annex III, Appendix 1, paragraph 1.4.4), a sample shall be bagged during the last three minutes of each mode, and the bag sample analyzed and recorded.

[redacted]

[redacted]

3.6.5. Particulate Sampling

The particulate sampling can be done either with the single filter method or with the multiple filter method (Annex III, Appendix 1, paragraph 1.5). Since the results of the methods may differ slightly, the method used must be declared with the results.

For the single filter method the modal weighting factors specified in the test cycle procedure shall be taken into account during sampling by adjusting sample flow rate and/or sampling time, accordingly.

Sampling must be conducted as late as possible within each mode. The sampling time per mode must be at least 20 second for the single filter method and at least 60 seconds for the multi-filter method. For systems without bypass capability, the sampling time per mode must be a least 60 seconds for single and multiple filter methods.

3.6.6. Engine Conditions

The engine speed and load, intake air temperature, fuel flow and air or exhaust gas flow shall be measured for each mode once the engine has been stabilised.

If the measurement of the exhaust gas flow or the measurement of combustion air and fuel consumption is not possible, it can be calculated using the carbon and oxygen balance method (see Annex III, Appendix 1, paragraph 1.2.3).

Any additional data required for calculation shall be recorded (see Annex III, Appendix 3, paragraphs 1.1 and 1.2).

3.7. Re-checking the Analyzers

After the emission test a zero gas and the same span gas will be used for re-checking. The test will be considered acceptable if the difference between the two measuring results is less than 2%.

[redacted]

[redacted]

Appendix 1

1. **Measurement and Sampling Procedures**

Gaseous and particulate components emitted by the engine submitted for testing shall be measured by the methods described in Annex V. The methods of annex V describe the recommended analytical systems for the gaseous emissions (paragraph 1.1) and the recommended particulate dilution and sampling systems (paragraph 1.2).

1.1. <u>Dynamometer Specification</u>

An engine dynamometer with adequate characteristics to perform the test cycle described in Annex III, paragraph 3.6.1 shall be used. The instrumentation for torque and speed measurement shall allow the measurement of the shaft power within the given limits. Additional calculations may be necessary.

The accuracy of the measuring equipment must be such that the maximum tolerances of the figures given in paragraph 1.3 are not exceeded.

1.2. <u>Exhaust Gas Flow</u>

The exhaust gas flow shall be determined by one of the methods mentioned in paragraphs 1.2.1 to 1.2.4.

1.2.1. <u>Direct Measurement Method</u>

Direct measurement of the exhaust flow by flow nozzle or equivalent metering system (for detail see ISO 5167).

<u>Note</u>:

Direct gaseous flow measurement is a difficult task. Precautions must be taken to avoid measurement errors which will impact emission value errors.

1.2.2. <u>Air and Fuel Measurement Method</u>

Measurement of the air flow and the fuel flow.

Air flowmeters and fuel flowmeters with an accuracy defined in paragraph 1.3 shall be used.
The calculation of the exhaust gas flow is as follows:

$$G_{EXHW} = G_{AIRW} + G_{FUEL} \quad \text{(for wet exhaust mass)}$$

or:

$$V_{EXHD} = V_{AIRD} - 0.766 \times G_{FUEL} \quad \text{(for dry exhaust volume)}$$

[redacted]

or:

$$V_{EXHW} = V_{AIRW} + 0.746 \times G_{FUEL} \quad \text{(for wet exhaust volume)}$$

1.2.3. Carbon Balance Method

Exhaust mass calculation from fuel consumption and exhaust gas concentrations using the carbon balance method (see Annex III, Appendix 3).

1.2.4. Total Dilute Exhaust Gas Flow

When using a full flow dilution system, the total flow of the dilute exhaust (G_{TOTW} , V_{TOTW}) shall be measured with a PDP or CFV - Annex V, paragraph 1.2.1.2. The accuracy shall conform to the provisions of Annex III, Appendix 2, paragraph 2.2.

1.3. Accuracy

The calibration of all measurement instruments shall be traceable to national (international) standards and comply with the following requirements:

Number	Item	Permissible Deviation (± Values based on Engines Maximum Values)	Permissible Deviation (± Values According to ISO 3046)	Calibration Intervals (Months)
1	Engine Speed	2%	2%	3
2	Torque	2%	2%	3
3	Power	2% ★	3%	not applicable
4	Fuel Consumption	2% ★	3%	6
5	Specific Fuel Consumption	not applicable	3%	not applicable
6	Air Consumption	2% ★	5%	6
7	Exhaust Gas Flow	4% ★	not applicable	6
8	Coolant Temperature	2K	2K	3
9	Lubricant Temperature	2K	2K	3
10	Exhaust Gas Pressure	5% of max	5%	3
11	Inlet Manifold Depressions	5% of max	5%	3
12	Exhaust Gas Temperature	15K	15K	3
13	Air Inlet Temperature (Combustion Air)	2K	2K	3
14	Atmospheric Pressure	0.5% of reading	0.5%	3

[redacted]

15	Intake Air Humidity (Relative)	3%	not applicable	1
16	Fuel Temperature	2K	5K	3
17	Dilution Tunnel Temperatures	1.5K	not applicable	3
18	Dilution Air Humidity	3%	not applicable	1
19	Diluted Exhaust Gas Flow	2% of reading	not applicable	24 (Partial flow) (full flow) **

Key:

* The calculations of the exhaust emissions as described in this Directive are, in some cases, based on different measurement and/or calculation methods. Because of limited total tolerances for the exhaust emission calculation, the allowable values for some items, used in the appropriate equations, must be smaller than the allowed tolerances given in ISO 3046-3

** Full flow systems - The CVS positive displacement pump or critical flow Venturi shall be calibrated following initial installation, major maintenance or as necessary when indicated by the CVS system verification described in Annex V.

1.4. Determination of the Gaseous Components

1.4.1. General Analyser Specifications

The analysers shall have a measuring range appropriate for the accuracy required to measure the concentrations of the exhaust gas components (paragraph 1.4.1.1). It is recommended that the analysers be operated such that the measured concentration falls between 15% and 100% of full scale.

If the full scale value is 155 ppm (or ppm C) or less or if read-out systems (computers, data loggers) that provide sufficient accuracy and resolution below 15% of full scale are used concentrations below 15% of full scale are also acceptable. In this case, additional calibrations are to be made to ensure the accuracy of the calibration curves - Annex III, Appendix 2, paragraph 1.5.5.2.

The electromagnetic compatibility (EMC) of the equipment shall be on a level as to minimise additional errors.

1.4.1.1. Measurement Error

The total measurement error, including the cross sensitivity to other gases - see Annex III, Appendix 2, paragraph 1.9 shall not exceed ±5% of the reading or 3.5 % of full scale, whichever is smaller. For concentrations of less than 100 ppm the measurement error shall not exceed ± 4 ppm.

[redacted]

1.4.1.2. Repeatability

The repeatability, defined as 2.5 times the standard deviation of ten repetitive responses to a given calibration or span gas, must be no greater than ±1% of full scale concentration for each range used above 155 ppm (or ppm C) or ±2% of each range used below 155 ppm (or ppm C).

1.4.1.3. Noise

The analyser peak-to-peak response to zero and calibration or span gases over any ten seconds period shall not exceed 2% of full scale on all ranges used.

1.4.1.4. Zero Drift

The zero drift during a one hour period shall be less than 2% of full scale on the lowest range used. The zero response is defined as the mean response, including noise, to a zero gas during a 30 seconds time interval.

1.4.1.5. Span Drift

The span drift during a one hour period shall be less than 2% of full scale on the lowest range used. Span is defined as the difference between the span response and the zero response. The span response is defined as the mean response, including noise, to a span gas during a 30 seconds time interval.

1.4.2. Gas Drying

The optional gas drying device must have a minimal effect on the concentration of the measured gases. Chemical dryers are not an acceptable method of removing water from the sample.

1.4.3. Analysers

Paragraphs 1.4.3.1 to 1.4.3.5 of this Appendix describe the measurement principles to be used. A detailed description of the measurement systems is given in Annex V.

The gases to be measured shall be analysed with the following instruments. For non-linear analysers, the use of linearising circuits is permitted.

1.4.3.1. Carbon Monoxide (CO) Analysis

The carbon monoxide analyser shall be of the Non-Dispersive Infra-Red (NDIR) absorption type.

1.4.3.2. Carbon Dioxide (CO_2) Analysis

The carbon dioxide analyser shall be of the Non-Dispersive Infra-Red (NDIR) absorption type.

[redacted]

[redacted]

1.4.3.3. Hydrocarbon (HC) Analysis

The hydrocarbon analyser shall be of the Heated Flame Ionisation Detector (HFID) type with detector, valves, pipework, etc, heated so as to maintain a gas temperature of 463K (190°C) ± 10K.

1.4.3.4. Oxides of Nitrogen (NO_x) Analysis)

The oxides of nitrogen analyser shall be of the ChemiLuminescent Detector (CLD) or Heated ChemiLuminescent Detector (HCLD) type with a NO_2/NO converter, if measured on a dry basis. If measured on a wet basis, a HCLD with converter maintained above 333K (60°C) shall be used, provided the water quench check (Annex III, Appendix 2, paragraph 1.9.2.2) is satisfied.

1.4.4. Sampling for Gaseous Emissions

The gaseous emissions sampling probes must be fitted at least 0.5m or three times the diameter of the exhaust pipe - whichever is the larger - upstream of the exit of the exhaust gas system as far as applicable and sufficiently close to the engine as to ensure an exhaust gas temperature of at least 343K (70°C) at the probe.

In the case of a multi-cylinder engine with a branched exhaust manifold, the inlet of the probe shall be located sufficiently far downstream so as to ensure that the sample is representative of the average exhaust emissions from all cylinders. In multi-cylinder engines having distinct groups of manifolds, such as in a 'V'-engine configuration, it is permissable to acquire a sample from each group individually and calculate an average exhaust emission. Other methods which have been shown to correlate with the above methods may be used. For exhaust emissions calculation the total exhaust mass flow of the engine must be used.

If the composition of the exhaust gas is influenced by any exhaust after-treatment system, the exhaust sample must be taken downstream of this device. When a full flow dilution system is used for the determination of the particulates, the gaseous emissions may also be determined in the diluted exhaust gas. The sampling probes shall be close to the particulate sampling probe in the dilution tunnel (Annex V, paragraph 1.2.1.2, DT and paragraph 1.2.2, PSP). CO and CO_2 may optionally be determined by sampling into a bag and subsequent measurement of the concentration in the sampling bag.

1.5. Determination of the Particulates

The determination of the particulates requires a dilution system.Dilution may be accomplished by a partial flow dilution system or a full flow dilution system. The flow capacity of the dilution system shall be large enough to completely eliminate water condensation in the dilution and sampling systems, and maintain the temperature of the diluted exhaust gas at or below 325K (52°C) immediately upstream of the filter holders. De-humidifying the dilution air before entering

[redacted]

[redacted]

the dilution system is permitted, if the air humidity is high. Dilution air pre-heating above the temperature limit of 303K (30°C) is recommended, if the ambient temperature is below 293K (20°C). However, the diluted air temperature must not exceed 325K (52°C) prior to the introduction of the exhaust in the dilution tunnel.

For a partial flow dilution system, the particulate sampling probe must be fitted close to and upstream of the gaseous probe as defined in paragraph 4.4 and in accordance with Annex V, paragraph 1.2.1.1, figures 4-12 EP and SP.

The partial flow dilution system has to be designed to split the exhaust stream into two fractions, the smaller one being diluted with air and subsequently used for particulate measurement. From that it is essential that the dilution ratio be determined very accurately. Different splitting methods can be applied, whereby the type of splitting used dictates to a significant degree the sampling hardware and procedures to be used (Annex V, paragraph 1.2.1.1).

To determine the mass of the particulates, a particulate sampling system, particulate sampling filters, a microgram balance and a temperature and humidity controlled weighing chamber are required.

For particulate sampling, two methods may be applied:

- <u>The Single Filter Method</u> uses one pair of filters (see paragraph 1.5.1.3 of this Appendix) for all modes of the test cycle. Considerable attention must be paid to sampling times and flows during the sampling phase of the test. However, only one pair of filters will be required for the test cycle.

- <u>The Multiple Filter Method</u> dictates that one pair of filters (see paragraph 1.5.1.3. of this Appendix) is used for each of the individual modes of the test cycle. This method allows more lenient sample procedures but uses more filters.

1.5.1. <u>Particulate Sampling Filters</u>

1.5.1.1. <u>Filter Specification</u>

Fluorocarbon coated glass fibre filters or fluorocarbon based membrane filters are required for certification tests. For special applications different filter materials may be used. All filter types shall have a 0.3 µm DOP (di-octylphthalate) collection efficiency of at least 95% at a gas face velocity between 35 and 80 cm/s. When performing correlation tests between laboratories or between a manufacturer and an approval authority, filters of identical quality must be used.

1.5.1.2. <u>Filter Size</u>

Particulate filters must have a minimum diameter of 47mm (37mm stain diameter). Larger diameter filters are acceptable (paragraph 1.5.1.5).

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1.5.1.3. Primary and Back-up Filters

The diluted exhaust shall be sampled by a pair of filters placed in series (one primary and one back-up filter) during the test sequence. The back-up filter shall be located no more than 100mm downstream of, and shall not be in contact with the primary filter. The filters may be weighed separately or as a pair with the filters placed stain side to stain side.

1.5.1.4. Filter Face Velocity

A gas face velocity through the filter of 35 to 80 cm/s shall be achieved.

1.5.1.5. Filter Loading

The recommended minimum filter loading shall be 0.5 mg/1075 mm^2 stain area for the single filter method. For the most common filter size the values are as follows:

Filter Diameter (mm)	Recommended Stain Diameter (mm)	Recommended Minimum Loading (mg)
47	37	0.5
70	60	1.3
90	80	2.3
110	100	3.6

For the multiple filter method, the recommended minimum filter loading for the sum of all filters shall be the product of the appropriate value above and the square root of the total number of modes.

1.5.2. Weighing Chamber and Analytical Balance Specifications

1.5.2.1. Weighing Chamber Conditions

The temperature of the chamber (or room) in which the particulate filters are conditioned and weighed shall be maintained to within 295K (22°C) ± 3K during all filter conditioning and weighing. The humidity shall be maintained to a dewpoint of 282.5 (9.5°C) ± 3K and a relative humidity of 45 ± 8%.

1.5.2.2. Reference Filter Weighing

The chamber (or room) environment shall be free of any ambient contaminants (such as dust) that would settle on the particulate filters during their stabilisation. Disturbances to weighing room specifications as outlined in paragraph 1.5.2.1 will be allowed if the duration of the disturbances does not exceed 30 minutes. The weighing room should meet the required specifications

[redacted]

prior to personnel entrance into the weighing room. At least two unused reference filters or reference filter pairs shall be weighed within four hours of, but preferably at the same time as the sample filter (pair) weighing. They shall be the same size and material as the sample filters.

If the average weight of the reference filters (reference filter pairs) changes between sample filter weighing by more than ±5% (±7.5% for the filter pair) of the recommended minimum filter loading (paragraph 1.5.1.5), then all sample filters shall be discarded and the emissions test repeated.

If the weighing room stability criteria outlined in paragraph 1.5.2.1 is not met, but the reference filter (pair) weighing meet the above criteria, the engine manufacturer has the option of accepting the sample filter weights or voiding the tests, fixing the weighing room control system and re-running the test.

1.5.2.3. <u>Analytical Balance</u>

The analytical balance used to determine the weights of all filters shall have a precision (standard deviation) of 20µg and a resolution of 10µg (1 digit = 10µg). For filters less than 70mm diameter, the precision and resolution shall be 2µg and 1µg, respectively.

1.5.2.4. <u>Elimination of Static Electricity Effects</u>

To eliminate the effects of static electricity, the filters shall be neutralised prior to weighing, for example, by a Polonium neutraliser or a device of similar effect.

1.5.3. <u>Additional Specifications for Particulate Measurement</u>

All parts of the dilution system and the sampling system from the exhaust pipe up to the filter holder, which are in contact with raw and diluted exhaust gas, must be designed to minimise deposition or alteration of the particulates. All parts must be made of electrically conductive materials that do not react with exhaust gas components, and must be electrically grounded to prevent electrostatic effects.

Appendix 2

1. **Calibration of the analytical instruments**

1.1. Introduction

Each analyser shall be calibrated as often as necessary to fulfil the accuracy requirements of this standard. The calibration method that shall be used is described in this paragraph for the analysers indicated in Appendix 1, paragraph 1.4.3.

1.2. Calibration Gases

The shelf life of all calibration gases must be respected.

The expiry date of the calibration gases stated by the manufacturer shall be recorded.

1.2.1. Pure Gases

The required purity of the gases is defined by the contamination limits given below. The following gases must be available for operation:

- Purified Nitrogen

  (Contamination ≤ 1 ppm C, ≤ 1 ppm CO, ≤ 400 ppm CO_2, ≤ 0.1 ppm NO)

- Purified Oxygen

  (Purity > 99.5% vol O_2)

- Hydrogen-Helium Mixture

  (40 ± 2% hydrogen, balance helium)

  (Contamination ≤ 1 ppm C, ≤ 400 ppm CO)

- Purified Synthetic Air

  (Contamination ≤ 1 ppm C, ≤ 1 ppm CO, ≤ 400 ppm CO_2, ≤ 0.1 ppm NO)
  (Oxygen content between 18-21% vol)

1.2.2. Calibration and Span Gases

Mixture of gases having the following chemical compositions shall be available:

- C_3H_8 and purified synthetic air (see paragraph 1.2.1)

- CO and purified nitrogen

- NO and purified nitrogen (the amount of NO_2 contained in this calibration gas must not exceed 5% of the NO content)
- O_2 and purified nitrogen
- CO_2 and purified nitrogen
- CH_4 and purified synthetic air
- C_2H_6 and purified synthetic air

Note: Other gas combinations are allowed provided the gases do not react with one another.

The true concentration of a calibration and span gas must be within ±2% of the nominal value. All concentrations of calibration gas shall be given on a volume basis (volume percent or volume ppm).

The gases used for calibration and span may also be obtained by means of a gas divider, diluting with purified N_2 or with purified synthetic air. The accuracy of the mixing device must be such that the concentration of the diluted calibration gases may be determined to within ±2%.

1.3. Operating Procedure for Analysers and Sampling System

The operating procedure for analysers shall follow the start-up and operating instructions of the instrument manufacturer. The minimum requirements given in paragraphs 1.4 to 1.9 shall be included.

1.4. Leakage Test

A system leakage test shall be performed. The probe shall be disconnected from the exhaust system and the end plugged. The analyser pump shall be switched on. After an initial stabilisation period all flow meters should read zero. If not, the sampling lines shall be checked and the fault corrected. The maximum allowable leakage rate on the vacuum side shall be 0.5% of the in-use flow rate for the portion of the system being checked. The analyser flows and bypass flows may be used to estimate the in-use flow rates.

Another method is the introduction of a concentration step change at the beginning of the sampling line by switching from zero to span gas.

If after an adequate period of time the reading shows a lower concentration compared to the introduced concentration, this points to calibration or leakage problems.

1.5. Calibration Procedure

1.5.1. Instrument Assembly

The instrument assembly shall be calibrated and calibration curves checked against standard gases. The same gas flow rates shall be used as when sampling exhaust.

1.5.2. Warming-up Time

The warming-up time should be according to the recommendations of the manufacturer. If not specified, a minimum of two hours is recommended for warming-up the analysers.

1.5.3. NDIR and HFID Analyser

The NDIR analyser shall be tuned, as necessary, and the combustion flame of the HFID analyser shall be optimised (paragraph 1.8.1).

1.5.4. Calibration

Each normally used operating range shall be calibrated.

Using purified synthetic air (or nitrogen), the CO, CO_2, NO_x, HC and O_2 analysers shall be set at zero.

The appropriate calibration gases shall be introduced to the analysers, the values recorded, and the calibration curve established according to paragraph 1.5.6.

The zero setting shall be re-checked and the calibration procedure repeated, if necessary.

1.5.5. Establishment of the Calibration Curve

1.5.5.1. General Guidelines

The analyser calibration curve is established by at least five calibration points (excluding zero) spaced as uniformly as possible. The highest nominal concentration must be equal to or higher than 90% of full scale.

The calibration curve is calculated by the method of least squares. If the resulting polynomial degree is greater than three, the number of calibration points (zero included) must be at least equal to this polynomial degree plus two.

The calibration curve must not differ by more than ±2% from the nominal value of each calibration point and by more than ±1% of full scale at zero.

From the calibration curve and the calibration points, it is possible to verify that the calibration has been carried out correctly. The different characteristic parameters of the analyser must be indicated, particularly:

- the measuring range
- the sensitivity
- the date of carrying out the calibration

1.5.5.2. Calibration Below 15% of Full Scale

The analyser calibration curve is established by at least ten calibration points (excluding zero) spaced so that 50% of the calibration points is below 10% of full scale.

The calibration curve is calculated by the method of least squares.

The calibration curve must not differ by more than ±4% from the nominal value of each calibration point and by more than ±1% of full scale at zero.

1.5.5.3. Alternative Methods

If it can be shown that alternative technology (eg. computer, electronically controlled range switch, etc) can give equivalent accuracy, then these alternatives may be used.

1.6. Verification of the Calibration

Each normally used operating range shall be checked prior to each analysis in accordance with the following procedure.

The calibration is checked by using a zero gas and a span gas whose nominal value is more than 80% of full scale of the measuring range.

If, for the two points considered, the value found does not differ by more than ±4% of full scale from the declared reference value, the adjustment parameters may be modified. Should this not be the case, a new calibration curve shall be established in accordance with paragraph 1.5.4.

1.7. Efficiency Test of the NO_x Converter

The efficiency of the converter used for the conversion of NO_2 into NO is tested as given in paragraphs 1.7.1 to 1.7.8 (Figure 1).

1.7.1. Test Set-up

Using the test set-up as shown in figure 1 (see also Appendix 1, paragraph 1.4.3.5) and the procedure below, the efficiency of converters can be tested by means of an ozonator.

[redacted]

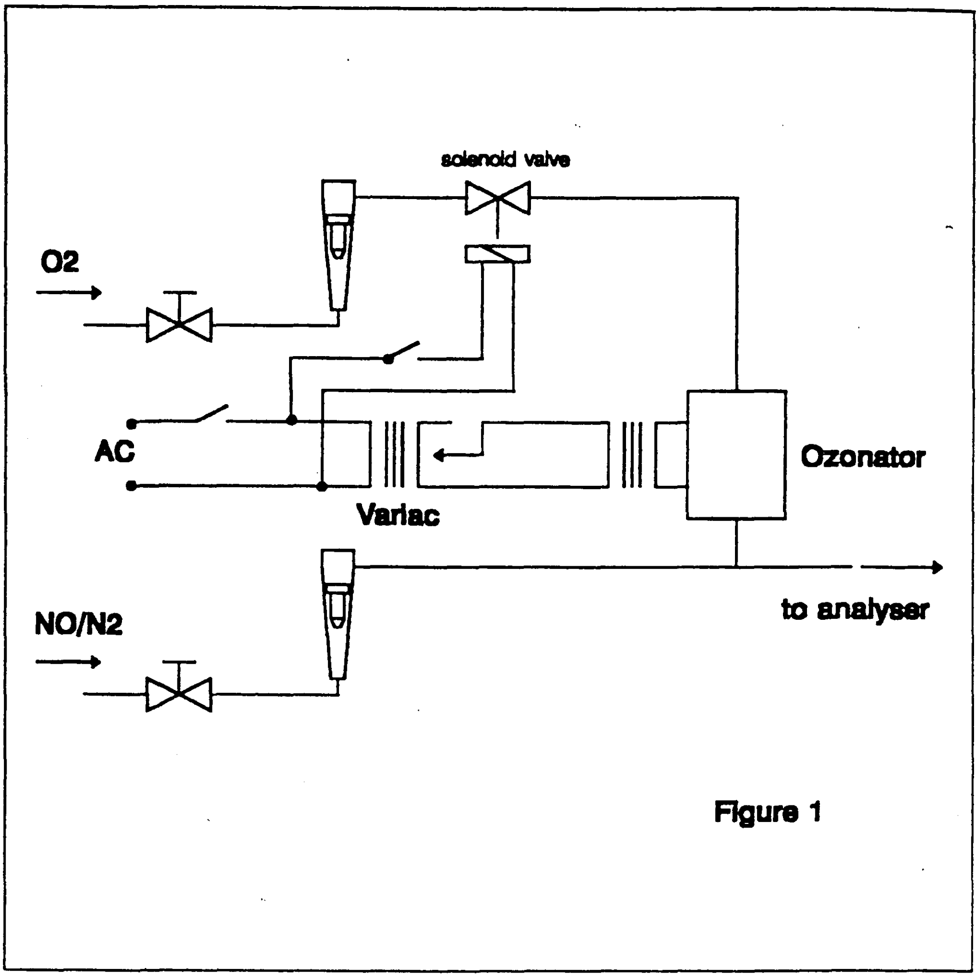

Figure 1 Schematic of NO_2 converter efficiency device

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[redacted]

1.7.2. Calibration

The CLD and the HCLD shall be calibrated in the most common operating range following the manufacturer's specifications using zero and span gas (the NO content of which must amount to about 80% of the operating range and the NO_2 concentration of the gas mixture to less than 5% of the NO concentration). The NO_x analyser must be in the NO mode so that the span gas does not pass through the converter. The indicated concentration has to be recorded.

1.7.3. Calculation

The efficiency of the NO_x converter is calculated as follows:

$$Efficiency\ (\%) = \left(1 + \frac{a-b}{c-d}\right) \times 100$$

(a) NO_x concentration according to paragraph 1.7.6;

(b) NO_x concentration according to paragraph 1.7.7;

(c) NO concentration according to paragraph 1.7.4;

(d) NO concentration according to paragraph 1.7.5.

1.7.4. Adding of Oxygen

Via a T-fitting, oxygen or zero air is added continuously to the gas flow until the concentration indicated is about 20% less than the indicated calibration concentration given in paragraph 1.7.2. (The analyser is in the NO mode.)

The indicated concentration (c) shall be recorded. The ozonator is kept deactivated throughout the process.

1.7.5. Activation of the Ozonator

The ozonator is now activated to generate enough ozone to bring the NO concentration down to about 20% (minimum 10%) of the calibration concentration given in paragraph 1.7.2. The indicated concentration (d) shall be recorded. (The analyser is in the NO mode.)

1.7.6. NO_x Mode

The NO analyser is then switched to the NO_x mode so that the gas mixture (consisting of NO, NO_2, O_2 and N_2) now passes through the converter. The indicated concentration (a) shall be recorded. (The analyser is in the NO_x mode.)

[redacted]

[redacted]

1.7.7. De-activation of the Ozonator

The ozonator is now de-activated. The mixture of gases described in paragraph 1.7.6 passes through the converter into the detector. The indicated concentration (b) shall be recorded. (The analyser is in the NO_x mode.)

1.7.8. NO Mode

Switched to NO mode with the ozonator de-activated, the flow of oxygen or synthetic air is also shut off. The NO_x reading of the analyser shall not deviate by more than ±5% from the value measured according to paragraph 1.7.2. (The analyser is in the NO mode.)

1.7.9. Test Interval

The efficiency of the converter must be tested prior to each calibration of the NO_x analyser.

1.7.10. Efficiency Requirement

The efficiency of the converter shall not be less than 90%, but a higher efficiency of 95% is strongly recommended.

Note: If, with the analyser in the most common range, the ozonator cannot give a reduction from 80% to 20% according to paragraph 1.7.5, then the highest range which will give the reduction shall be used.

1.8. Adjustment of the FID

1.8.1. Optimisation of the Detector Response

The HFID must be adjusted as specified by the instrument manufacturer. A propane in air span gas should be used to optimise the response on the most common operating range.

With the fuel and air flow rates set at the manufacturer's recommendations, a 350 ±75 ppm C span gas shall be introduced to the analyser. The response at a given fuel flow shall be determined from the difference between the span gas response and the zero gas response. The fuel flow shall be incrementally adjusted above and below the manufacturer's specification. The span and zero response at these fuel flows shall be recorded. The difference between the span and zero response shall be plotted and the fuel flow adjusted to the rich side of the curve.

1.8.2. Hydrocarbon Response Factors

The analyser shall be calibrated using propane in air and purified synthetic air, according to paragraph 1.5

[redacted]

[redacted]

Response factors shall be determined when introducing an analyser into service and after major service intervals. The response factor (R_f) for a particular hydrocarbon species is the ratio of the FID C1 reading to the gas concentration in the cylinder expressed by ppm C1.

The concentration of the test gas must be at a level to give a response of approximately 80% of full scale. The concentration must be known to an accuracy of ±2% in reference to a gravimetric standard expressed in volume. In addition, the gas cylinder must be pre-conditioned for 24 hours at a temperature of 298 (25°C) ± 5K.

The test gases to be used and the recommended relative response factor ranges are as follows:

- Methane and purified synthetic air: $1.00 \leq R_f \leq 1.15$
- Propylene and purified synthetic air: $0.90 \leq R_f \leq 1.1$
- Toluene and purified synthetic air: $0.90 \leq R_f \leq 1.10$

These values are relative to the response factor (R_f) of 1.00 for propane and purified synthetic air.

1.8.3. Oxygen Interference Check

The oxygen interference check shall be determined when introducing an analyser into service and after major service intervals.

The response factor is defined and shall be determined as described in paragraph 1.8.2. The test gas to be used and the recommended relative response factor range are as follows:

- Propane and nitrogen: $0.95 \leq R_f \leq 1.05$

This value is relative to the response factor (R_f) of 1.00 for propane and purified synthetic air.

The FID burner air oxygen concentration must be within ±1 mole % of the oxygen concentration of the burner air used in the latest oxygen interference check. If the difference is greater, the oxygen interference must be checked and the analyser adjusted, if necessary.

1.9. Interference Effects with NDIR and CLD Analysers

Gases present in the exhaust other than the one being analysed can interfere with the reading in several ways. Positive interference occurs in NDIR instruments where the interfering gas gives the same effect as the gas being measured, but to a lesser degree. Negative interference occurs in NDIR instruments by the interfering gas broadening the absorption band of the

[redacted]

measured gas, and in CLD instruments by the interfering gas quenching the radiation. The interference checks in paragraphs 1.9.1 and 1.9.2 shall be performed prior to an analyser's initial use and after major service intervals.

1.9.1. CO Analyser Interference Check

Water and CO_2 can interfere with the CO analyser performance. Therefore a CO_2 span gas having a concentration of 80 to 100% of full scale of the maximum operating range used during testing shall be bubbled through water at room temperature and the analyser response recorded. The analyser response must not be more than 1% of full scale for ranges equal to or above 300 ppm or more than 3 ppm for ranges below 300 ppm.

1.9.2. NO_x Analyser Quench Checks

The two gases of concern for CLD (and HCLD) analysers are CO_2 and water vapour. Quench responses of these gases are proportional to their concentrations, and therefore require test techniques to determine the quench at the highest expected concentrations experienced during testing.

1.9.2.1. CO_2 Quench Check

A CO_2 span gas having a concentration of 80 to 100% of full scale of the maximum operating range shall be passed through the NDIR analyser and the CO_2 value recorded as A. It shall then be diluted approximately 50% with NO span gas and passed through the NDIR and (H)CLD with the CO_2 and NO values recorded as B and C, respectively. The CO_2 shall be shut off and only the NO span gas be passed through the (H)CLD and the NO value recorded as D.

The quench shall be calculated as follows:

$$\%\ CO_2\ Quench = \left[1 - \left(\frac{(C x A)}{(D \times A) - (D x B)}\right)\right] x 100$$

and must not be greater than 3% of full scale.

where:

A: Undiluted CO_2 concentration measured with NDIR %

B: Diluted CO_2 concentration measured with NDIR %

C: Diluted NO concentration measured with CLD ppm

D: Undiluted NO concentration measured with CLD ppm

[redacted]

1.9.2.2. Water Quench Check

This check applies to wet gas concentration measurements only. Calculation of water quench must consider dilution of the NO span gas with water vapour and scaling of water vapour concentration of the mixture to that expected during testing. A NO span gas having a concentration of 80 to 100% of full scale to the normal operating range shall be passed through the (H)CLD and the NO value recorded as D. The NO gas shall be bubbled through water at room temperature and passed through the (H)CLD and the NO value recorded as C. The analyser's absolute operating pressure and the water temperature shall be determined and recorded as E and F, respectively. The mixture's saturation vapour pressure that corresponds to the bubbler water temperature (F) shall be determined and recorded as G. The water vapour concentration (in %) of the mixture shall be calculated as follows:

$$H = 100 \times \left(\frac{G}{E}\right)$$

and recorded as H. The expected diluted NO span gas (in water vapour) concentration shall be calculated as follows:

$$De = D \times \left(1 - \frac{H}{100}\right)$$

and recorded as De. For diesel exhaust, the maximum exhaust water vapour concentration (in%) expected during testing shall be estimated, under the assumption of a fuel atom H/C ratio of 1.8 to 1, from the undiluted CO_2 span gas concentration (A, as measured in paragraph 1.9.2.1) as follows:

$$Hm = 0.9 \times A$$

and recorded as Hm.

The water quench shall be calculated as follows:

$$\%\ H_2O\ Quench = 100 \times \left(\frac{De - C}{De}\right) \times \left(\frac{Hm}{H}\right)$$

and must not be greater than 3% of full scale

De:	Expected diluted NO concentration (ppm)
C:	Diluted NO concentration (ppm)
Hm:	Maximum water vapour concentration (%)
H:	Actual water vapour concentration (%)

[redacted]

Note:

It is important that the NO span gas contains minimal NO_2 concentration for this check, since absorbtion of NO_2 in water has not been accounted for in the quench calculations.

1.10. Calibration Intervals

The analysers shall be calibrated according to paragraph 1.5 at least every three months or whenever a system repair or change is made that could influence calibration.

2. Calibration of the Particulate Measuring System

2.1. Introduction

Each component shall be calibrated as often as necessary to fulfil the accuracy requirements of this standard. The calibration method to be used is described in this paragraph for the components indicated in Annex III, Appendix 1, paragraph 1.5 and Annex V.

2.2. Flow Measurement

The calibration of gas flowmeters or flow measurement instrumentation shall be traceable to national and/or international standards.

The maximum error of the measured value shall be within ±2% of reading.

If the gas flow is determined by differential flow measurement, the maximum error of the difference shall be such that the accuracy of G_{EDF} is within ±4% (see also Annex V, paragraph 1.2.1.1 EGA). It can be calculated by taking the root-mean-square of the errors of each instrument.

2.3. Checking the Dilution Ratio

When using particulate sampling systems without EGA (Annex V, paragraph 1.2.1.1), the dilution ratio shall be checked for each new engine installation with the engine running and the use of either the CO_2 or NO_x concentration measurements in the raw and dilute exhaust.

The measured dilution ratio shall be within ±10% of the calculated dilution ratio from CO_2 or NO_x concentration measurement.

2.4. Checking the Partial Flow Conditions

The range of the exhaust gas velocity and the pressure oscillations shall be checked and adjusted according to the requirements of Annex V, paragraph 1.2.1.1, EP, if applicable.

2.5. Calibration Intervals

The flow measurement instrumentation shall be calibrated at least every three months, or whenever a system change is made that could influence calibration.

Appendix 3

1. **Data Evaluation and Calculations**

1.1. Gaseous Emissions Data Evaluation

For the evaluation of the gaseous emissions, the chart reading of the last 60 seconds of each mode shall be averaged, and the average concentrations (conc) of HC, CO, NO_x and CO_2 if the carbon balance method is used, during each mode shall be determined from the average chart readings and the corresponding calibration data. A different type of recording can be used if it ensures an equivalent data acquisition.

The average background concentrations ($conc_d$) may be determined from the bag readings of the dilution air or from the continuous (non-bag) background reading and the corresponding calibration data.

1.2. Particulate Emissions

For the evaluation of the particulates, the total sample masses ($M_{SAM,i}$) or volumes ($V_{SAM,i}$) through the filters shall be recorded for each mode.

The filters shall be returned to the weighing chamber and conditioned for at least one hour, but not more than 80 hours, and then weighed. The gross weight of the filters shall be recorded and the tare weight (see paragraph 11.1) subtracted. The particulate mass (M_f for the single filter method; $M_{f,i}$ for the multiple filter method) is the sum of the particulate masses collected on the primary and back-up filters.

If background correction is to be applied, the dilution air mass (M_{DIL}) or volume (V_{DIL}) through the filters and the particulate mass (M_d) shall be recorded. If more than one measurement was made, the quotient M_d/M_{DIL} or M_d/V_{DIL} must be calculated for each single measurement and the values averaged.

1.3. Calculation of the Gaseous Emissions

The finally reported test results shall be derived through the following steps:

1.3.1. Determination of the Exhaust Gas Flow

The exhaust gas flow rate (G_{EXHW}, V_{EXHW} or V_{EXHD}) shall be determined for each mode according to Annex III, Appendix 1, paragraphs 1.2.1 to 1.2.3.

When using a full flow dilution system, the total dilute exhaust gas flow rate (G_{TOTW}, V_{TOTW}) shall be determined for each mode according to Annex III, Appendix 1, paragraph 1.2.4.

[redacted]

[redacted]

1.3.2. <u>Dry/Wet Correction</u>

When applying G_{EXHW}, V_{EXHW}, G_{TOTW} or V_{TOTW}, the measured concentration shall be converted to a wet basis according to the following formulae, if not already measured on a wet basis:

$$conc\ (wet) = k_w \times conc\ (dry)$$

For the raw exhaust gas:

$$k_{w,r,1} = \left(1 - F_{FH} \times \frac{G_{FUEL}}{G_{AIRD}}\right) - k_{w2}$$

or:

$$k_{w,r,2} = \left(\frac{1}{1 + 1.88 \times 0.005 \times (\%CO[dry] + \%CO_2[dry])}\right) - k_{w2}$$

For the diluted exhaust gas:

$$k_{w,e,1} = \left(1 - \frac{1.88 \times CO_2\%\ (wet)}{200}\right) - k_{w1}$$

or:

$$k_{w,e,2} = \left(\frac{1 - k_{w1}}{1 + \frac{1.88 \times CO_2\%\ (dry)}{200}}\right)$$

F_{FH} may be calculated by:

$$F_{FH} = \frac{1.969}{\left(1 + \frac{G_{FUEL}}{G_{AIRW}}\right)}$$

For the dilution air:

$$k_{w,d} = 1 - k_{w1}$$

[redacted]

[redacted]

$$k_{W1} = \frac{1.608 \times [H_d \times (1 - 1/DF) + H_a \times (1/DF)]}{1000 + 1.608 \times [H_d \times (1 - 1/DF) + H_a \times (1/DF)]}$$

$$H_d = \frac{6.22 \times R_d \times p_d}{p_B - p_d \times R_d \times 10^{-2}}$$

For the intake air (if different from the dilution air):

$$k_{W,a} = 1 - k_{W2}$$

$$k_{W2} = \frac{1.608 \times H_a}{1000 + (1.608 \times H_a)}$$

$$H_a = \frac{6.22 \times R_a \times p_a}{p_B - p_a \times R_a \times 10^{-2}}$$

where:

H_a: absolute humidity of the intake air, g water per kg dry air
H_d: absolute humidity of the dilution air, g water per kg dry air
R_d: relative humidity of the dilution air, %
R_a: relative humidity of the intake air, %
p_d: saturation vapour pressure of the dilution air, kPa
p_a: saturation vapour pressure of the intake air, kPa
p_B: total barometric pressure, kPa

1.3.3. <u>Humidity Correction for NO_x</u>

As the NO_x emission depends on ambient air conditions, the NO_x concentration shall be corrected for ambient air temperature and humidity by the factors K_H given in the following formula:

$$K_H = \frac{1}{1 + A \times (H_a - 10.71) + B \times (T_a - 298)}$$

where:
A: $0.309\ G_{Fuel} / G_{AIRD} - 0.0266$
B: $-0.209\ G_{Fuel} / G_{AIRD} + 0.00954$
T: temperatures of the air in K

[redacted]

[redacted]

$$\frac{G_{FUEL}}{G_{AIRD}} = \textit{Fuel air ratio (dry air basis)}$$

H_a: humidity of the intake air, g water per kg dry air:

$$H_a = \frac{6.220 \times R_a \times p_a}{p_B - p_a \times R_a \times 10^{-2}}$$

R_a: relative humidity of the intake air, %
p_a: saturation vapour pressure of the intake air, kPa
p_B: total barometric pressure, kPa

1.3.4. Calculation of Emission Mass Flow Rates

The emission mass flow rates for each mode shall be calculated as follows:

a) For the raw exhaust gas(1):

$$Gas_{mass} = u \times conc \times G_{EXHW}$$

or:

$$Gas_{mass} = v \times conc \times V_{EXHD}$$

or:

$$Gas_{mass} = w \times conc \times V_{EXHW}$$

b) For the dilute exhaust gas(1):

$$Gas_{mass} = u \times conc_c \times G_{TOTW}$$

or:

$$Gas_{mass} = w \times conc_c \times V_{TOTW}$$

where:

$conc_c$ is the background corrected concentration
$conc_c = conc - conc_d \times (1 - (1/DF))$
$DF = 13.4/(concCO_2 + (concCO + concHC) \times 10^{-4})$
or:

$DF = 13.4/concCO_2$

(1) In the case of NO_x, the NO_x cocentration (NO_xconc or NO_xconc$_c$) has to be multiplied by K_{HNOX} (humidity correction factor for NO_x quoted in the previous paragraph 1.3.3.) as follows:

$K_{HNOX} \cdot conc$ or $K_{HNOX} \cdot conc_c$

[redacted]

The coefficients u - wet, v - dry, w - wet shall be used according to the following table:

Gas	u	v	w	conc
NO_x	0.001587	0.002053	0.002053	ppm
CO	0.000966	0.00125	0.00125	ppm
HC	0.000479	-	0.000619	ppm
CO_2	15.19	19.64	19.64	percent

The density of HC is based upon an average carbon to hydrogen ratio of 1/1.85.

1.3.5. Calculation of the Specific Emissions

The specific emission (g/kWh) shall be calculated for all individual components in the following way:

$$Individual\ gas = \frac{\sum_{i=1}^{n} Gas_{mass_i} \times WF_i}{\sum_{i=1}^{n} P_i \times WF_i}$$

where $P_i = P_{m,i} + P_{AE,i}$

The weighting factors and the number of modes(n) used in the above calculation are according to Annex III, paragraph 3.6.1.

1.4. Calculation of the Particulate Emission

The particulate emission shall be calculated in the following way:

1.4.1. Humidity Correction Factor for Particulates

As the particulate emission of diesel engines depends on ambient air conditions, the particulate mass flow rate shall be corrected for ambient air humidity with the factor K_p given in the following formula:

$$K_p = 1/(1 + 0.0133 \times (H_a - 10.71))$$

H_a = humidity of the intake air, grammes of water per kg dry air

$$H_a = \frac{6.22 \times R_a \times p_a}{p_B - p_a \times R_a \times 10^{-2}}$$

R_a = relative humidity of the intake air, %

p_a = saturation vapour pressure of the intake air, kPa

p_B = total barometric pressure, kPa

1.4.2. Partial Flow Dilution System

The final reported test results of the particulate emission shall be derived through the following steps. Since various types of dilution rate control may be used, different calculation methods for equivalent diluted exhaust gas mass flow rate G_{EDF} or equivalent diluted exhaust gas volume flow rate V_{EDF} apply. All calculations shall be based upon the average values of the individual modes (i) during the sampling period.

1.4.2.1. Isokinetic Systems

$$G_{EDFW,i} = G_{EXHW,i} \times q_i$$

or:

$$V_{EDFW,i} = V_{EXHW,i} \times q_i$$

$$q_i = \frac{G_{DILW,i} + (G_{EXHW,i} \times r)}{(G_{EXHW,i} \times r)}$$

or:

$$q_i = \frac{V_{DILW,i} + (V_{EXHW,i} \times r)}{(V_{EXHW,i} \times r)}$$

where r corresponds to the ratio of the cross sectional areas of the isokinetic probe A_p and the exhaust pipe A_T:

$$r = \frac{A_p}{A_T}$$

[redacted]

1.4.2.2. Systems with Measurement of CO_2 or NO_x Concentration

$$G_{EDFW,i} = G_{EXHW,i} \times q_i$$

or:

$$V_{EDFW,i} = V_{EXHW,i} \times q_i$$

$$q_i = \frac{Conc_{E,i} - Conc_{A,i}}{Conc_{D,i} - Conc_{A,i}}$$

where:

$Conc_E$ = wet concentration of the tracer gas in raw exhaust
$Conc_D$ = wet concentration of the tracer gas in the diluted exhaust
$Conc_A$ = wet concentration of the tracer gas in the dilution air

Concentrations measured on a dry basis shall be converted to a wet basis according to paragraph 1.3.2. of this Appendix.

1.4.2.3. Systems with CO_2 Measurement and Carbon Balance Method

$$G_{EDFW,i} = \frac{206.6 \times G_{FUEL,i}}{CO_{2D,i} - CO_{2A,i}}$$

where:

CO_{2D} = CO_2 concentration of the diluted exhaust

CO_{2A} = CO_2 concentration of the dilution air

(concentrations in volume % on wet basis)

This equation is based upon the carbon balance assumption (carbon atoms supplied to the engine are emitted as CO_2) and derived through the following steps:

$$G_{EDFW,i} = G_{EXHW,i} \times q_i$$

and:

$$q_i = \frac{206.6 \times G_{FUEL,i}}{G_{EXHW,i} \times (CO_{2D,i} - CO_{2A,i})}$$

[redacted]

[redacted]

1.4.2.4. <u>Systems with Flow Measurement</u>

$$G_{EDFW,i} = G_{EXHW,i} \times q_i$$

$$q_i = \frac{G_{TOTW,i}}{(G_{TOTW,i} - G_{DILW,i})}$$

1.4.3. <u>Full Flow Dilution System</u>

The final reported test results of the particulate emission shall be derived through the following steps.
All calculations shall be based upon the average values of the individual modes (i) during the sampling period.

$$G_{EDFW,i} = G_{TOTW,i}$$

or:

$$V_{EDFW,i} = V_{TOTW,i}$$

1.4.4. <u>Calculation of the Particulate Mass Flow Rate</u>

The particulate mass flow rate shall be calculated as follows:

For the Single Filter Method:

$$PT_{mass} = \frac{M_f}{M_{SAM}} \times \frac{(G_{EDFW})_{aver}}{1000}$$

or:

$$PT_{mass} = \frac{M_f}{V_{SAM}} \times \frac{(V_{EDFW})_{aver}}{1000}$$

where:

$(G_{EDFW})_{aver}$, $(V_{EDFW})_{aver}$, $(M_{SAM})_{aver}$, $(V_{SAM})_{aver}$ over the test cycle shall be determined by summation of the average values of the individual modes during the sampling period:

$$(G_{EDFW})_{aver} = \sum_{i=1}^{n} G_{EDFW,i} \times WF_i$$

$$(V_{EDFW})_{aver} = \sum^{n} V_{EDFW,i} \times WF_i$$

[redacted]

[redacted]

$$M_{SAM} = \sum_{i=1}^{n} M_{SAM,i}$$

$$V_{SAM} = \sum_{i=1}^{n} V_{SAM,i}$$

where i = 1,... n

For the Multiple Filter Method:

$$PT_{mass,i} = \frac{M_{f,i}}{M_{SAM,i}} \times \frac{(G_{EDFW,i})}{1000}$$

or:

$$PT_{mass,i} = \frac{M_{f,i}}{V_{SAM,i}} \times \frac{(V_{EDFW,i})}{1000}$$

where i = 1,...n

The particulate mass flow rate may be background corrected as follows:

For Single Filter Method:

$$PT_{mass} = \left[\frac{M_f}{M_{SAM}} - \left(\frac{M_d}{M_{DIL}} \times \left(1 - \frac{1}{DF}\right)\right)\right] \times \left[\frac{(G_{EDFW})_{aver}}{1000}\right]$$

or:

$$PT_{mass} = \left[\frac{M_f}{V_{SAM}} - \left(\frac{M_d}{V_{DIL}} \times \left(1 - \frac{1}{DF}\right)\right)\right] \times \left[\frac{(V_{EDFW})_{aver}}{1000}\right]$$

If more than one measurement is made, (M_d/M_{DIL}) or (M_d/V_{DIL}) shall be replaced with $(M_d/M_{DIL})_{aver}$ or $(M_d/V_{DIL})_{aver}$, respectively.

$$DF = \frac{13.4}{concCO_2 + (concCO + concHC) \times 10^{-4}}$$

or:

[redacted]

[redacted]

$$DF = 13.4/concCO_2$$

For Multiple Filter Method:

$$PT_{mass,\,i} = \left[\frac{M_{f,\,i}}{M_{SAM,\,i}} - \left(\frac{M_d}{M_{DIL}} \times \left(1 - \frac{1}{DF}\right)\right)\right] \times \left[\frac{G_{EDFW,\,i}}{1000}\right]$$

or:

$$PT_{mass,\,i} = \left[\frac{M_{f,\,i}}{V_{SAM,\,i}} - \left(\frac{M_d}{V_{DIL}} \times \left(1 - \frac{1}{DF}\right)\right)\right] \times \left[\frac{V_{EDFW,\,i}}{1000}\right]$$

If more than one measurement is made, (M_d/M_{DIL}) or (M_d/V_{DIL}) shall be replaced with $(M_d/M_{DIL})_{aver}$ or $(M_d/V_{DIL})_{aver}$, respectively.

$$DF = \frac{13.4}{concCO_2 + (concCO + concHC) \times 10^{-4}}$$

or:

$$DF = 13.4/concCO_2$$

1.4.5. Calculation of the Specific Emissions

The specific emission of particulates PT (g/kWh) shall be calculated in the following way([1]):

For the single filter method:

$$PT = \frac{PT_{mass}}{\sum_{i=1}^{n} P_i \times WF_i}$$

(1) The Particulate mass flow rate PT_{mass} has to be multiplied by K_p (humidity correction factor for particulates quoted in paragraph 1.4.1.).

[redacted]

[redacted]

For the multiple filter method:

$$PT = \frac{\sum_{i=1}^{n} PT_{mass,i} \times WF_i}{\sum_{i=1}^{n} P_i \times WF_i}$$

$$P_i = P_{m,i} + P_{AE,i}$$

1.4.6. Effective Weighting Factor

For the single filter method, the effective weighting factor $WF_{E,i}$ for each mode shall be calculated in the following way:

$$WF_{E,i} = \frac{M_{SAM,i} \times (G_{EDFW})_{aver}}{M_{SAM} \times (G_{EDFW,i})}$$

or:

$$WF_{E,i} = \frac{V_{SAM,i} \times (V_{EDFW})_{aver}}{V_{SAM} \times (V_{EDFW,i})}$$

where $i = 1,...n$

The value of the effective weighting factors shall be within ±0.005 (absolute value) of the weighting factors listed in Annex III, paragraph 3.6.1.

[redacted]

[redacted]

ANNEX IV

TECHNICAL CHARACTERISTICS OF REFERENCE FUEL PRESCRIBED FOR APPROVAL TESTS AND TO VERIFY CONFORMITY OF PRODUCTION

NON-ROAD MOBILE MACHINERY REFERENCE FUEL (1)

Note: Key properties for engine performance/exhaust emissions are highlighted.

	Limits and Units (2)	Test Method
Cetane Number (4)	min. 45 (7) max. 50	ISO 5165
Density at 15°C	min. 835 kg/m³ max. 845 kg/m³ (10)	ISO 3675, ASTM D4052
Distillation (3) - 95% point	Maximum 370°C	ISO 3405
Viscosity at 40°C	Minimum 2.5 mm²/s Maximum 3.5 mm²/s	ISO 3104
Sulphur content	Minimum 0.1% mass (9) Maximum 0.2% mass (8)	ISO 8754, EN 24260
Flash Point	Minimum 55°C	ISO 2719
CFPP	Minimum - Maximum +5°C	EN 116
Copper corrosion	Maximum: 1	ISO 2160
Conradson carbon residue (10% DR)	Maximum 0.3% mass	ISO 10370
Ash content	Maximum 0.01% mass	ASTM D482 (12)
Water content	Maximum 0.05% mass	ASTM D95, D1744
Neutralisation (strong acid) number	Minimum 0.20 mg KOH/g	
Oxidation stability (5)	Maximum 2.5 mg/100 ml	ASTM D2274
Additives (6)		

[redacted]

Note 1: If it is required to calculate thermal efficiency of an engine or vehicle, the calorific value of the fuel can be calculated from:

Specific energy (calorific value) (net) MJ/kg =

$$(46.423 - 8.792 \cdot d^2 + 3.17 \cdot d) \times (1 - (x + y + s)) + 9.42 \cdot s - 2.499 \cdot x$$

where:

- d is the density at 288 K (15°C)
- x is the proportion by mass of water (%/100)
- y is the proportion by mass of ash (%/100)
- s is the proportion by mass of sulphur (%/100)

Note 2: The values quoted in the specification are "true values". In establishment of their limit values the terms of ASTM D3244 "Defining a basis for petroleum produce quality disputes" have been applied and in fixing a minimum value, a minimum difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (R = reproducibility).

Notwithstanding this measure, which is necessary for statistical reasons, the manufacturer of fuel should nevertheless aim at a zero value where the stipulated maximum value is 2R and at the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify the question as to whether a fuel meets the requirements of the specifications, the terms of ASTM D3244 should be applied.

Note 3: The figures quoted show the evaporated quantities (percentage recovered + percentage loss).

Note 4: The range of cetane is not in accordance with the requirement of a minimum range of 4R. However, in cases of dispute between fuel supplier and fuel user, the terms in ASTM D3244 can be used to resolve such disputes provided replicate measurements, of sufficient number to achieve the necessary precision, are made in preference to single determinations.

Note 5: Even though oxidation stability is controlled, it is likely that shelf life will be limited. Advice should be sought from the supplier as to storage conditions and life.

Note 6: This fuel should be based straight run and cracked hydrocarbon distillate components only; desulphurization is allowed. It must not contain any metallic additives or cetane improver additives.

Note 7: Lower values are permitted, in which case the cetane number of the reference fuel used is to be reported.

[redacted]

Note 8: Higher values are permitted, in which case the sulphur content of the reference fuel used is to be reported.

Note 9: To be kept under constant review in the light of trends in the markets. For measurements to prove compliance with the limit values as set out in the table in section 4.2.3. of Annex I to this Directive (Stage II), 0.05% mass sulphur minimum is permissible.

Note 10: Higher values are permitted up to 855 kg/m³, in which case the density of the reference fuel used is to be reported.

Note 11: All fuel characteristics and limit values are to be kept under review in light of trends in the markets.

Note 12: To be replaced by EN/ISO 6245 with effect of the date of implementation

[redacted]

[redacted]

ANNEX V

1. Analytical and Sampling System

Gaseous and particulate sampling systems

Figure Number	Description
2	Exhaust gas analysis system for raw exhaust;
3	Exhaust gas analysis system for dilute exhaust;
4	Partial flow, isokinetic flow, suction blower control, fractional sampling;
5	Partial flow, isokinetic flow, pressure blower control, fractional sampling;
6	Partial flow, CO_2 or NO_x control, fractional sampling;
7	Partial flow, CO_2 and carbon balance, total sampling;
8	Partial flow, single venturi and concentration measurement, fractional sampling;
9	Partial flow, twin venturi or orifice and concentration measurement, fractional sampling;
10	Partial flow, multiple tube splitting and concentration measurement, fractional sampling;
11	Partial flow, flow control, total sampling;
12	Partial flow, flow control, fractional sampling;
13	Full flow, positive displacement pump or critical flow venturi, fractional sampling;
14	Particulate sampling system;
15	Dilution system for full flow system.

1.1. Determination of the Gaseous Emissions

Paragraph 1.1.1 and figures 2 and 3 contain detailed descriptions of the recommended sampling and analysing systems. Since various configurations can produce equivalent results, exact conformance with these figures is not

[redacted]

[redacted]

required. Additional components such as instruments, valves, solenoids, pumps and switches may be used to provide additional information and co-ordinate the functions of the component systems. Other components which are not needed to maintain the accuracy on some systems, may be excluded if their exclusion is based upon good engineering judgement.

1.1.1. Gaseous Exhaust Components CO, CO_2, HC, NO_x

An analytical system for the determination of the gaseous emissions in the raw or diluted exhaust gas is described based on the use of:

- HFID analyser for the measurement of hydrocarbons;
- NDIR analysers for the measurement of carbon monoxide and carbon dioxide;
- HCLD or equivalent analyser for the measurement of nitrogen oxide.

For the *raw exhaust gas* (see figure 2), the sample for all components may be taken with one sampling probe or with two sampling probes located in close proximity and internally split to the different analysers. Care must be taken that no condensation of exhaust components (including water and sulphuric acid) occurs at any point of the analytical system.

For the *diluted exhaust gas* (see figure 3), the sample for the hydrocarbons shall be taken with another sampling probe than the sample for the other components. Care must be taken that no condensation of exhaust components (including water and sulphuric acid) occurs at any point of the analytical system.

[redacted]

[redacted]

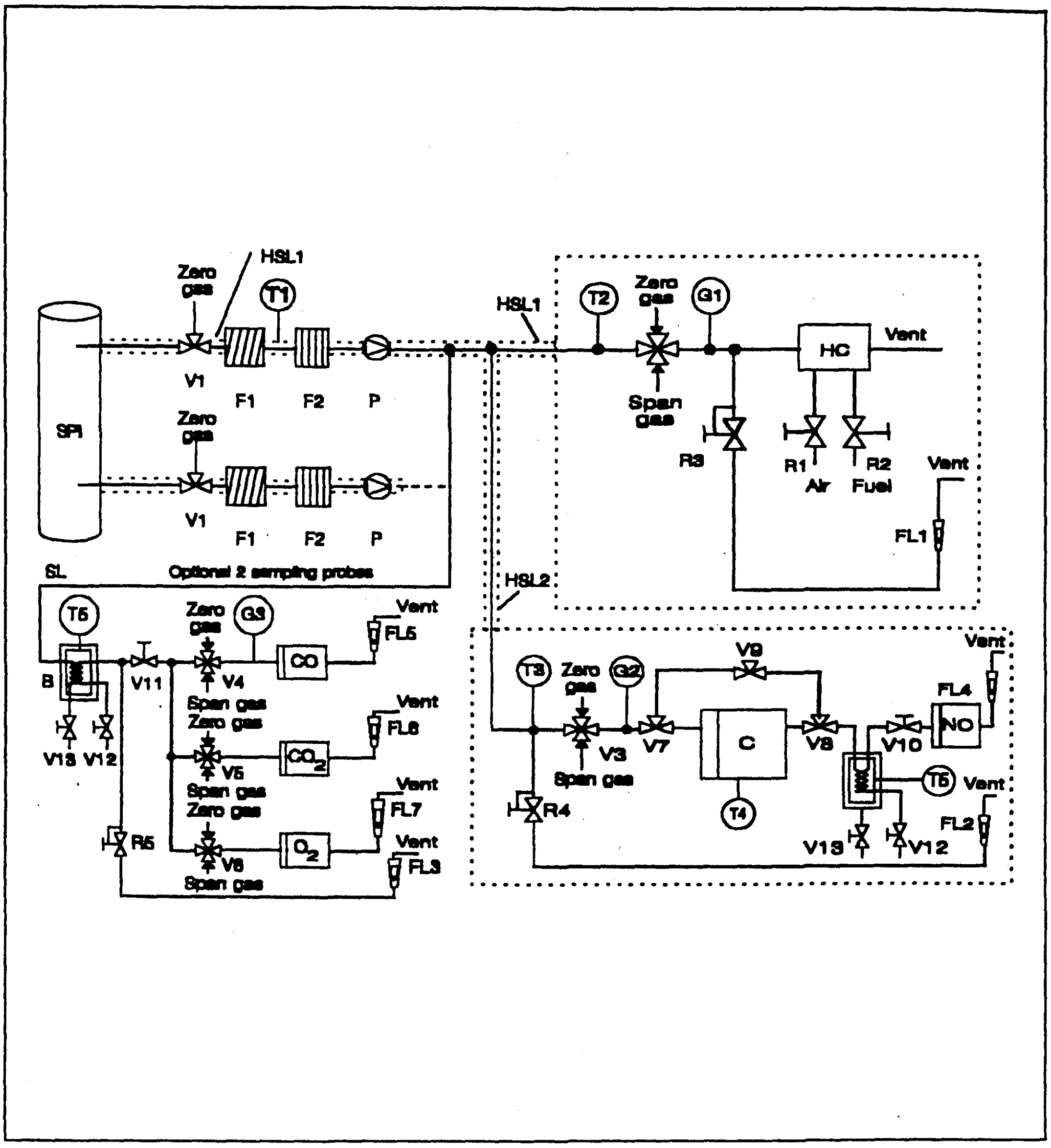


Figure 2 Flow Diagram of Exhaust Gas Analysis System for CO, NO_x and HC

[redacted]

[redacted]

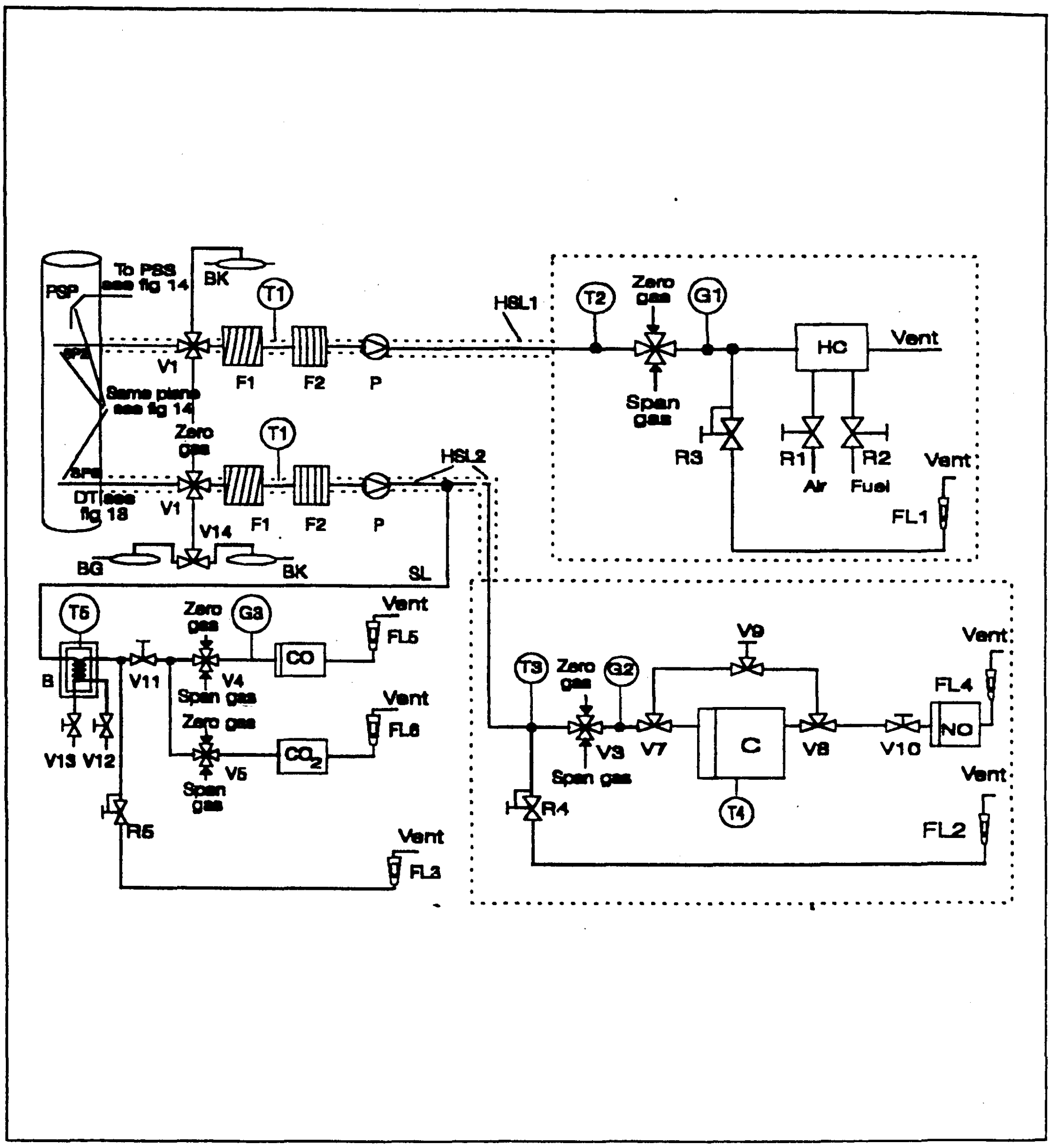


Figure 3 Flow Diagram of Dilute Exhaust Gas Analysis System for CO, CO_2, NO_x and HC

[redacted]

Descriptions - Figures 2 and 3

General statement:

All components in the sampling gas path must be maintained at the temperature specified for the respective systems.

- SP1 Raw Exhaust Gas Sampling Probe (figure 2 only)

  A stainless steel straight closed end multi-hole probe is recommended. The inside diameter shall not be greater than the inside diameter of the sampling line. The wall thickness of the probe shall not be greater than 1mm. There shall be a minimum of three holes in three different radial planes sized to sample approximately the same flow. The probe must extend across at least 80% of the diameter of the exhaust pipe.

- SP2 Dilute Exhaust Gas HC Sampling Probe (figure 3 only)

  The probe shall

  - Be defined as the first 254mm to 762mm of the hydrocarbon sampling line (HSL3);
  - Have a 5mm minimum inside diameter;
  - Be installed in the dilution tunnel DT (paragraph 1.2.1.2) at a point where the dilution air and exhaust gas are well mixed (ie. approximately 10 tunnel diameters downstream of the point where the exhaust enters the dilution tunnel);
  - Be sufficiently distant (radially) from other probes and the tunnel wall so as to be free from the influence of any wakes or eddies;
  - Be heated so as to increase the gas stream temperature to 463K (190°C) ± 10K at the exit of the probe.

- SP3 Dilute Exhaust Gas CO, CO_2, NO_x Sampling Probe (figure 3 only)

  The probe shall:

  - Be in the same plane as SP2;
  - Be sufficiently distant (radially) from other probes and the tunnel wall so as to be free from the influence of any wakes or eddies;
  - Be heated and insulated over its entire length to a minimum temperature of 328K (55°C) to prevent water condensation.

- HSL1 Heated Sampling Line

The sampling line provides gas sampling from a single probe to the split point(s) and the HC analyser.

The sampling line shall:

- Have a 5mm minimum and a 13,5mm maximum inside diameter;

- Be made of stainless steel or PTFE;

- Maintain a wall temperature of 463 (190°C) ± 10K as measured at every separately controlled heated section, if the temperature of the exhaust gas at the sampling probe is equal or below 463K (190°C);

- Maintain a wall temperature greater than 453K (180°C) if the temperature of the exhaust gas at the sampling probe is above 463K (190°C);

- Maintain a gas temperature of 463K (190°C) ± 10K immediately before the heated filter (F2) and the HFID.

- HSL2 Heated NO_x Sampling Line

The sampling line shall:

- Maintain a wall temperature of 328 to 473K (55 to 200°C) up to the converter when using a cooling bath, and up to the analyser when a cooling bath is not used;

- Be made of stainless steel or PTFE;

  Since the sampling line need only be heated to prevent condensation of water and sulphuric acid, the sampling line temperature will depend on the sulphur content of the fuel.

- SL Sampling Line for CO (CO_2)

The line shall be made of PTFE or stainless steel. It may be heated or unheated.

- BK Background Bag (optional; Figure 3 only)

For the measurement of the background concentrations.

- BG Sample Bag (optional; Figure 3 CO and CO_2 only)

For the measurement of the sample concentrations.

[redacted]

- F1 Heated Pre-Filter (Optional)

  The temperature shall be the same as HSL1

- F2 Heated Filter

  The filter shall extract any solid particles from the gas sample prior to the analyser. The temperature shall be the same as HSL1. The filter shall be changed as needed.

- P Heated Sampling Pump

  The pump shall be heated to the temperature of HSL1.

- HC

  Heated flame ionisation detector (HFID) for the determination of the hydrocarbons. The temperature shall be kept at 453 to 473K (180 to 200°C).

- CO, CO_2

  NDIR analysers for the determination of carbon monoxide and carbon dioxide.

- NO_2

  (H)CLD analyser for the determination of the oxides of nitrogen. If a HCLD is used it shall be kept at a temperature of 328 to 473K (55 to 200°C).

- C Converter

  A converter shall be used for the catalytic reduction of NO_2 to NO prior to analysis in the CLD or HCLD.

- B Cooling Bath

  To cool and condense water from the exhaust sample. The bath shall be maintained at a temperature of 273 to 277K (0 to 4°C) by ice or refrigeration. It is optional if the analyser is free from water vapour interference as determined in Annex III, Appendix 3, paragraphs 1.9.1 and 1.9.2.

  Chemical dryers are not allowed for removing water from the sample.

- T1, T2, T3 Temperature Sensor

  To monitor the temperature of the gas stream.

[redacted]

- T4 Temperature Sensor

  Temperature of the NO_2 - NO converter.

- T5 Temperature Sensor

  To monitor the temperature of the cooling bath.

- G1, G2, G3 Pressure Gauge

  To measure the pressure in the sampling lines.

- R1, R2 Pressure Regulator

  To control the pressure of the air and the fuel, respectively, for the HFID.

- R3, R4, R5 Pressure Regulator

  To control the pressure in the sampling lines and the flow to the analysers.

- FL1, FL2, FL3 Flowmeter

  To monitor the sample bypass flow.

- FL4 to FL7 Flowmeter (optional

  To monitor the flow rate through the analysers

- V1 to V6 Selector Valve

  Suitable valving for selecting sample, span gas or zero gas flow to the analyser.

- V7, V8 Solenoid Valve

  To bypass the NO_2 - NO converter.

- V9 Needle Valve

  To balance the flow through the NO_2 - NO converter and the bypass.

- V10, V11 Needle Valve

  To regulate the flows to the analysers.

- V12, V13 Toggle Valve

  To drain the condensate from the Bath B.

- V14 Selector Valve

  Selecting the sample or background bag.

1.2. Determination of the Particulates

Paragraphs 1.2.1 and 1.2.2 and figures 4 to 15 contain detailed descriptions of the recommended dilution and sampling systems. Since various configurations can produce equivalent results, exact conformance with these figures is not required. Additional components such as instruments, valve, solenoids, pumps and switches may be used to provide additional information and co-ordinate the functions of the component systems. Other components which are not needed to maintain the accuracy on some systems, may be excluded if their exclusion is based upon good engineering judgement.

1.2.1. Dilution System

1.2.1.1. Partial Flow Dilution System (Figures 4 to 12)

A dilution system is described based upon the dilution of a part of the exhaust stream. Splitting of the exhaust stream and the following dilution process may be done by different dilution system types. For subsequent collection of the particulates, the entire dilute exhaust gas or only a portion of the dilute exhaust gas may be passed to the particulate sampling system (paragraph 1.2.2, figure 14). The first method is referred to as total sampling type, the second method as fractional sampling type.

The calculation of the dilution ratio depends upon the type of system used. The following types are recommended:

- Isokinetic Systems (figures 4 and 5)

  With these systems, the flow into the transfer tube is matched to the bulk exhaust flow in terms of gas velocity and/or pressure, thus requiring an undisturbed and uniform exhaust flow at the sampling probe. This is usually achieved by using a resonator and a straight approach tube upstream of the sampling point. The split ratio is then calculated from easily measurable values like tube diameters. It should be noted that isokinesis is only used for matching the flow conditions and not for matching the size distribution. The latter is typically not necessary, as the particles are sufficiently small as to follow the fluid streamlines.

- Flow Controlled Systems with Concentration Measurement (figures 6 to 10)

  With these systems, a sample is taken from the bulk exhaust stream by adjusting the dilution air flow and the total dilution exhaust flow. The dilution ratio is determined from the concentrations of tracer gases, such as CO_2 or NO_x , naturally occurring in the engine exhaust. The concentrations in the dilution exhaust gas and in the dilution air are measured, whereas the concentration in the raw exhaust gas can be either measured directly or determined from fuel flow and the carbon balance equation, if the fuel composition is known. The systems may be controlled by the calculated dilution ratio (figures 6 and 7) or by the flow into the transfer tube (figures 8, 9 and 10).

- Flow Controlled Systems with Flow Measurement (figures 11 and 12)

With these systems, a sample is taken from the bulk exhaust stream by setting the dilution air flow and the total dilution exhaust flow. The dilution ratio is determined from the difference of the two flow rates. Accurate calibration of the flow meters relative to one another is required, since the relative magnitude of the two flow rates can lead to significant errors at higher dilution ratios (figures 9 and above). Flow control is very straightforward by keeping the dilute exhaust flow rate constant and varying the dilution air flow rate, if needed.

In order to realise the advantages of the partial flow dilution systems, attention must be paid to avoiding the potential problems of loss of particulates in the transfer tube, ensuring that a representative sample is taken from the engine exhaust, and determination of the split ratio.

The systems described pay attention to these critical areas.

[redacted]

Figure 4 Partial Flow Dilution System with Isokinetic Probe and Fractional Sampling (SB Control)

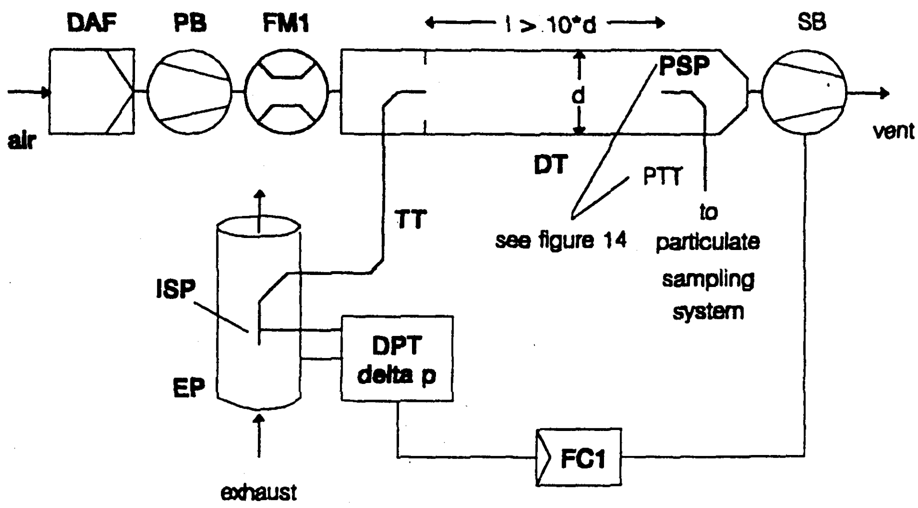


Figure 4

Raw exhaust gas is transferred from the exhaust pipe to EP to the dilution tunnel DT through the transfer tube TT by the isokinetic sampling probe ISP. The differential pressure of the exhaust gas between exhaust pipe and inlet to the probe is measured with the pressure transducer DPT. This signal is transmitted to the flow controller FC1 that controls the suction blower SB to maintain a differential pressure of zero at the tip of the probe. Under these conditions, exhaust gas velocities in EP and ISP are identical, and the flow through ISP and TT is a constant fraction (split) of the exhaust gas flow. The split ratio is determined from the cross sectional areas of EP and ISP. The dilution air flow rate is measured with the flow measurement device FM1. The dilution ratio is calculated from the dilution air flow rate and the split ratio.

[redacted]

Figure 5 Partial Flow Dilution System with Isokinetic Probe and Fractional Sampling (PB Control)

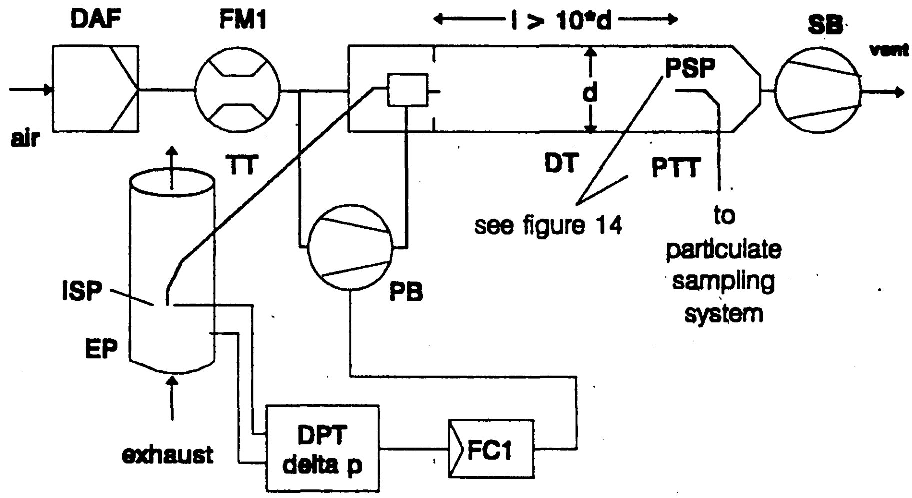


Figure 5

Raw exhaust gas is transferred from the exhaust pipe EP to the dilution tunnel DT through the transfer tube TT by the isokinetic sampling probe ISP. The differential pressure of the exhaust gas between exhaust pipe and inlet to the probe is measured with the pressure transducer DPT. This signal is transmitted to the flow controller FC1 that controls the pressure blower PB to maintain a differential pressure of zero at the tip of the probe. This is done by taking a small fraction of the dilution air whose flow rate has already been measured with the flow measurement device FM1, and feeding it to TT by means of a pneumatic orifice. Under these conditions, exhaust gas velocities in EP and ISP are identical, and the flow through ISP and TT is a constant fraction (split) of the exhaust gas flow. The split ratio is determined from the cross sectional areas of EP and ISP. The dilution air is sucked through DT by the suction blower SB, and the flow rate is measured with FM1 at the inlet to DT. The dilution ratio is calculated from the dilution air flow rate and the split ratio.

Figure 6 Partial Flow Dilution System with CO_2 or NO_x Concentration Measurement and Fractional Sampling

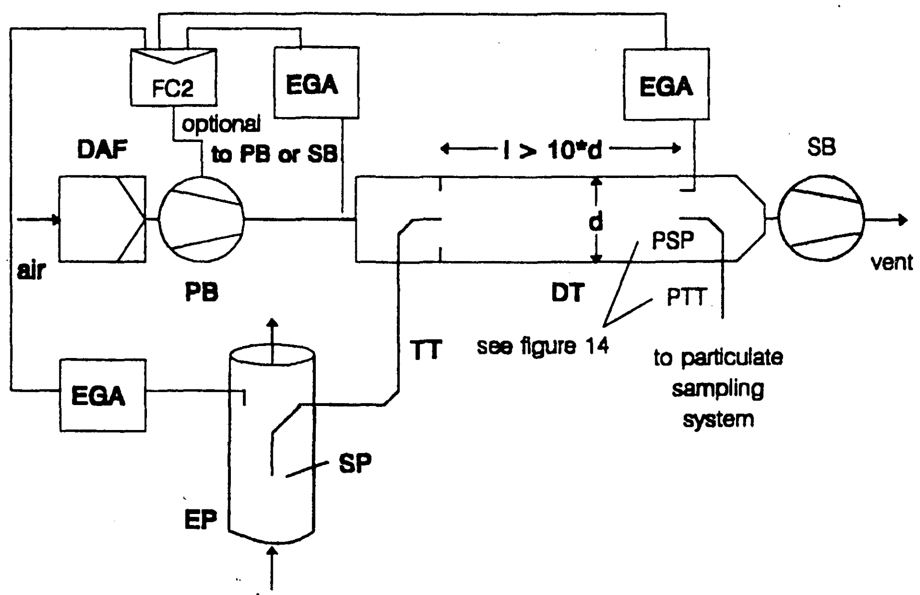
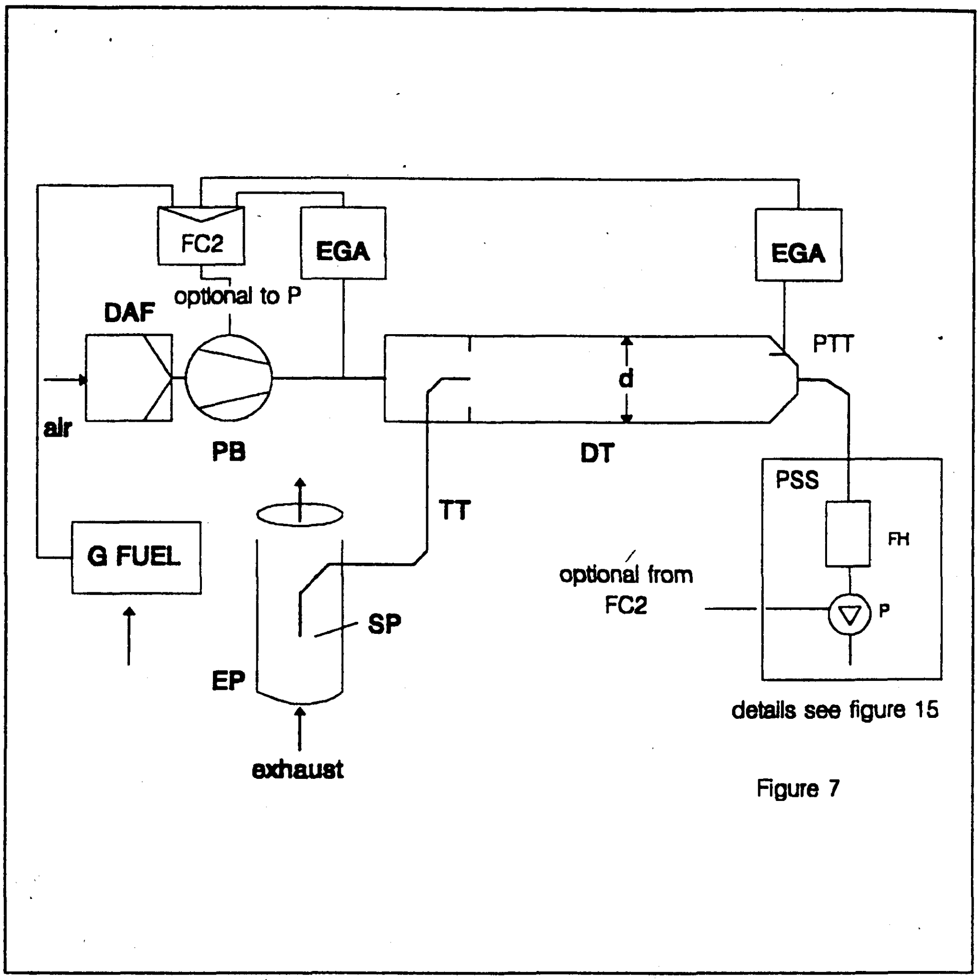


Figure 6

Raw exhaust gas is transferred from the exhaust pipe EP to the dilution tunnel DT through the sampling probe SP and the transfer tube TT. The concentrations of a tracer gas (CO_2 or NO_x) are measured in the raw and diluted exhaust gas as well as in the dilution air with the exhaust gas analyser(s) EGA. These signals are transmitted to the flow controller FC2 that controls either the pressure blower PB or the suction blower SB to maintain the desired exhaust split and dilution ratio in DT. The dilution ratio is calculated from the tracer gas concentrations in the raw exhaust gas, the diluted exhaust gas, and the dilution air.

[redacted]

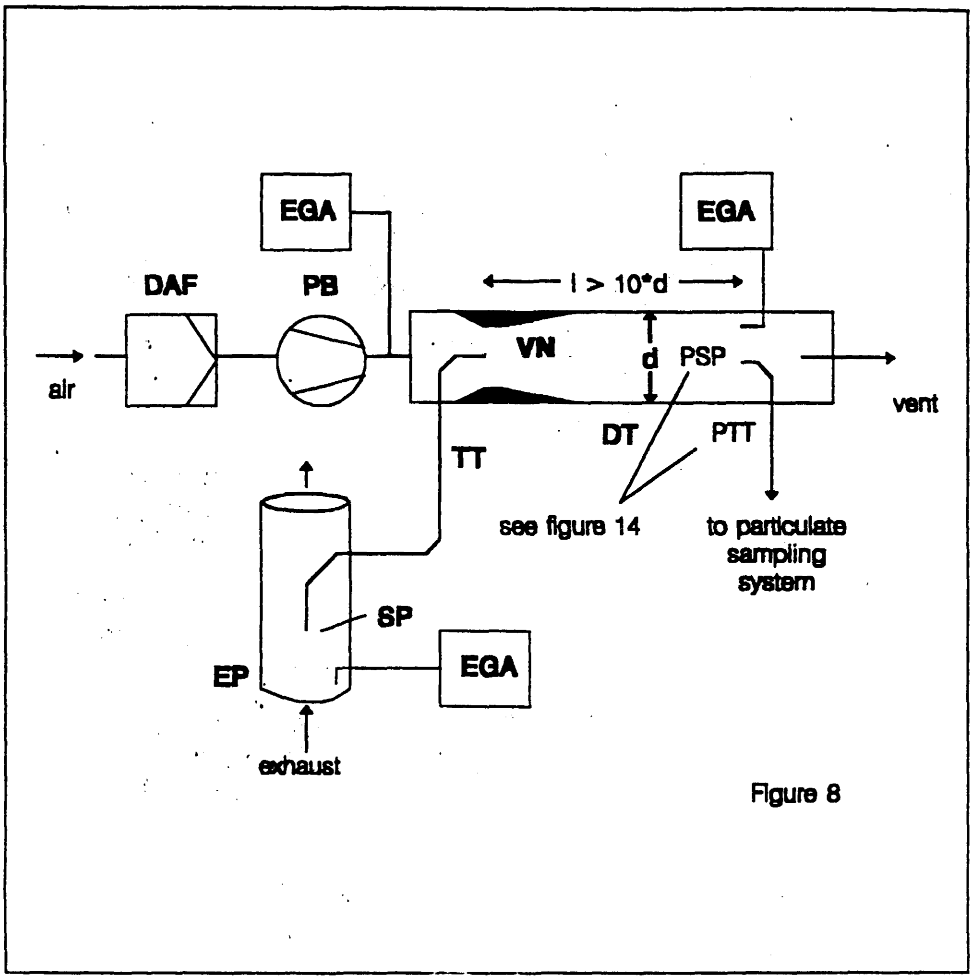
Figure 7 Partial Flow Dilution System with CO_2 Concentration Measurement, Carbon Balance and Total Sampling



Raw exhaust gas is transferred from the exhaust pipe EP to the dilution tunnel DT through the sampling probe SP and the transfer tube TT. The CO_2 concentrations are measured in the diluted exhaust gas and in the dilution air with the exhaust gas analyser(s) EGA. The CO_2 and fuel flow G_{FUEL} signals are transmitted either to the flow controller FC2, or to the flow controller FC3 of the particulate sampling system (see figure 14). FC2 controls the pressure blower PB, while FC3 controls the particulate sampling system (see figure 14), thereby adjusting the flows into and out of the system so as to maintain the desired exhaust split and dilution ration in DT. The dilution ratio is calculated from the CO_2 concentrations and G_{FUEL} using the carbon balance assumption.

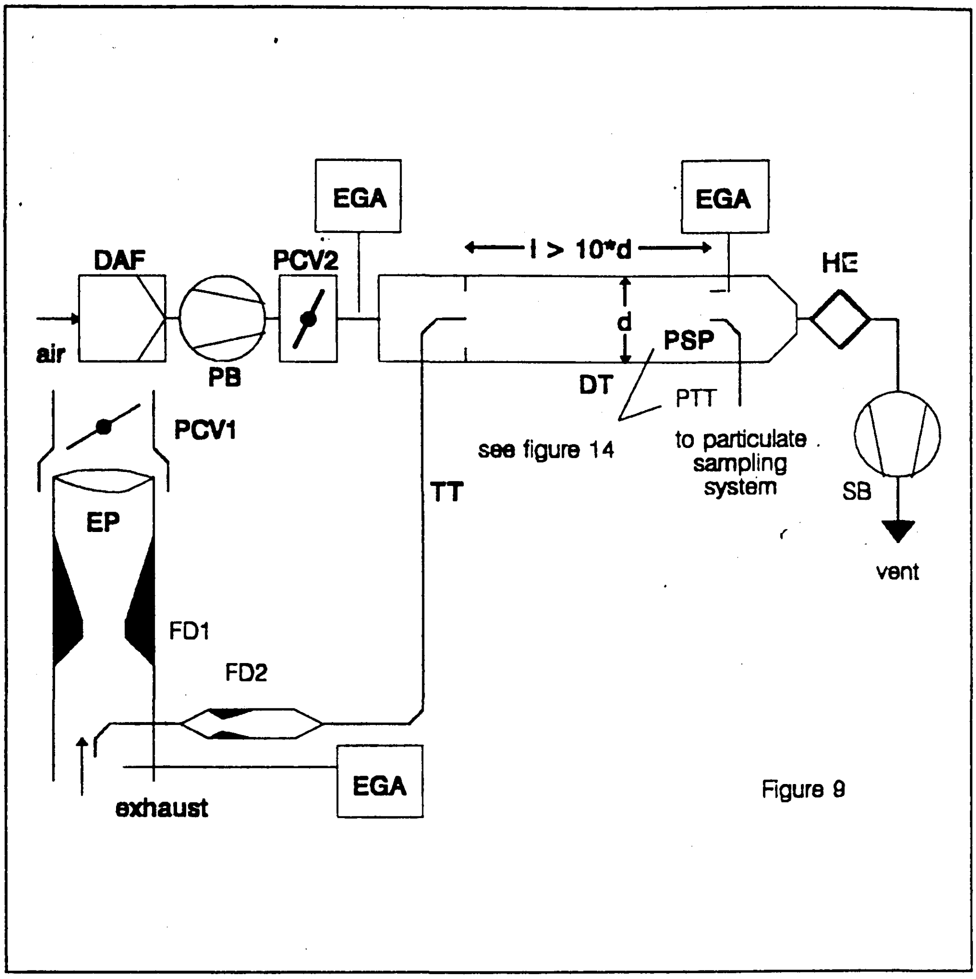
[redacted]

Figure 8 Partial Flow Dilution System with Single Venturi, Concentration Measurement and Fractional Sampling



Raw exhaust gas is transferred from the exhaust pipe EP to the dilution tunnel DT through the sampling probe SP and the transfer tube TT due to the negative pressure created by the venturi VN in DT. The gas flow rate through TT depends on the momentum exchange at the venturi zone, and is therefore affected by the absolute temperature of the gas at the exit of TT. Consequently, the exhaust split for a given tunnel flow rate is not constant, and the dilution ratio at low load is slightly lower than at high load. The tracer gas concentrations (CO_2 or NO_x) are measured in the raw exhaust gas, the diluted exhaust gas, and the dilution air with the exhaust gas analyser(s) EGA, and the dilution ratio is calculated from the values so measured.

Figure 9 Partial Flow Dilution System Twin Venturi or Twin Orifice, Concentration Measurement and Fractional Sampling



Raw exhaust gas is transferred from the exhaust pipe EP to the dilution tunnel DT through the sampling probe SP and the transfer tube TT by a flow divider that contains a set of orifices or venturis. The first one FD1) is located in EP, the second one (FD2) in TT. Additionally, two pressure control valves (PCV1 and PCV2) are necessary to maintain a constant exhaust split by controlling the backpressure in EP and the pressure in DT. PCV1 is located downstream of SP in EP, PCV2 between the pressure blower PB and DT. The tracer gas concentrations (CO_2 or NO_x) are measured in the raw exhaust gas, the diluted exhaust gas, and the dilution air with the exhaust gas analyser(s) EGA. They are necessary for checking the exhaust split, and may be used to adjust PCV1 and PCV2 for precise split control. The dilution ration is calculated from the tracer gas concentrations.

[redacted]

Figure 10 Partial Flow Dilution System with Multiple Tube Splitting, Concentration Measurement and Fractional Sampling

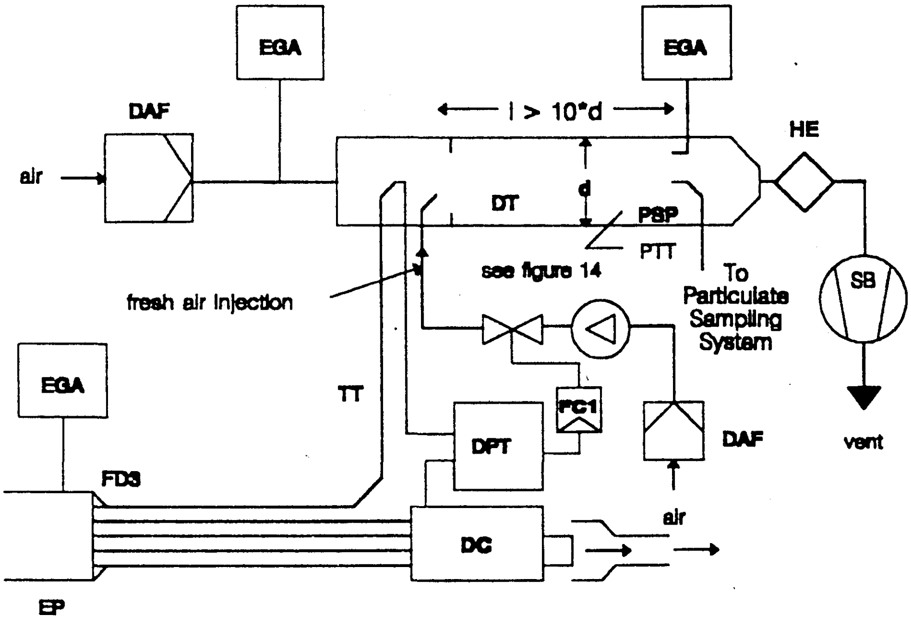


Figure 10

Raw exhaust gas is transferred from the exhaust pipe EP to the dilution tunnel DT through the transfer tube TT by the flow divider FD3 that consists of a number of tubes of the same dimensions (same diameter, length and bed radius) installed in EP. The exhaust gas through one of these tubes is lead to DT, and the exhaust gas through the rest of the tubes is passed through the damping chamber DC. Thus, the exhaust split is determined by the total number of tubes. A constant split control requires a differential pressure of zero between DC and the outlet of TT, which is measured with the differential pressure transducer DPT. A differential pressure of zero is achieved by injecting fresh air into DT at the outlet of TT. The tracer gas concentrations (CO_2 or NO_x) are measured in the raw exhaust gas, the diluted exhaust gas, and the dilution air with the exhaust gas analyser(s) EGA. They are necessary for checking the exhaust split and may be used to control the injection air flow rate for precise split control. The dilution ratio is calculated from the tracer gas concentrations.

[redacted]

Figure 11 Partial Flow Dilution System with Flow Control and Total Sampling

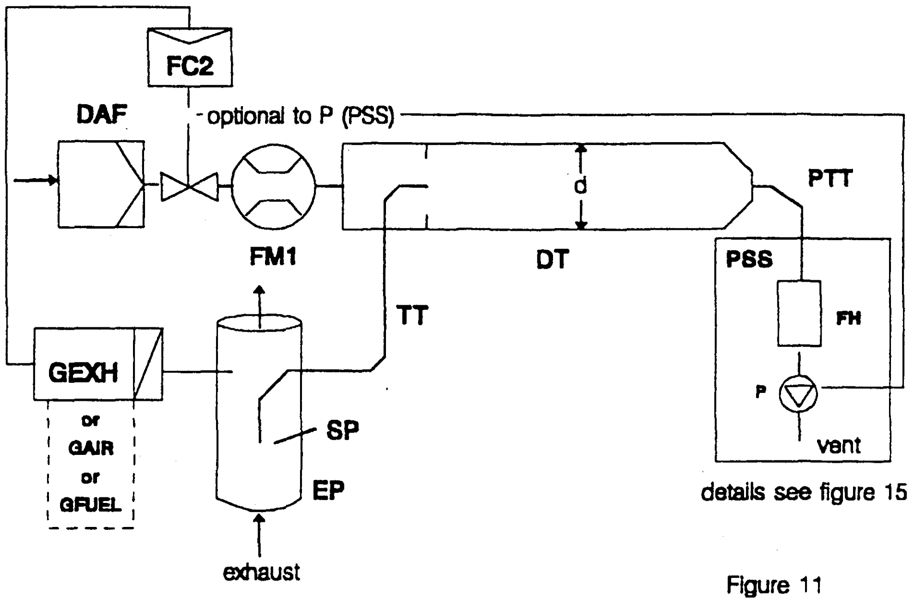
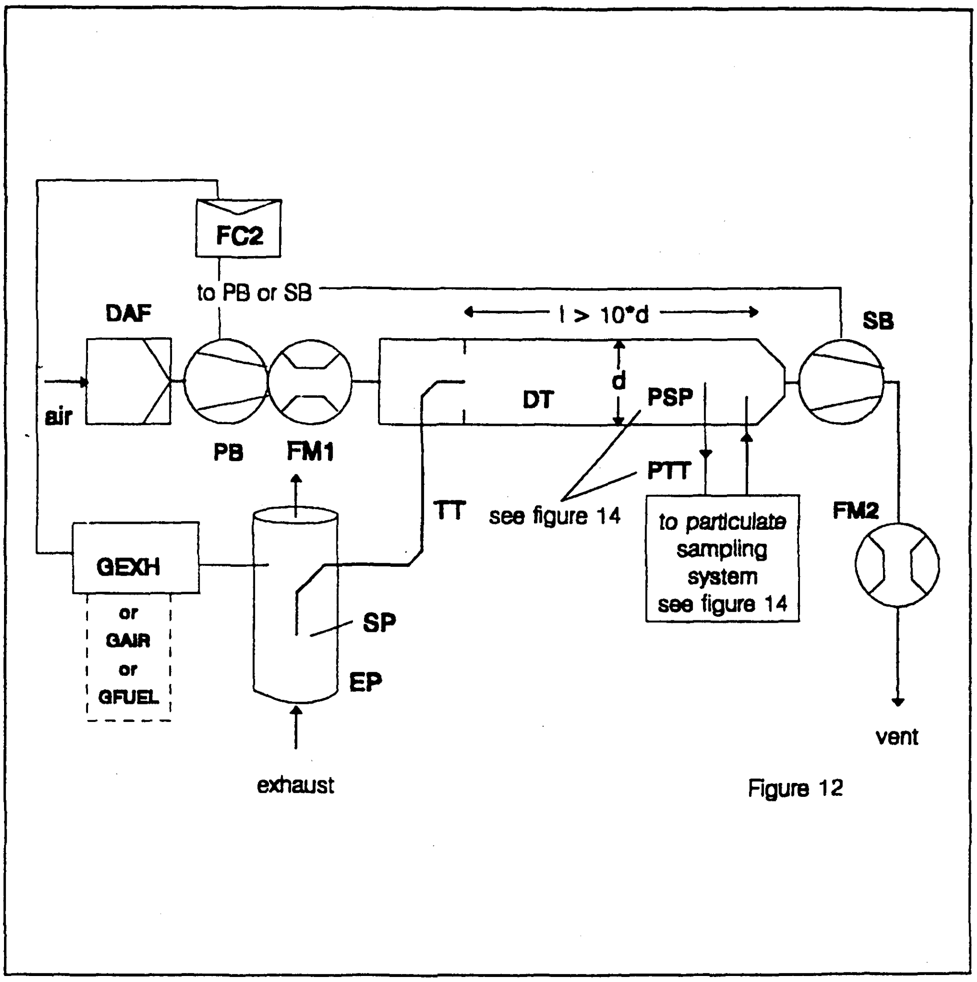


Figure 11

Raw exhaust gas is transferred from the exhaust pipe EP to the dilution tunnel DT through the sampling probe SP and the transfer tube TT. The total flow through the tunnel is adjusted with the flow controller FC3 and the sampling pump P of the particulate sampling system (see figure 16). The dilution air flow is controlled by the flow controller FC2, which may use G_{EXH}, G_{AIR}, or G_{FUEL} as command signals, for the desired exhaust split. The sample flow into DT is the difference of the total flow and the dilution air flow. The dilution air flow rate is measured with flow measurement device FM1, the total flow rate with the flow measurement device FM3 of the particulate sampling system (see figure 14). The dilution ratio is calculated from these two flow rates.

[redacted]

Figure 12 Partial Flow Dilution System with Flow Control and Fractional Sampling



Raw exhaust gas is transferred from the exhaust pipe EP to the dilution tunnel DT through the sampling probe SP and the transfer tube TT. The exhaust split and the flow into DT is controlled by the flow controller FC2 that adjusts the flows (or speeds) of the pressure blower PB and the suction blower SB, accordingly. This is possible since the sample taken with the particulate sampling system is returned into DT. G_{EXH}, G_{AIR}, or G_{FUEL} may be used as command signals for FC2. The dilution air flow rate is measured with the flow measurement device FM1, the total flow with the flow measurement device FM2. The dilution ratio is calculated from these two flow rates.

[redacted]

Description - Figures 4 to 12

- EP Exhaust Pipe

  The exhaust pipe may be insulated. To reduce the thermal inertia of the exhaust pipe a thickness to diameter ratio of 0.015 or less is recommended. The use of flexible sections shall be limited to a length to diameter ratio of 12 or less. Bends will be minimised to reduce inertial deposition. If the system includes a test bed silencer, the silencer may also be insulated.

  For an isokinetic system, the exhaust pipe must be free of elbows, bends and sudden diameter changes for at least six pipe diameters upstream and three pipe diameters downstream of the tip of the probe. The gas velocity at the sampling zone must be higher than 10 m/s except at idle mode. Pressure oscillations of the exhaust gas must not exceed ±500 Pa on the average. Any steps to reduce pressure oscillations beyond using a chassis-type exhaust system (including silencer and after treatment device) must not alter engine performance nor cause the deposition of particulates.

  For systems without isokinetic probes, it is recommended to have a straight pipe of six pipe diameters upstream and three pipe diameters downstream of the tip of the probe.

- SP Sampling Probe (figures 6 to 12)

  The minimum inside diameter shall be 4mm. The minimum diameter ratio between exhaust pipe and probe shall be four. The probe shall be an open tube facing upstream on the exhaust pipe centre-line, or a multiple hole probe as described under SP1 in paragraph 1.1.1.

- ISP Isokinetic Sampling Probe (figures 4 and 5)

  The isokinetic sampling probe must be installed facing upstream on the exhaust pipe centre-line where the flow conditions in section EP are met, and designed to provide a proportional sample of the raw exhaust gas. The minimum inside diameter shall be 12mm.

  A control system is necessary for isokinetic exhaust splitting by maintaining a differential pressure of zero between EP and ISP. Under these conditions exhaust gas velocities in EP and ISP are identical and the mass flow through ISP is a constant fraction of the exhaust gas flow. The ISP has to be connected to a differential pressure transducer. The control to provide a differential pressure of zero between EP and ISP is done with blower speed or flow controller.

[redacted]

- <u>FD1, FD2 Flow Divider (figure 9)</u>

  A set of venturis or orifices is installed in the exhaust pipe EP and in the transfer tube TT, respectively, to provide a proportional sample of the raw exhaust gas. A control system consisting of two pressure control valves PCV1 and PCV2 is necessary for proportional splitting by controlling the pressures in EP and DT.

- <u>FD3 Flow Divider (figure 10)</u>

  A set of tubes (multiple tube unit) is installed in the exhaust pipe EP to provide a proportional sample of the raw exhaust gas. One of the tubes feeds exhaust gas to the dilution tunnel DT, whereas the other tubes exit exhaust gas to a damping chamber DC. The tubes must have the same dimensions (same diameter, length, bend radius), so that the exhaust split depends on the total number of tubes. A control system is necessary for proportional splitting by maintaining a differential pressure of zero between the exit of the multiple tube unit into DC and the exit of TT. Under these conditions, exhaust gas velocities in EP and FD3 are proportional, and the flow TT is a constant fraction of the exhaust gas flow. The two points have to be connected to a differential pressure transducer DPT. The control to provide a differential pressure of zero is done with the flow controller FC1.

- <u>EGA Exhaust Gas Analyser (figures 6 to 10)</u>

  CO_2 or NO_x analysers may be used (with carbon balance method CO_2 only). The analysers shall be calibrated like the analysers for the measurement of the gaseous emissions. One or several analysers may be used to determine the concentration differences.

  The accuracy of the measuring systems has to be such that the accuracy of $G_{EDFW,i}$ or $V_{EDFW,i}$ is within ±4%.

- <u>TT Transfer Tube (figures 4 to 12)</u>

  The particulate sample transfer tube shall be:

  - As short as possible, but not more than 5m in length;

  - Equal to or greater than the probe diameter, but not more than 25mm in diameter;

  - Exiting on the centre-line of the dilution tunnel and pointing down-stream.

  If the tube is 1 metre or less in length, it is to be insulated with material with a maximum thermal conductivity of 0.05 W/(m · K) with

[redacted]

a radial insulation thickness corresponding to the diameter of the probe. If the tube is longer than 1 metre, it must be insulated and heated to a minimum wall temperature of 523K (250°C).

Alternatively, the transfer tube wall temperatures required may be determined through standard heat transfer calculations.

- DPT Differential Pressure Transducer (figures 4, 5 and 10)

The differential pressure transducer shall have a range of ±500 Pa or less.

- FC1 Flow Controller (figures 4, 5 and 10)

For the *isokinetic systems* (figures 4 and 5) a flow controller is necessary to maintain a differential pressure of zero between EP and ISP. The adjustment can be done by:

a) Controlling the speed or flow of the suction blower (SB) and keeping the speed of the pressure blower (PB) constant during each mode (figure 4);

or:

b) Adjusting the suction blower (SB) to a constant mass flow of the diluted exhaust and controlling the flow of the pressure blower PB, and therefore the exhaust sample flow in a region at the end of the transfer tube (TT) (figure 5).

In the case of a pressure controlled system the remaining error in the control loop must not exceed ±3Pa. The pressure oscillations in the dilution tunnel must not exceed ±250Pa on the average.

For a *multi-tube system* (figure 10) a flow controller is necessary for proportional exhaust splitting to maintain a differential pressure of zero between the outlet of the multi-tube unit and the exit of TT. The adjustment can be done by controlling the injection air flow rate into DT at the exit of TT.

- PCV1, PCV2 Pressure Control Valve (figure 9)

Two pressure control valves are necessary for the twin venturi/twin orifice system for proportional flow splitting by controlling the backpressure of EP and the pressure in DT. The valves shall be located downstream of SP in EP and between PB and DT.

- DC Damping Chamber (figure 10)

A damping chamber shall be installed at the exit of the multiple tube

[redacted]

unit to minimise the pressure oscillations in the exhaust pipe EP.

- VN Venturi (figure 8)

  A venturi is installed in the dilution tunnel DT to create a negative pressure in the region of the exit of the transfer tube TT. The gas flow rate through TT is determined by the momentum exchange at the venturi zone, and is basically proportional to the flow rate of the pressure blower PB leading to a constant dilution ratio. Since the momentum exchange is affected by the temperature at the exit of TT and the pressure difference between EP and DT, the actual dilution ratio is slightly lower at low load than at high load.

- FC2 Flow Controller (figures 6, 7, 11 and 12; optional)

  A flow controller may be used to control the flow of the pressure blower PB and/or the suction blower SB. It may be connected to the exhaust flow or fuel flow signal and/or to the CO_2 or NO_x differential signal.

  When using a pressurised air supply (figure 11) FC2 directly controls the air flow.

- FM1 Flow Measurement Device (figures 6, 7, 11 and 12)

  Gas meter or other flow instrumentation to measure the dilution air flow. FM1 is optional if PB is calibrated to measure the flow.

- FM2 Flow Measurement Device (figure 12)

  Gas meter or other flow instrumentation to measure the diluted exhaust gas flow. FM2 is optional if the suction blower SB is calibrated to measure the flow.

- PB Pressure Blower (figures 4, 5, 6, 7, 8, 9 and 12)

  To control the dilution air flow rate, PB may be connected to the flow controllers FC1 or FC2. PB is not required when using a butterfly valve. PB may be used to measure the dilution air flow, if calibrated.

- SB Suction Blower (figures 4, 5, 6, 9, 10 and 12)

  For fractional sampling systems only. SB may be used to measure the dilute exhaust gas flow, if calibrated.

- DAF Dilution Air Filter (figures 4 to 12)

  It is recommended that the dilution air be filtered and charcoal scrubbed to eliminate background hydrocarbons. The dilution air

[redacted]

shall have a temperature of 298K (25°C) ± 5K.

At the manufacturers request the dilution air shall be sampled according to good engineering practice to determine the background particulate levels, which can then be subtracted from the values measured in the diluted exhaust.

- <u>PSP Particulate Sampling Probe</u> (figures 4, 5, 6, 8, 9, 10 and 12)

The probe is the leading section of PTT and

- Shall be installed facing upstream at a point where the dilution air and exhaust gas are well mixed, i.e. on the dilution tunnel DT centre-line of the dilution systems approximately 10 tunnel diameters downstream of the point where the exhaust enters the dilution tunnel;

- Shall be 12 mm in minimum inside diameter;

- May be heated to no greater than 325K (52°C) wall temperature by direct heating or by dilution air pre-heating, provided the air temperature does not exceed 325K (52°C) prior to the introduction of the exhaust in the dilution tunnel;

- May be insulated.

- <u>DT Dilution Tunnel (figures 4 to 12)</u>

The dilution tunnel:

- Shall be of a sufficient length to cause complete mixing of the exhaust and dilution air under turbulent flow conditions;

- Shall be constructed of stainless steel with:

    - a thickness to diameter ratio of 0.025 or less for dilution tunnels of greater than 75mm inside diameter;

    - a nominal wall thickness of not less than 1.5mm for dilution tunnels of equal to or less than 75mm inside diameter;

- Shall be at least 75mm in diameter for the fractional sampling type;

- Is recommended to be at least 25mm in diameter for the total sampling type.

May be heated to no greater than 325K (52°C) wall temperature by direct heating or by dilution air pre-heating, provided the air temperature does not exceed 325K (52°C) prior to the introduction of the exhaust in the dilution tunnel.

May be insulated.

The engine exhaust shall be thoroughly mixed with the dilution air. For fractional sampling systems, the mixing quality shall be checked after introduction into service by means of a CO_2 profile of the tunnel with the engine running (at least four equally spaced measuring points). If necessary, a mixing orifice may be used.

Note: If the ambient temperature in the vicinity of the dilution tunnel (DT) is below 293K (20°C), precautions should be taken to avoid particle losses onto the cool walls of the dilution tunnel. Therefore, heating and/or insulating the tunnel within the limits given above is recommended.

At high engine loads, the tunnel may be cooled by a non-aggressive means such as a circulating fan, as long as the temperature of the cooling medium is not below 293K (20°C).

- HE Heat Exchanger (figures 9 and 10)

  The heat exchanger shall be of sufficient capacity to maintain the temperature at the inlet to the suction blower SB within ± 11K of the average operating temperature observed during the test.

1.2.1.2. Full Flow Dilution System (figure 13)

A dilution system is described based upon the dilution of the total exhaust using the Constant Volume Sampling (CVS) concept. The total volume of the mixture of exhaust and dilution air must be measured. Either a PDP or a CFV system may be used.

For subsequent collection of the particulates, a sample of the dilute exhaust gas is passed to the particulate sampling system (paragraph 1.2.2, figures 14 and 15). If this is done directly, it is referred to as *single dilution*. If the sample is diluted once more in the secondary dilution tunnel, it is referred to as *double dilution*. This is useful, if the filter face temperature requirement cannot be met with single dilution. Although partly a dilution system, the double dilution system is described as a modification of a particulate sampling system in paragraph 1.2.2, figure 15, since it shares most of the parts with a typical particulate sampling system.

The gaseous emissions may also be determined in the dilution tunnel of a full flow dilution system. Therefore, the sampling probes for the gaseous components are shown in figure 13 but do not appear in the description list. The respective requirements are described in paragraph 1.1.1.

Descriptions - Figure 13

- EP Exhaust Pipe

  The exhaust pipe length from the exit of the engine exhaust manifold, turbocharger outlet or aftertreatment device to the dilution tunnel is required to be not more than 10m. If the system exceeds 4m in length, then all tubing in excess of 4m shall be insulated, except for an in-line smokemeter, if used. The radial thickness of the insulation must be at least 25mm. The thermal conductivity of the insulating material must have a value no greater than 0.1 W/(m · K) measured at 673K (400°C). To reduce the thermal inertia of the exhaust pipe a thickness to diameter ratio of 0.015 or less is recommended. The use of flexible sections shall be limited to a length to diameter ratio of 12 or less.

[redacted]

Figure 13 Full Flow Dilution System

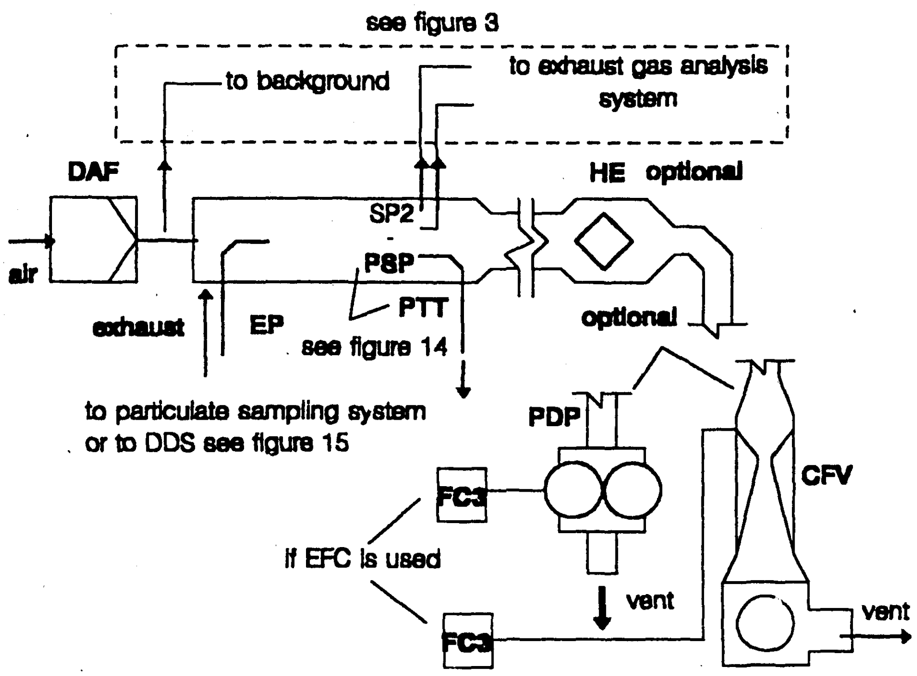


Figure 13

The total amount of raw exhaust gas is mixed in the dilution tunnel DT with the dilution air.

The diluted exhaust gas flow rate is measured either with a Positive Displacement Pump PDP or with a Critical Flow Venturi CFV. A heat exchanger HE or electronic flow compensation EFC may be used for proportional particulate sampling and for flow determination. Since particulate mass determination is based on the total diluted exhaust gas flow, the dilution ratio is not required to be calculated.

[redacted]

- PDP Positive Displacement Pump

The PDP meters total diluted exhaust flow from the number of the pump revolutions and the pump displacement. The exhaust system back pressure must not be artificially lowered by the PDP or dilution air inlet system. Static exhaust back pressure measured with the CVS system operating shall remain within ± 1.5 kPa of the static pressure measured without connection to the CVS at identical engine speed and load.

The gas mixture temperature immediately ahead of the PDP shall be within ± 6K of the average operating temperature observed during the test, when no flow compensation is used.

Flow compensation can only be used if the temperature at the inlet of the PDP does not exceed 50°C (323K).

- CFV Critical Flow Venturi

CFV measures total diluted exhaust flow by maintaining the flow at choked conditions (critical flow). Static exhaust backpressure measured with the CFV system operating shall remain within ±1.5 kPa of the static pressure measured without connection to the CFV at identical engine speed and load. The gas mixture temperature immediately ahead of the CFV shall be within ± 11K of the average operating temperature observed during the test, when no flow compensation is used.

- HE Heat Exchanger (optional if EFC is used)

The heat exchanger shall be of sufficient capacity to maintain the temperature within the limits required above.

- EFC Electronic Flow Compensation (optional if HE is used)

If the temperature at the inlet to either the PDP or CFV is not kept within the limits stated above, a flow compensation system is required for continuous measurement of the flow rate and control of the proportional sampling in the particulate system.

To that purpose, the continuously measured flow rate signals are used to correct the sample flow rate through the particulate filters of the particulate sampling system (see figures 14 and 15), accordingly.

- DT Dilution Tunnel

The dilution tunnel:

- Shall be small enough in diameter to cause turbulent flow

(Reynolds number greater than 4,000) and of sufficient length to cause complete mixing of the exhaust and dilution air. A mixing orifice may be used;

- Shall be at least 75mm in diameter;

- May be insulated.

The engine exhaust shall be directed downstream at the point where it is introduced into the dilution tunnel, and thoroughly mixed.

When using *single dilution*, a sample from the dilution tunnel is transferred to the particulate sampling system (paragraph 1.2.2, figure 14). The flow capacity of the PDP or CFV must be sufficient to maintain the diluted exhaust at a temperature of less than or equal to 325K (52°C) immediately before the primary particulate filter.

When using *double dilution*, a sample from the dilution tunnel is transferred to the secondary dilution tunnel where it is further diluted, and then passed through the sampling filters (paragraph 1.2.2, figure 15).

The flow capacity of the PDP or CFV must be sufficient to maintain the diluted exhaust stream in the DT at a temperature of less than or equal to 464K (191°C) at the sampling zone. The secondary dilution system must provide sufficient secondary dilution air to maintain the doubly-diluted exhaust stream at a temperature of less than or equal to 325K (52°C) immediately before the primary particulate filter.

- <u>DAF Dilution Air Filter</u>

  It is recommended that the dilution air be filtered and charcoal scrubbed to eliminate background hydrocarbons. The dilution air shall have a temperature of 298K (25°C) ± 5K. At the manufacturers request the dilution air shall be sampled according to good engineering practice to determine the background particulate levels, which can then be subtracted from the values measured in the diluted exhaust.

- <u>PSP Particulate Sampling Probe</u>

  The probe is the leading section of PTT and

  - Shall be installed facing upstream at a point where the dilution air and exhaust gas are well mixed, i.e. on the dilution tunnel DT centre-line of the dilution systems approximately 10 tunnel diameters downstream of the point where the exhaust enters the dilution tunnel;

[redacted]

- Shall be 12 mm in minimum inside diameter;

- May be heated to no greater than 325K (52°C) wall temperature by direct heating or by dilution air pre-heating, provided the air temperature does not exceed 325K (52°C) prior to the introduction of the exhaust in the dilution tunnel;
- May be insulated.

1.2.2 Particulate Sampling System (figures 14 and 15)

The particulate sampling system is required for collecting the particulates on the particulate filter. In the case of *total sampling partial flow dilution*, which consists of passing the entire dilute exhaust sample through the filters, dilution (paragraph 1.2.1.1, figures 7 and 11) and sampling system usually form an integral unit. In the case of *fractional sampling partial flow dilution* or *full flow dilution*, which consists of passing through the filters only a portion of the diluted exhaust, the dilution (paragraph 1.2.1.1, figures 4, 5, 6, 8, 9, 10 and 12 and paragraph 1.2.1.2, figure 13) and sampling systems usually form different units.

In this Directive, the double dilution system DDS (figure 15) of a full flow dilution system is considered as a specific modification of a typical particulate sampling system as shown in figure 14. The double dilution system includes all important parts of the particulate sampling system, like filter holders and sampling pump, and additionally some dilution features, like a dilution air supply and a secondary dilution tunnel.

In order to avoid any impact on the control loops, it is recommended that the sample pump be running throughout the complete test procedure. For the single filter method, a bypass system shall be used for passing the sample through the sampling filters at the desired times. Interference of the switching procedure on the control loops must be minimised.

Descriptions - Figure 14 and 15

- PSP Particulate Sampling Probe (figures 14 and 15)

  The particulate sampling probe shown in the figures is the leading section of the particulate transfer tube PTT.

  The probe:

  - Shall be installed facing upstream at a point where the dilution air and exhaust gas are well mixed, i.e. on the dilution tunnel DT centre-line of the dilution systems (see paragraph 1.2.1), approximately 10 tunnel diameters downstream of the point where the exhaust enters the dilution tunnel)

  - Shall be 12mm in minimum inside diameter.

[redacted]

- May be heated to no greater than 325K (52°C) wall temperature by direct heating or by dilution air pre-heating, provided the air temperature does not exceed 325K (52°C) prior to the introduction of the exhaust in the dilution tunnel.

- May be insulated.

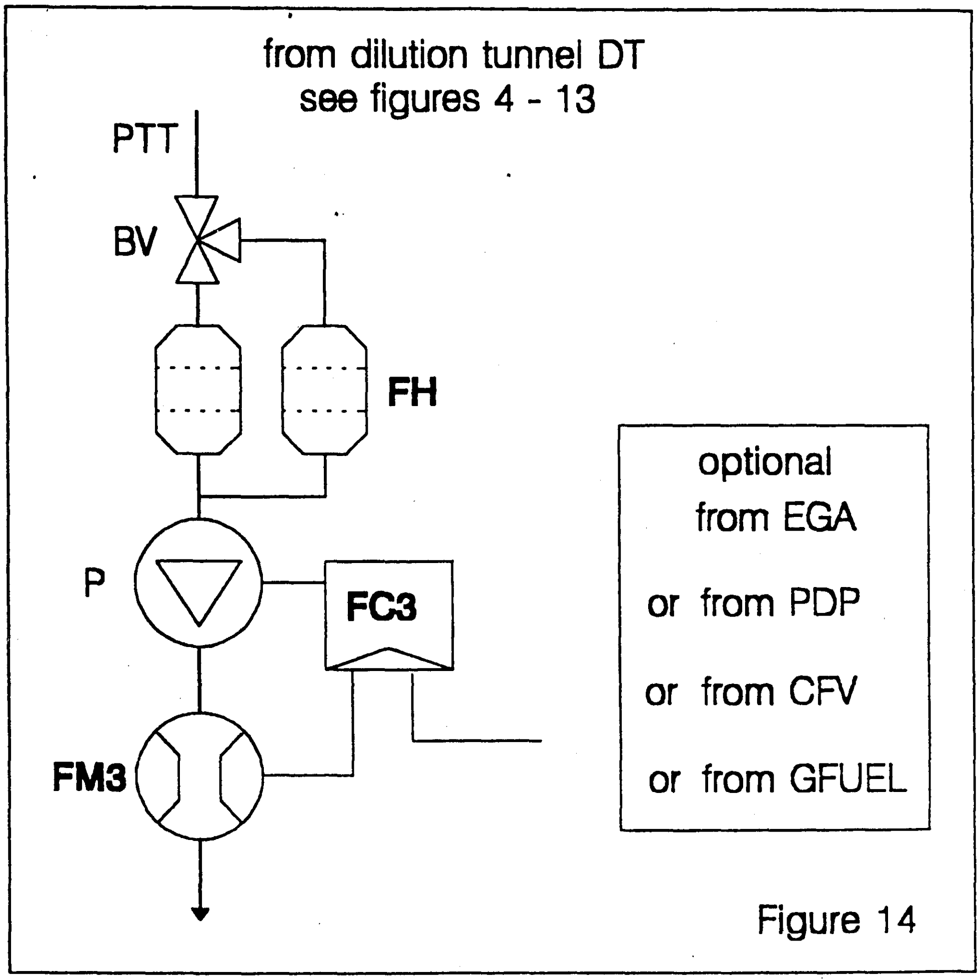


Figure 14

A sample of the diluted exhaust gas is taken from the dilution tunnel DT of a partial flow or full flow dilution system through the particulate sampling probe PSP and the particulate transfer tube PTT by means of the sampling pump P. The sample is passed through the filter holder(s) FH that contain the particulate sampling filters. The sample flow rate is controlled by the flow controller FC3. If electronic flow compensation EFC (see figure 13) is used, the diluted exhaust gas flow is used as command signal for FC3.

[redacted]

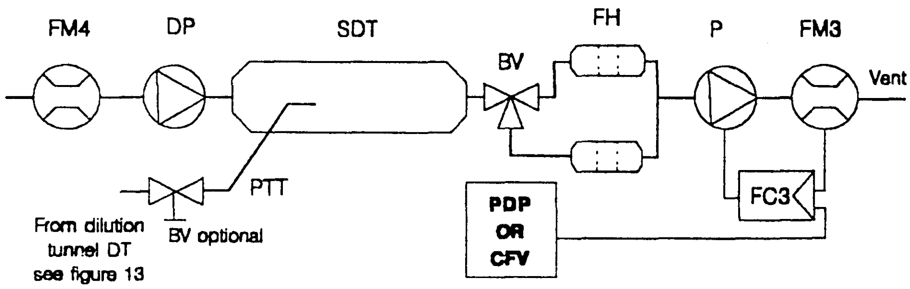


Figure 15

A sample of the diluted exhaust gas is transferred from the dilution tunnel DT of a full flow dilution system through the particulate sampling probe PSP and the particulate transfer tube PTT to the secondary dilution tunnel SDT, where it is diluted once more. The sample is then passed through the filter holder(s) FH that contain the particulate sampling filters. The dilution air flow rate is usually constant whereas the sample flow rate is controlled by the flow controller FC3. If electronic flow compensation EFC (see figure 13) is used, the total diluted exhaust gas flow is used as command signal for FC3.

[redacted]

[redacted]

- PTT Particulate Transfer Tube (figures 14 and 15)

  The particulate transfer tube must not exceed 1020mm in length, and must be minimised in length whenever possible.

  The dimensions are valid for:

  The partial flow dilution fractional sampling type and the full flow single dilution system from the probe tip to the filter holder.

  The partial flow dilution total sampling type from the end of the dilution tunnel to the filter holder.

  The full flow double dilution system from the probe tip to the secondary dilution tunnel.

  The transfer tube:

  - May be heated to no greater than 325K (52°C) wall temperature by direct heating or by dilution air pre-heating, provided the air temperature does not exceed 325K (52°C) prior to the introduction of the exhaust in the dilution tunnel;

  - May be insulated.

- SDT Secondary Dilution Tunnel (figure 15)

  The secondary dilution tunnel should have a minimum diameter of 75mm and should be sufficient length so as to provide a residence time of at least 0.25 seconds for the doubly-diluted sample. The primary filter holder, FH, shall be located within 300mm of the exit of the SDT.

  The secondary dilution tunnel:

  - May be heated to no greater than 325K (52°C) wall temperature by direct heating or by dilution air pre-heating, provided the air temperature does not exceed 325K (52°C) prior to the introduction of the exhaust in the dilution tunnel;

  - May be insulated.

- FH Filter Holder(s) (figures 14 and 15)

  For primary and back-up filters one filter housing or separate filter housings may be used. The requirements of Annex III, Appendix 1, paragraph 1.5.1.3 have to be met.

[redacted]

[redacted]

The filter holder(s):

- May be heated to no greater than 325K (52°C) wall temperature by direct heating or by dilution air pre-heating, provided the air temperature does not exceed 325K (52°C);

- May be insulated.

- P Sampling Pump (figures 14 and 15)

  The particulate sampling pump shall be located sufficiently distant from the tunnel so that the inlet gas temperature is maintained constant (±3K), if flow correction by FC3 is not used.

- DP Dilution Air Pump (figure 15) (full flow double dilution only)

  The dilution air pump shall be located so that the secondary dilution air is supplied at a temperature of 298K (25°C) ± 5K.

- FC3 Flow Controller (figures 14 and 15)

  A flow controller shall be used to compensate the particulate sample flow rate for temperature and backpressure variations in the sample path, if not other means are available. The flow controller is required if electronic flow compensation EFC (see figure 13) is used.

- FM3 Flow Measurement Device (figures 14 and 15) (particulate sample flow)

  The gas meter or flow instrumentation shall be located sufficiently distant from the sample pump so that the inlet gas temperature remains constant (±3K), if flow correction by FC3 is not used.

- FM4 Flow Measurement Device (figure 15) (dilution air, full flow double dilution only)

  The gas meter or flow instrumentation shall be located so that the inlet gas temperature remains at 298K (25°C) ± 5K.

- BV Ball Valve (optional)

  The ball valve shall have a diameter not less than the inside diameter of the sampling tube and a switching time of less than 0.5 seconds.

  Note: If the ambient temperature in the vicinity of PSP, PTT, SDT, and FH is below 239K (20°C), precautions should be taken to avoid particle losses onto the cool wall of these parts. Therefore, heating and/or insulating these parts within the limits given in the respective descriptions is recommended. It is also recommended that the filter

[redacted]

[redacted]

face temperature during sampling be not below 293K (20°C).

At high engine loads, the above parts may be cooled by a non-aggressive means such as a circulating fan, as long as the temperature of the cooling medium is not below 293°K (20°C).

[redacted]

[redacted]

ANNEX VI

(MODEL)

EC TYPE-APPROVAL CERTIFICATE

Stamp of administration

Communication concerning the:

- type-approval/extension/refusal/withdrawal ([1]) of type-approval

of an engine type or family of engine types with regard to the emission of pollutants pursuant to Directive 95/.../EEC as last amended by Directive.../.../EEC

EEC type-approval No: . . . .   Extension No: . . . .

Reason for extension (where appropriate): . . . .

SECTION I

0. **General**

0.1 Make (name of undertaking): . . . .

0.2. Manufacturer's designation of the parent- /and (if applicable) of the family engine(s) type(s) ([1]) : . . . .

0.3. Manufacturer's type coding as marked on the engine(s): . . . . . .

Location : . . . .

Method of affixing : . . . .

0.4. Specification of machinery to be propelled by the engine ([2]): . . .

---

(1) Delete as appropriate

(2) As defined in Annex I, section 1 of this Directive (e.g. : "A")

[redacted]

0.5. Name and address of manufacturer: . . . .

Name and address of manufacturer's authorized representative (if any):

. . . .

0.6. Location, coding and method of affixing of the engine identification number : . . . . .

. . . .

0.7. Location and method of affixing of the EEC approval mark : . . .

0.8 Address(es) of assembly plant(s) : . . . .

SECTION II

1. Restriction of use (if any): . . . .

1.1. Particular conditions to be respected in the installation of the engine(s) on the machinery

1.1.1. Maximum allowable intake depression: . . . . kPa

1.1.2. Maximum allowable back pressure: . . . . kPa

2. Technical service responsible for carrying out the tests[1]: . . . .

. . . .

3. Date of test report : . . . .

4. Number of test report : . . . .

---

(1) Fill in n.a. where the tests are carried out by the approval authority itself

[redacted]

5.The undersigned hereby certifies the accuracy of the manufacturer's description in the attached information document of the engine(s) described above and that the attached test results are applicable to the type. The sample(s) has (have) been selected by the approval authority and submitted by the manufacturer as the (parent) engine type(s) ([1]).

Type-approval is granted/refused/withdrawn ([1])

Place: . . . .

Date: . . . .

Signature: . . . .

Attachments : Information package.

Test results (see Appendix 1)

Correlation study relevant to sampling systems used which are different from the reference systems ([2]) (if applicable)

([1]) Delete as appropriate

([2]) Specified in Annex I paragraph 4.2

[redacted]

[redacted]

Appendix 1

TEST RESULTS

1. Information concerning the conduct of the test(s) ([1]):

1.1. Reference fuel used for test

1.1.1. Cetane number: . . . .

1.1.2. Sulphur content: . . . .

1.2. Lubricant

1.2.1. Make(s): . . . .

1.2.2. Type(s): . . . .
(state percentage of oil in mixture if lubricant and fuel are mixed)

1.3. Engine driven equipment (if applicable)

1.3.1. Enumeration and identifying details: . . . .

1.3.2. Power absorbed at indicated engine speeds (as specified by the manufacturer):

	Power P_{AE} (kW) absorbed at various engine speeds ([2])	
Equipment	Intermediate	Rated
TOTAL:		

([1]) For the case of several parent engines to be indicated for each of them

([2]) Must not be greater than 10% of the power measured during the test.

[redacted]

[redacted]

1.4. Engine performance

1.4.1. Engine speeds:

Idle: . . . . rpm

Intermediate: . . . . rpm

Rated: . . . . rpm

1.4.2. Engine power ([1])

	Power setting (kW) at various engine speeds	
Condition	Intermediate	Rated
Maximum power measured on test (P_M) (kW) (a)		
Total power absorbed by engine driven equipment as per paragraph 1.3.2 of this appendix, or paragraph 2.8 of Annex III, (P_{AE}) (kW) (b)		
Net engine power as specified in paragraph 2.4. of Annex I (kW) (c)		

c = a + b

([1]) Uncorrected power measured in accordance with the provisions of paragraph 2.4. of Annex I.

[redacted]

1.5. Emission levels

1.5.1. Dynamometer setting (kW)

	Dynamometer setting (kW) at various engine speeds	
Percent Load	Intermediate	Rated
10	XXXXXXX	
50		
75		
100		

1.5.2. 8 mode emission test results:

CO: .... g/kWh

HC: .... g/kWh

NO_x: .... g/kWh

Particulates: .... g/kWh

1.5.3. Sampling system used for the test:

1.5.3.1. Gaseous emissions [1]: ....

1.5.3.2. Particulates [1]: ....

1.5.3.2.1. Method [2]: Single / Multiple Filter

---

(1) Indicate figure numbers defined in Annex V paragraph 1.

(2) Delete as appropriate

[redacted]

[redacted]

ANNEX VII

APPROVAL CERTIFICATE NUMBERING SYSTEM
(see Article 4, paragraph 2)

1. The number shall consist of 5 sections separated by the '*' character.

Section 1: the lowercase letter 'e' followed by the distinguishing letter(s) or number of the Member State issuing the approval :

'1'	for Germany	'13'	for Luxembourg
'2'	for France		
'3'	for Italy	'17'	for Finland
'5'	for Sweden	'18'	for Denmark
'4'	for the Netherlands	'21'	for Portugal
'6'	for Belgium	'EL'	for Greece
'9'	for Spain		
'11'	for the United Kingdom		
'12'	for Austria	'IRL'	for Ireland

Section 2: the number of this Directive. As it contains different implementation dates and different technical standards, two alphabetical characters are added. These characters refer to the different application dates for the stages of severity and to the application of the engine for different specification of mobile machinery, on the basis of which type-approval was granted. The first character is defined in Article 9. The second character is defined in Annex I, section 1 with regard to the test mode defined in Annex III, section 3.6..

Section 3: the number of the latest amending Directive applicable to the approval. If applicable two further alphabetical characters are to be added depending on the conditions described in section 2, even if due to the new parameters only one of the characters was to be changed. If no change of these characters apply they shall be omitted.

Section 4: a 4-digit sequential number (with leading zeros as applicable) to denote the base approval number. The sequence shall start from 0001.

Section 5: a 2-digit sequential number (with a leading zero if applicable) to denote the extension. The sequence shall start from 01 for each base approval number.

2. Example of the third approval (with, as yet, no extension) corresponding to application date A (Stage I, upper powerband) and to the application of the engine for specification A of mobile machinery, issued by the United Kingdom:

e 11*95/...AA*00/000XX*0003*00

4. Example of the second extension to the fourth approval corresponding to application date E (Stage II, medium powerband) for the same specification of machinery (A), issued by Germany: e 1*95/...EA*00/000XX*0004*02

[redacted]

[redacted]

ANNEX VIII

LIST OF ENGINE (FAMILY) TYPE APPROVALS ISSUED

Stamp of administration

List number : . . . .

Covering the period . . . . to . . . .

The following information in respect of each approval granted, refused or withdrawn in the above mentioned period shall be given :

Manufacturer

Approval number

Reason for extension (where applicable)

Make

Type of engine / engine family [1]

Date of issue

First issued date (in the case of extensions)

---

(1) Delete as appropriate

[redacted]

[redacted]

ANNEX IX

LIST OF ENGINES PRODUCED

Stamp of administration

List number : . . . .

Covering the period . . . . to . . . .

The following information in respect of identification numbers, types, families and type-approval numbers of engines produced in the above mentioned period in accordance with the requirements of this Directive shall be given :

Manufacturer : . . . .

Make : . . . .

Approval number : . . . .

Engine family name ([1]) : . . .

Type of engine :	1:..........	2:..........	---	n :............
Engine identification numbers :	...001 ...002 . . . .m	...001 ...002 . . . .p		...001 ...002 . . . .q

Date of issue : . . . .

First issued date (in the case of addenda): . . . .

([1]) Omit as appropriate; the example shows an engine family containing 'n' different engine types of which were produced units bearing identification numbers from...001 up to .....m of type 1
...001 up to .....p of type 2
...001 up to .....q of type n

[redacted]

[redacted]

ANNEX X

DATA SHEET OF TYPE-APPROVED ENGINES

Stamp of administration

				engine description							emissions (g/kWh)			
no.	**date of certifi-cation**	**manu-facturer**	**type / family**	**cooling medium ([1])**	**no. of cylinders**	**swept volume (cm^3)**	**power (kW)**	**rated speed (min^{-1})**	**combustion ([2])**	**after treatment ([3])**	**PT**	**NOx**	**CO**	**HC**

---

(1) liquid or air

(2) Abbreviate: DI = Direct Injection, PC = Pre/Wirl Chamber, NA = Natural Aspirated, TC = Turbocharged, TCA = Turbocharged incl. Aftercooling.

Examples: DI NA, DI TC, DI TCA, PC NA, PC TC, PC TCA

(3) Abbreviate: CAT = Catalyst, TP = Particulate Trap, EGR = Exaust Gas Recirculation

[redacted]

FINANCIAL STATEMENT

SECTION I - Financial Consequences (part B of the budget)

1. TITLE OF OPERATION

Proposal for a Directive of the Council and the European Parliament on the approximation of the laws of the Member States relating to the measures to be taken against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery

2. BUDGET HEADING INVOLVED

B4-304 Environmental Legislation and other general actions based on the 5th Action Programme relating to the environment, [Projects (XI/D/3)].

3. LEGAL BASIS

EU Treaty Article 100a,

Resolution of the Council and the Representatives of the Governments of the Member States meeting within the Council of 1 February 1993 on a Community programme of policy and action in relation to the environment and sustainable development (OJ No C 138, 17.05.1993, p.1).

4. DESCRIPTION OF OPERATION

4.1 General Objective

Recent investigations[1] undertaken by the Commission show that the category of engines covered by the scope of the Directive Proposal is responsible for a considerable share of air pollution by nitrogenoxides (NOx) and particulates (PT). This is particularly true when it is compared with that coming from the road transport sector. Thus the proposal aims at significant reduction of air pollution in respect of these and other pollutants coming from new engines of this category. NOx emissions cause acidification and ozone formation. Particulate emissions are harmful or mutagenic and therefore recognized as a serious health risk. These reductions of emissions will be beneficial for human health and the environment.

---

(1) "The Estimation of the Emissions of 'Other Mobile Sources and Machinery' Subparts - 'Off-Road Vehicles and Machines', 'Railways', and 'Inland Waterways' in the European Union. (Final Report September 1994, prepared for the European Commission, Andrias/Samaras/Zierock).

[redacted] [redacted]

for human health and the environment.

Based on Article 100a of the Treaty, the proposed Directive will not cause restrictions to the free circulation of products within the framework of the internal market.

4.2 <u>Period covered and arrangements for renewal or extension</u>

The proposed Directive requires:

- that Member States:
  - take all necessary steps to ensure that engines covered by its scope comply with the defined requirements in respect of emissions of pollutants. The stringency of the requirements is graded into two stages, and their application is staggered depending on the power output of the engines. Different kinds of application dates are foreseen in respect of type-approval, production or sale of the engines. In total the first obligatory date of the proposed Directive is 31 March 1997, the last 31 December 2005;

  - inform each other with regard to type-approval issues including particular queries in respect of COP (Conformity of Production);

  - inform the Commission yearly with regard to emission-relevant data on the engines certified, and with regard to exemptions granted;

  - participate in the meetings of the Committee for Adaptation to Technical Progress.

- that the Commission:
  - investigates the need, and the possibilities, for an eventual extension of the scope to engine types not yet covered. If necessary a corresponding amending proposal shall be presented after 1 July 1996;

  - holds appropriate consultations for the purpose of reaching a settlement in the case of disputes between Member States in respect of type-approval and COP issues;

  - convenes the meetings of the Committee for Adaptation to Technical Progress.

[redacted] [redacted]

5. **Classification of expenditure or revenue**

DNO and CD
There are no receipts following this action

6. **Type of expenditure**

Technical services directly linked with the achievement of the objective of the measure of which they form an integrated part in order to give the necessary scientific and technical advice in the implementation of the proposal.

7. **Financial Impact**

7.1 Method of calculating total cost of operation (definition of unit costs)

- technical assistance (services) 15.000 ECU/year

7.2 Itemised breakdown of cost (in 1000 1994 ECUs)

	1995	1996	1997	1998	TOTAL
Technical Assistance	15	15	25	30	85

8. **Anti-Fraud Dispositions**

- It will be explicitly specified in contracts that all work performed is the property of the Commission

- Final payment of contractors will only take place after reception and examination of the reports and services requested

[redacted] [redacted]

9.1 Specific and quantifiable objectives;target population

The general objective of the operation is to increase the protection of:

- human health, ecosystems, vegetation and materials against the impact of nitrogen oxides, hydrocarbons and ozone;

- human health additionally against the impact of particulate emissions;

- ecosystems additionally against the impact of nitrogen oxides deposition ("acid rain") on land or water.

According to the calculations described in ([1]), the sector covered by the proposed Directive is responsible for air pollution by nitrous oxides(NOx) to 855 kilotons and by particulate emissions(PT) to 100 kilotons per year.

If compared with the total emissions from EU diesel road traffic (2300/300 kilotons NOx/PT) the achievable amount of emission reduction from non-road mobile machinery engines (42% NOx, 67% PT - Stage II) is relatively high. Also beneficial will be the reduction of hydrocarbon and carbon monoxide emissions. However these are not very significant in comparison with other major polluters.

The envisaged reduction of emissions will only reduce the environmental and health impact, not eliminate it.

9.2 Grounds for the operation

The engines covered by the scope of the proposed Directive have not been subject to any emission requirement until now. According to the considerations that are described above and in chapter 2.3 of the explanatory memorandum the amount of air pollution coming from these sources is relatively high in respect of nitrogen oxide and particulate emissions.

Thus it would be unreasonable to neglect this source of pollutants which can be reduced by economically feasible measures, in particular as the envisaged further reduction requirements for road vehicle engines may have

[redacted] [redacted]

a higher cost/benefit ratio(2). This is caused by more sophisticated technology needed in the latter case.

9.3 Monitoring and evaluation of the operation

The type-approval Authorities of the Member States that granted approvals are committed to control the compliance of new engines with the requirements. As appropriate means "Conformity of Production Assessments" (COP) have been defined.

The results obtained once all engines covered by the scope of the proposed Directive will comply with the requirements have been calculated in advance(1) [see 9.1 and explanatory memorandum 2.3].

For further evaluation of engine emission performance and state of the art of technology it is planned to use the type-approval data which yearly have to be sent to the Commission by the type-approval Authorities of the Member States (Article 4(5) of the proposed Directive). A date for a possible review of the requirements on compression ignition engines has not been set now as the proposed standards will be applicable in two stages, the latest of which enters into force not before 2004 with respect to the engine production dates.

An amendment with regard to an expansion of the scope to gasoline engines might be appropriate at an earlier stage, but this is considered as a separate operation.

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(2) Proposal for a Directive amending Directive 88/77/EEC; to be presented by the Commission before the end of 1996. (Article 5(3) of Directive 91/542/EEC, OJ No L 295, p.1, 25.10.1991)

[redacted] [redacted]

SECTION III - **Administrative Expenses (part A of the budget)**

A 2510: Meeting expenses of Committees whose consultation is compulsory in the making of Community acts.

i) increase in personnel

Adoption of the proposal will mean no net increase of personnel

ii) operating expenses generated by the action (in 1994 prices)

From 1997 at the earliest:

Travel for the Committee foreseen in Article 15 of the proposal. Cost:

15 x 825 ECU/meeting x 2 meetings/year = 24.750 ECU/year

The granting of resources by the Commission, including staff and additional sums agreed by the budget authority, will enable the necessary administrative resources to be mobilized.

[redacted] [redacted]

IMPACT ASSESSMENT FORM

THE IMPACT OF THE PROPOSAL ON BUSINESS
with special reference to small and medium-sized enterprises (SMEs)

Title of Proposal:

Proposal for a Directive of the Council and the European Parliament on the approximation of the laws of the Member States relating to the measures to be taken against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery

Reference Number (Repertoire):

1. Taking account of the principle of subsidiarity, why is Community legislation necessary in this area and what are its main aims?

The engines subject to this legislation are mobile and will be used in mobile machinery. In order to protect human health and the environment, but without restriction to the free circulation of products within the framework of the internal market, Union-wide action needs to be taken in order to avoid any distortions of the market. In 1993 the Commission was asked by a Memorandum of four Member States to proceed with the preparation of Community legislation in this area.

In accordance with the "Fifth Action Programme" the proposed Directive aims at diminishing air pollution by reducing emissions of carbon monoxide (CO), nitrogen oxides (NO_x), hydrocarbons (HC), and diesel particulates (PT) from non-road mobile machinery. For this purpose the permissible level of emission of these pollutants shall be limited for new engine types which are to be installed in this machinery.

These measures also contribute to the implementation of the so-called 'VOC protocol' and 'NOx-protocol' which are part of the follow-up activities related to the implementation of the

[redacted] [redacted]

UN-ECE Geneva Convention on Long Range Transboundary Transport of Air Pollutants.

2. *Who will be affected by the proposal?*

- **Which sectors of business?**

  Primarily the proposal affects the manufacturers of diesel engines of the regulated range of power output (18 - 560 kW). Secondly the buyers of the engines i.e. the manufacturers of non-road mobile machinery are concerned. Finally the users of this machinery such as construction/road building enterprises, airport ground services, agricultural contractors, forestry Commissions and industry in general are affected but only at a negligible level.

- **Which sizes of business?**

  As far as the manufacturers of engines are concerned, all of them belong to the group of large firms which act at international level.

  As far as the manufacturers of non-road mobile machinery are concerned, for most of them the statement made above is valid. There are also some which belong to the group of small and medium-sized firms in respect of production of small mobile machinery.

  As far as the users of this machinery are concerned, the exact size distribution of firms is not well known, but it is evident that the number of small and medium size businesses indirectly affected, because they are the users of the equipment, is relatively large.

- **Are there particular geographical areas of the Community where these businesses are found?**

  As far as engine manufacturers are concerned, France, F.R. Germany, Italy and the United Kingdom are most affected by the proposal. This is also true for manufacturers of bigger machinery. Manufacturers of smaller machinery, and users of all classes of machinery, can be found throughout the whole Community. Their density depends mainly on the extent of industrialisation of a country or a region.

[redacted] [redacted]

3. *What will business have to do to comply with the proposal?*

As far as engine manufacturers are concerned, they will have to improve the engine design. Additionally they must arrange the necessary procedures for the type-approval and if not already existing they must provide the facilities for emission testing. If they have not yet integrated appropriate quality assurance systems into their manufacturing processes, they will now be forced to do so in order to guarantee conformity of production. These requirements are expected to result also from other legislation in the international area which is in preparation or has just been published, such as the new rule of the USA(1).

The technologies necessary for achieving compliance with the provisions of the Directive are already available in principle, but need to be adapted to the "non-road engines" currently manufactured. Therefore, additional time periods for compliance with the more stringent limit values (Stage II) have been provided in the proposal. Stage I limit values are already met by many engines currently marketed.

With regard to the machine manufacturers the proposal demands little. They just have to follow the instructions of the engine manufacturers for possible changes of installation. In some cases due to changes of the outer shape of the engine type, corresponding adaptation of the machine design may be necessary.

As far as the users are concerned, there are no obligations associated with the proposed Directive because existing machinery does not have to comply with the requirements set for new machinery.

4. *Which economic effects is the proposal likely to have?*

- **On employment?**

  The measures proposed should have a positive overall effect on employment because new jobs will be created in industrial sectors dealing with the design and manufacturing of environmentally friendly engines. Bigger engine manufacturers which have not yet produced "on-road engines" for which type-approval certification procedures have had to be carried out already some years, may have to create jobs in order to provide the necessary

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(1) "Determination of Significance for Nonroad Sources and Emission Standards for New Nonroad Compression-Ignition Engines at or above 37 kW".
(US EPA, 40 CFR Parts 9 and 89)

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certifications.

This is also true in respect of additional work for Technical Services and Type-Approval Authorities. Major direct negative effects on the employment in the sectors covered by the proposal cannot be identified.

- **On investment and creation of new business?**

The proposal requires manufacturers of engines to modify engine models. In practical terms, the estimated annual costs for technically up-grading the engines are estimated to be in the range of about 31 to 125 million ECUs per year, is ultimately to be shared by several thousands of firms using this type of equipment, because it can be assumed that manufacturers will pass on the costs to the users.

The timetable for the implementation has been designed in such a way that, in practical terms, it stretches over a period of about 9 years, avoiding peak accumulations of expenditures for the Industry. It can be expected that most of the costs, from the point of view of the manufacturers, will be covered by higher prices. However, the potential price increase will be very small given that the additional costs in respect of the improved engine design are in general in the range of a few per cent(2) of the price of an engine. These have been calculated to be in the range of 214 - 356 ECU for Stage I and 300 - 1050 ECU for Stage II depending on the size of the engine.

Taking into account that the costs for the engines in general are only a small fraction of the total costs of the final machinery, the impact of the additional requirements on the prices of the completed machines is estimated to be marginal. Therefore, it is expected that the proposal as such will not have any negative, but will rather have positive repercussions on the generation of new businesses in the sectors concerned.

In respect of necessary investments in the production-line it is estimated that these are marginal for the following reasons:

Stage I would come into force between 07/1997 and

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(2) "The Estimation of the Emissions of 'Other Mobile Sources and Machinery' Subparts - 'Off-Road Vehicles and Machines', 'Railways', and 'Inland Waterways' in the European Union.
(Final Report September 1994, prepared for the European Commission, Andrias/Samaras/Zierock).

[redacted] [redacted]

01/1999, and compliance would only necessitate the non-usage of obsolete engine technology, i.e. some engine types would have to be replaced by new models. These changes could in any case have been pending due to competition forces. Stage II would come into force between 01/2001 and 01/2004, thus allowing industry time to plan the coinciding of application dates for new emission performance with pending engine model changes. Thus additional costs only would arise if in single cases the investment had to be made earlier than foreseen by the original depreciation calculation. And even then the investment does not appear to be excessive. Most of the technical changes can be made by adaptation of existing tools and the integration of more sophisticated components (e.g. turbocharger, injection pumps, injection nozzles) which are available on the market.

In addition to these costs, those necessary for additional research and development work and for related facilities must be mentioned.

All in all, these additional costs will differ from manufacturer to manufacturer depending on the infrastructure which he already has available.

For example if a manufacturer is used to produce engines for "on-road" purposes, then emission measurement hardware, know-how and operational facilities for the preparation of certification applications, are already there. Another manufacturer, not yet experienced with emission type-approval may be required to invest some capital in measuring facilities and in some additional personnel costs. In other words, in this cases new employment will be created.

The certification charges to be paid for the local administration will raise the funds necessary for additional manpower. Also this fact will have positive repercussions on the creation of new employment.

- **On the competitiveness of businesses?**

All relevant competitors will be equally affected by the costs for the improvement of the engines. The certification charges might only marginally differ between the Member States.

In respect of the additional costs which depend on the already existing infrastructure of the firms, it must be taken into account that they compete at international level. Thus, if not today due to the proposed EC-

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Directive, very soon these costs will have to be invested anyway as international requirements will also create this need. For example just in June 1994, the United States of America published a new rule(3) which, to a large extent, covers the same sector of application as this proposed Directive. The title of the US rule is:

> "Determination of Significance for Nonroad Sources and Emission Standards for New Nonroad Compression-Ignition Engines at or above 37 kW".

As a result of cooperation between the Commission services and the US Environmental Protection Agency (EPA) during the preparation of both the new US Rule and the proposed Directive, an significant consensus of the requirements in terms of measuring procedures and limit values has been achieved for this particular category of mobile emission sources. Both the European and the US industry have confirmed that this compatibility of emission legislation on mobile sources covering this worldwide market is very important.

In parallel, this Proposal is in line with an UN/ECE Draft Regulation on emissions from agricultural tractors, which was recently proposed for adoption under the framework of the UN/ECE "1958 Agreement". This regulatory document covers some of the same kind of engines as this Directive Proposal, and is based on the same test procedure.

All in all, the additional costs of manufactured products generated by the requirements of the proposed Directive is estimated to be so low that no negative effects on the competitive position of businesses can be identified.

On the contrary, in the case that single engine manufacturers may be forced to improve their quality assurance systems, this will increase their efficiency and thus competitiveness.

Moreover, as declared above, international competitors will have to comply with the same emission standards. Therefore, the accelerated development of environmentally friendly products might strengthen the position of the sectors affected, seeing that environmental protection is becoming a major field of policy all over the world.

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(3) US EPA, 40 CFR Parts 9 and 89

[redacted] [redacted]

5. ***Does the proposal contain measures to take into account the specific situation of small and medium-size firms (reduced or different requirements etc)?***

The manufacturers of the engines subject to this regulation can all be considered to be large.

Manufacturers of machinery are only indirectly concerned as the prices for the engines to be installed will increase marginally. This condition will be the same for all competitive enterprises, independent from their size.

The users of the machinery will be insignificantly affected by negligibly increased prices for new machinery.

Thus particular measures in favour of small and medium sized firms appear to be inadequate.

6. ***Consultation***

List of organizations which have been consulted with regard to the proposal, and outline of their main views:

- **CECE** (Industry; Committee for European Construction Equipment)
- **CEMA** (Industry; Comité Européen des Groupements de Constructeurs du Machinisme Agricole)
- **EUROMOT** (Industry; Association of European Manufacturers of Internal Combustion Engines)
- **ICOMIA** (Industry; International Council of Marine Industry Associations)

ICOMIA's concern is that marine engines are as yet not covered by the scope of the proposed Directive. Not for environmental reasons, but with the intention to avoid inconsistencies in requirements arising in different regions from various Authorities, they would welcome a union-wide requirement on emissions from light marine engines (inland waterways).

Unfortunately the study on the estimation of European-wide emissions from all kinds of machinery, has shown clearly that, with regard to air pollution from light marine engines, an emergency situation does not exist. Thus the proposed Directive focuses firstly on the main polluters in respect of NOx and PT emissions.

A future extension of the Directive could cover these engines

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in context with abatement of other pollutants coming from gasoline engines to be installed in different machinery. To enable this, comprehensive investigations with regard to the state of the art of emission performance of the engines concerned would have to be firstly carried out.

CECE, CEMA and EUROMOT expressed similar concerns and were all related to the certification and manufacturing of engines. With regard to the production of machinery, there was no great apprehension. In fact, this proposal does not give rise to anxieties of SMEs, but rather there are concerns with regard to engine production and certification i.e. of large-scale industry.

Related to the associations' specific desires outlined during the consultations such as engine marking and exemptions for end-of-series engines, the proposal has been extensively aligned. This was possible, as during the advisory meetings held by DG XI in respect of these topics, a final agreement was reached in compliance with the opinion of the experts of the governments of the Member States and the EFTA countries.

The outstanding Industry criticisms were as follows:

- too strict limit values of Stage II;

- too strict time scale;

- too burdensome administrative procedures.

and there was limited flexibility for corresponding amendments in relation to same. But in accordance with the opinions of Member States' experts some minor alignments of the proposal have been made also in respect of these wishes expressed by the Industry.

With regard to the achievable emission performance and state of the art of technology of today's engines and up to 9 years in the future, amongst the statements of the industry organizations own evaluations have been carried out. While certain of the elements used for this investigation have been challenged by some industry representatives, as being overly optimistic the industry organizations were unwilling for reasons of confidentiality to substantiate their position with technical data to a sufficient extent. The Research[4] carried out in addition showed clearly the feasibility of the proposed requirements. Thus the final proposal does not completely follow industry suggestions.

The time table for the application of the requirements has

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[4] Emission Limits of Non-Road Mobile Machinery Engines, G.Cornetti 31/08/1994

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been designed in order to comply as far as possible with the wishes of the Industry. Thus the corresponding implementation scheme has become rather complex due to staggering in respect of different powerbands and different stages of stringency. The lead time is sufficient, as for Stage I (coming into force between 01/1997 and 01/1999 for the production of the engines) just obsolete engine technology has to be suppressed. Up to the application of Stage II a period of stability of five years has been foreseen. Thus the application dates of stage II will come into force 9 years from now at the latest (01/2004).

The reporting requirements and the type-approval approach were not appreciated by EUROMOT, and this view was supported by the other two associations. The industry resistance may be explained mostly with anxieties of those companies whose products have not yet been subject to any type approval. They are unaccustomed to these procedures. It should be noted that almost all of the procedures foreseen are in harmony with the pattern in force for the type approval of "on-road engines" defined in Directive 88/77/EEC[5], as last amended by Directive 91/542/EEC[6], in conjunction with Directive 70/156/EEC[7], as last amended by Directive 93/81/EEC[8]. The desired self-certification approach has not been considered as appropriate mainly for the following reason:

In contrast to requirements related to security aspects of technology, engine manufacturers do not risk becoming liable for possible damages caused by engines which did not comply with emission certificates. Thus it can be expected that, by the application of a self-certification regime, contractors - in respect of emission compliance - would be willing to accept higher risks than in other areas. Therefore a certain control regime is indispensable and the type-approval approach taken, is a European method which has stood the test of time. However, in comparison to existing legislation related to engines for on-road use, substantial relief has been incorporated with the Family-Concept, where only the parent engine has to be tested, and the waiver of any registration of the machinery once it has been completed with the certified engine at the time of entry into service.

With regard to the complaints concerning the reporting requirements it must be pointed out that these objections do not appear reasonable in the current era of modern electronic

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5) OJ No L 36, 09.02.1988, p.33

6) OJ No L 295, 25.10.1991, p.1

7) OJ No L 42, 23.02.1970,p.1.

8) OJ No L 264, 23.10.1993, p.49

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data processing. Given the examples from type-approval for "on-road engines", gathering, maintaining and regular reporting of the relevant data should not be an administrative and bureaucratic burden on the Industry. However, where the type-approval Authority can fulfil its surveillance duties with less reports from the manufacturers using other means than that foreseen by the drafted scheme, a flexibility clause has been integrated which commits the manufacturers to report only on demand by the Authority. Of course the provisions of the proposed Directive must always be safeguarded by the Authorities i.e. the effective control of compliance in respect of the implementation dates with regard to production and sales, and the compliance with the special conditions for the case of exemptions to be granted (see Explanatory Memorandum esp. 9.6 and 9.11).

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