OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

21108

June 1993

REGIONAL NETWORK ON CONTROL AND REGULATORY MEASURES CONCERNING MOTOR VEHICLE EMISSION

DP/RAS/89/057

ASIA-PACIFIC REGION

Guidelines */

for New Motor Vehicle Emission Control
in the Asia-Pacific Region

Prepared for countries of the Asia-Pacific Region
by the United Nations Industrial Development Organization
acting as Executing Agency for the
United Nations Development Programme

Based on the work of S. Radzimirski UNIDO Consultant

Backstopping officer: G. Anestis
Engineering Industries Branch

United Nations Industrial Development Organization
Vienna

*/ This document has not been edited

EXECUTIVE SUMMARY

Today, the Asia-Pacific region has probably the most rapid motor vehicle growth in the world. As a result, countries of this region are now starting to experience severe air pollution problems or are projecting that this will occur in the near future. One of the main reasons for severe, and worsening, air pollution problems in some areas of the region is that the motor vehicle emission reduction programmes are usually not sufficiently comprehensive and effective. It applies in the first place to the new vehicle control.

With regard to new motor vehicle emission control the situation in the region varies from country to country. Seven, out of eleven countries participating in the project, have already started some sort of such control. The conducted programmes differ considerably in respects of the severity of requirements, scope of coverage of standards, enforcement procedures etc. The most comprehensive programme comprising, among others, low-emission standards for cars and light-duty vehicles and effective control procedures is conducted in Republic of Korea. It can be held up as a very good model for all others. Four countries have not implemented any new motor vehicle control with regard to emission up till now.

To address vehicle related pollution problems, the upgrading of new vehicle emission control is necessary in the region as a whole. For this purpose, the regional cooperation, including, among others, the gradual harmonization of standards and control procedure, is required. The present "Guidelines" recommends the control system to be aimed at by participating countries. It comprises all elements required for effective control and reduction of emissions and takes into account specific conditions of the region. This system should be implemented:

a) partly on regional levels, in the framework of cooperation among countries participating in the project,
b) partly on country levels.

The regional cooperation in the area of new vehicle emission control is based on the following common elements of the control programmes:

- common, harmonized emission standards,
- uniform conditions of approval,
- reciprocal recognition of approvals granted in participating countries.

Actions on country levels include the following elements:

- conformity of production verification,
- control of vehicles which are not subjected to type-approval,
- other elements if their application is deemed necessary for the reduction of emissions in individual countries.

Given differences among countries in respect of conditions affecting emissions, two kinds of common standards differing in terms of severity are recommended for the initial phase of regional cooperation:

a) reduced-emission standards,
b) low-emission standards.

The ultimate goal is, however, to introduce low-emission standards for vehicle categories which account for the considerable share of emissions. Reduced-emission standards are recommended in order to make it easier for particular countries to handle transitional problems connected with the introduction of advanced technologies and control procedures.

Vehicle categories for which the far-reaching harmonization of requirements and control procedures is in the first place possible are:

- cars and light-duty vehicles equipped with SI engines,
- light and medium/heavy-duty diesel vehicles.

For these categories, two options of standards, including limit values and test procedures, are specified in the present "Guidelines" for both reduced - and low-emission vehicles. These options are based on one of the existing standards used in Europe, USA or Japan.

The implementation of the recommended programme for new vehicle emission control requires the development of administrative and technical services in countries of the region capable of handling control-related problems. The precondition for introduction of low-emission technologies is the availability of suitable fuels. Moreover, the introduction of enhanced in-use inspection is recommended in order to encourage and enforce owners to take better care of their vehicles.

Table of Contents

1. INTRODUCTION

The present "Guidelines for new motor vehicle emission control in the Asia-Pacific region" were prepared in the framework of UNDP/ /UNIDO project DP/RAS/89/057 "Regional network on control and regulatory measures concerning motor vehicle emission". The following countries of the region have declared their participation or interest in the project: People's Republic of China, Hong Kong, India, Indonesia, Iran, Republic of Korea, Malaysia, the Philippines, Singapore, Sri Lanka and Thailand.

The main objectives of the project are as follows:

- to initiate, develop and promote the cooperation among participating countries in the area of motor vehicle emission control, to establish working contacts between organizations dealing with motor vehicle emission control in these countries and to set up the nucleus of the operational regional network which would develop recommendations for common standards and policy in the mentioned area,
- to lay down terms for the introduction of common standards and control procedures for motor vehicle emission control at least for certain groups of countries within the region.

For this purpose, a series of guidelines for vehicle emission related issues requiring a common approach within the region will be prepared to assist the individual governments to address motor vehicle emission problems. These guidelines will take into account region -specific conditions which affect potential solutions of common problems such as vehicle design, vehicle population structure and density, road traffic, vehicle maintenance, economic situations, atmospheric conditions, current air quality etc.

At the "Expert Group Meeting on Control and Regulatory Measures Concerning Motor Vehicle Emission in the Asia-Pacific Region" held in Seoul from 21 to 24 August 1990 during the preparatory phase of the project the following issues to be dealt with by a common regional approach were identified:

- emissions standards for new vehicles,
- procedures for inspection of in-use vehicles,
- fuel quality standards,
- practical policies to improve the maintenance of vehicles.

Guidelines will be prepared for each of the above issues. They will be discussed and agreed upon at workshops arranged in the framework of the project.

The first "Guidelines" in the series of four guidelines to be prepared under the project were devoted to the problem of in-use vehicle inspection for emission control. They were reviewed and adopted at the "Expert group meeting on in-use motor vehicle inspection for emission control in the Asia-Pacific region" held in Seoul in October 1992 [2]. The present "Guidelines" are the second in the series.

The draft "Guidelines" were prepared by the UNIDO consultant on the basis of:

i) reports of the expert group meetings held under the project [1], [2], in particular country papers included in the above reports,
ii) results of his fact-finding missions to the region and comments of concerned organizations in visited countries to his suggestions and recommendations with regard to new motor vehicle emission control in the region,
iii) experience of countries conducting comprehensive and effective motor vehicle emission reduction programmes and practices being followed in these countries.

The draft "Guidelines" were distributed to the national focal points of all the aforementioned countries and presented at "Expert group meeting on type approval procedures for new vehicles" held in Jakarta in June 1993. This meeting reviewed the draft in great detail, recommended to introduce editorial amendments and adopted the amended "Guidelines". The meeting recommended to use the "Guidelines "at the basis for the regional cooperation in the area of new motor vehicle emission control.

2. SCOPE AND OBJECTIVES

The present "Guidelines" apply to emission control from new vehicles driven by internal combustion engines (hereinafter referred to as "motor vehicles"). The scope is broader than that identified at the meeting in Seoul in August 1990 as it covers not only emission standards but control procedures as well. These two problems are interdependent and should be discussed jointly.

The main objective of the "Guidelines" is to lay down terms for the gradual harmonization of control procedures and emission standards, in particular emission limits, test procedures and test equipment for new motor vehicles. The term "new motor vehicles" used in the "Guidelines" has a meaning "motor vehicles first registered" in particular countries.

First registered vehicles include, in turn:
a) physically new vehicles from domestic production or imported,
b) imported second-hand or reconditioned vehicles, or those assembled from reconditioned components.

This distinction should be made as the share of group b) in the first registration is significant in some countries of the region.

In principle, the "Guidelines" do not concern policy measures related to new vehicle emission problems as well as fuels and lubricants as special separate guidelines will be prepared for these issues under the project.

3. CLASSIFICATION OF MOTOR VEHICLES

The definitions of individual motor vehicle categories are not identical in participating countries. Therefore, it is considered advisable, as the first step towards common policy and standards with regard to emissions, to adopt the common classification of motor vehicles.

For the purpose of "Guidelines" the whole vehicle population is divided into:

- categories with regard to design, size and application,
- groups with regard to emission level.

The splitting into categories is as follows:

- mopeds - two or three-wheeled vehicles with an engine displacement not exceeding 50 cc and a maximum speed not exceeding 50 km/h,
- motorcycles - two or three-wheeled vehicles other than mopeds,
- cars - vehicles used for the carriage of passengers and comprising not more than 6 passenger seats,
- light duty vehicles (LDV) - vehicles used for the carriage of passengers (other than cars) and/or goods and having a maximum mass not exceeding 3500 kg (this category includes, for example: minibuses, delivery vans etc.),
- medium and heavy duty vehicles (M/HDV) - vehicles used for the carriage of passengers, goods or special purpose ones and having a maximum mass exceeding 3500 kg (this category includes, for example: buses, trucks, municipal vehicles etc.),
- others (e.g. agricultural tractors).

The above terms are used in the main part of the "Guidelines". However, terms defined in respective national regulations are used in Annexes describing the emission control in countries participating in the project and those leading in the area of vehicle emission reduction.

With regard to their emission level, motor vehicles are divided into the following three groups:

- uncontrolled vehicles,
- reduced (medium) - emission vehicles,
- low - emission vehicles.

The first group includes vehicles which have been manufactured and registered before any emission standards for new vehicles were introduced (technically uncontrolled),

The second group comprises vehicles in which special technical measures are used in the process of designing and manufacturing in order to reduce emission level and which belong to types officially approved in individual countries either by own emission certification procedures or by recognition of emission conformity certificates issued in other countries. The reduced-emission group includes also vehicles which have been retrofitted with emission reducing devices.

Emission level of reduced-emission vehicles corresponds to that set for instance (Annex 2, 4):

- for cars and LDV - in ECE Regulation 15/00 - 15/04 and Regulation 83/01 approval A,
- for M/HDV - in ECE Regulations 49/00 - 49/01 and 24/00 - 24/03, Japanese regulations used before 1994,

- for mopeds - in ECE Regulation 47/00,
- for motorcycles - in ECE Regulation 40/00 - 40/01.

The group of low-emission vehicles comprises vehicles fitted with the state of the art emission controls, e.g. three-way catalytic converters for cars, and complying with standards in force in the leading countries at the beginning of the nineties e.g. ECE Regulation 83/01 (approval B and C), American and Japanese standards. These vehicles may be fitted with such controls when new or retrofitted. The low-emission vehicles are often referred to as "high-tech" vehicles.

4. STATUS OF NEW MOTOR VEHICLE EMISSION CONTROL AROUND THE WORLD

4.1. General

Emission control systems for new motor vehicles currently used around the world are based on standards and procedures developed in the USA, Japan or Europe. These standards and procedures are continually modified and amended in order to adopt them to requirements of environment protection and development of emission reduction technologies. They are presented in detail in the following Annexes to the present "Guidelines":

- for Europe, in particular Economic Commission for Europe (ECE) and European Communities (EC) - in Annex 2,
- for USA - in Annex 3,
- for Japan - in Annex 4.

For the purpose of comparison, the status of new motor vehicle emission control in countries of the region participating in the project is presented in Annex 1. Only a part of these countries has already started some sort of such control. This group includes: China, Hong Kong, Korea, India, Indonesia, Singapore and Thailand. In other countries, the emission control has been limited to in-use vehicle inspection up till now [2], [3].

The standards and procedures used around the world differ in many respects but at the same time have some common points. The main differences lie in applicability, control procedures, severity of emission standards and driving cycles. Common points are usually some elements of test procedures, except driving cycles, e.g. analytical methods and equipment, gas sampling systems.

The summary of the status of new motor vehicle emission control, pointing out differences and common points, as well as advantages and defects of particular programmes, is presented below in this chapter.

4.2. Emission standards

The current standards lay down requirements with regard to emissions from all main vehicle sources, i.e:

a) exhaust system (exhaust emissions), the following pollutants being controlled:
   - gaseous emissions (carbon monoxide (CO), total hydrocarbons (HC) and oxides of nitrogen (NO_x)),
   - particulate emissions (PM),
   - smoke (visible emissions),
b) crankcase (crankcase emissions),
c) fuel system (evaporative emissions or losses).

The exhaust gaseous emissions are controlled for vehicles equipped with SI engines and all the aforementioned exhaust emissions, i.e. gaseous, particulate and smoke ones, in the case of diesel vehicles. The future American standards are going to introduce changes to the above classification. These changes are as follows:
- non-methane hydrocarbons (NMHC) will be controlled parallelly with total hydrocarbons,
- particulate emissions will be limited also for vehicles with SI engines.

It is worth noting that exhaust emissions of lead and sulphur compounds are controlled by limiting the lead and sulphur content in fuels.

The severity of requirements laid down in individual countries varies very much. As a matter of fact, an exact comparison is difficult or even impossible because of differences in test procedures (point 4.3. below). In addition, vehicle classification is different. It is to note that the severity of requirements does not depend only on limits. Other factors, e.g. whether the standard is applicable to new vehicles or for the vehicle life, control (enforcement) procedures play a very important role.

As regards cars, the limits in force in the USA (Annex 3, point 3.2.) and EC (Annex 2, point 1.5.3.) are roughly comparable, Japanese (Annex 4, point 4.) being regarded as slightly more lenient. In all the cases the state of the art technologies have to be used to meet them. Similar standards are laid down in some other countries, including Korea, Hong Kong abd Singapore from among those participating in the project. In many countries, however, standards of reduced-emission level are still in force. Among them are those European ones which apply ECE Regulations 15/04, or Regulation 83/01, but have not specified in the framework of their national regulations, the classes of vehicles that have to run on unleaded petrol, as well as countries participating in the project e.g. India. The majority of reduced-emission standards is currently based on ECE Regulation 15. There are also standards for new vehicles that specify only limits for pollutant concentrations at idle speed (e.g. Indonesia, China).

It is worth noting that although the first ECE emission regulations were introduced as early as at the beginning of the seventies, until recently ECE (and EC) lagged behind the USA, Japan and some other countries. Up to the end of the eighties, ECE/EC regulations were very lenient and the use of the latest technology was not required to meet them. It did not result from technological

barriers, as many European manufacturers produced for export vehicles conforming to American and Japanese standards, but rather from economic considerations. In practice, the approach was aimed at taking inexpensive precautions in order to avoid the repetition of critical environmental situation which had occurred in some other areas rather than to tackle the problem. A considerable progress has been achieved since 1989 and the current ECE/EC standards for cars are, as already mentioned, comparable to those used in the USA and Japan.

The essential difference exists between the severity of American (Annex 3, point 3.2.) and ECE/EC (Annex 2, point 1.5.) limits for light-duty vehicles, American one being considerably stringent, for both diesel and petrol vehicles. As regards motorcycles, the standards in ECE are relatively lenient (Annex 2, point 1.8.). Moreover, they depend on the engine technology, those for two-stroke being more stringent for CO, but more lenient for HC which is not the case in the USA (Annex 3, point 3.5.).It is to note that more stringent requirements for LDV and motorcycles, as well as for mopeds are under preparation in EC.

For M/HDV equipped with diesel engines (ECE/EC legislation is not applicable to petrol M/HDV as this category is in practice not used in Europe), US limits (Annex 3, point 3.4.) for the main pollutants NO_x and PM are roughly comparable to those specified in the new ECE Regulation 49/02 (Annex 2, point 1.6.). The main difference is in CO limits, those in the USA being less stringent. It results from the fact that the American regulations are applicable also to vehicles equipped with SI engines. The Japanese standards that are going to be introduced from 1994 (Annex 4, point 4., Table A4/3) will considerably tighten current relatively liberal requirements for M/HDV.

The current emission standards fall into two broad categories. They are applicable either

- to new vehicles, or
- for vehicle useful life.

This factor considerably affects the severity of requirements. The first group specify limits which should be met after the vehicle has been run in and do not lay down any requirements to be satisfied afterwards. To this group belong ECE Regulations with the exception of 83/01 (Approval B and C) and Japanese ones for M/HDV. On the other hand, all American standards fall into the second group, the useful life depending on the category. To this group belongs also ECE Regulation 83/01, but only with regard to exhaust emission control. An assessment of useful life performance is part of certification/type approval procedure. It is accounted for by multiplying the values measured on new vehicles by so called deterioration factors established during accelerated durability tests conducted under specified driving conditions on test vehicles.

In the USA, the rule of "equal treatment" for vehicles which differ in terms of size, engine type (diesel, SI), used fuels (methanol fuel, petrol etc.) is used as far as possible to stimulate

technological development. The European approach is more pragmatic and limits often depend on the design. Moreover, US regulations set very strict requirements with regard to the scope of maintenance specified in manufacturer's instructions. Any emission related maintenance must be technologically necessary to ensure in-use vehicle compliance with the standards. Its schedule must be approved by the certification authority. The adjustment, cleaning, repair or replacement of, for instance, the following items within the 80000 km useful life of the vehicle is not regarded as technologically necessary for petrol vehicles:

- PCV valves,
- ignition wires,
- catalytic converters,
- fuel injectors,
- evaporative emission canisters.

Until recently most of air pollution problems were considered local in nature. Over the last decade, however, evidence has been increasing that some of severe impacts may occur over large distances from the source and over long periods after the actual emissions occurred. A comprehensive look at air pollution today has to consider local impacts, regional effects and global changes. This approach is now starting to affect emission legislation including that for new motor vehicles. The consideration of regional effects, e.g. acid deposition, gave rise to the introduction of high speed elements in European driving cycle (point 4.3. below). The introduction of CO_2 - related legislation for motor vehicles is now under consideration in some countries, among others in EC and Japan.

4.3. Test procedures

The three main test procedures used for the emission measurement around the world have differences and similar points. The main difference lies in the operating conditions under which tests are conducted. It applies to test procedures used for all vehicle categories: cars/LDV, M/HDV and motorcycles. As regards cars and LDV, American, European and Japanese current regulations are based on driving cycles which appreciably differ in such respects as maximum speeds, acceleration rates, the share of different modes (idling, steady speeds, deceleration, acceleration). It is to note that European and Japanese cycles developed more than twenty years ago have been lately modified. High speed sequences have been introduced in order to reproduce more representatively conditions at which high NO_x emissions occur. These sequences are intended to simulate highway operating conditions which account for a considerable share of total NO_x emissions. The US cycle is only an urban cycle. Therefore, in some countries using the US cycle e.g. in Stockholm Group ones, NO_x limits under highway conditions (US EPA Highway Fuel Economy Driving Schedule) are specified in addition to those for urban driving conditions.

It is worth noting that India is the only country which has

developed and implemented its own driving cycle representative of specific driving conditions (so called Indian driving cycle) and different from those specified in Japanese, American and European regulations (Annex 1, point 3.). Sampling, analytical and calculation methods used in different exhaust test procedures are, unlike driving schedules, similar and to some extent harmonized. So are the main components of test equipment.

The differences in the driving schedules make the comparison of emissions standards specified in respective regulations for cars and LDV very difficult. It results from the fact that the correlation of emission obtained using different cycles is usually poor, in particular for vehicles with SI engines. This is illustrated in Fig.1.

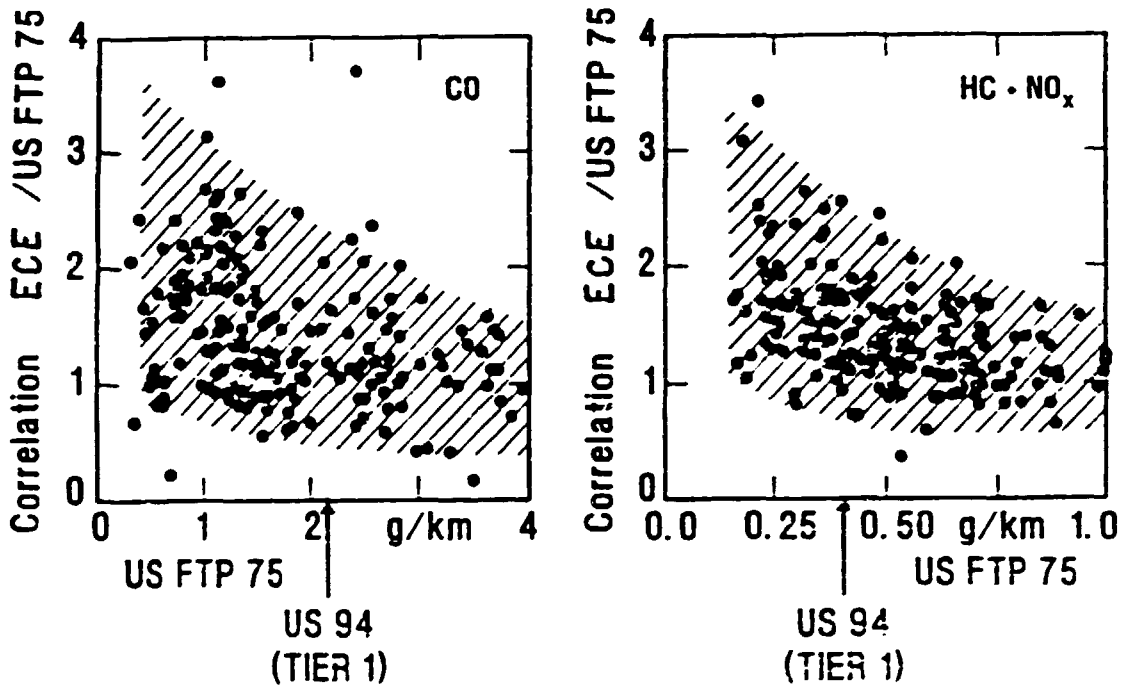


Fig.1. Comparison of tests results obtained in accordance with FTP 75 and ECE Regulation 83/01 [16]

The scatter of results is very large. One of the reasons for this scatter is the fact that the catalyst light-off temperatures are usually reached later in the ECE driving cycle due to lower average engine load in the first phase of operation after a cold start.

It is also to note that ECE Regulation 83/01 treats HC and NO_x emission jointly. It ensures more flexibility for meeting the requirements and consequently tends to make them less severe than Japanese and American regulations in which separate limits are specified for those components.

As far as medium - and heavy-duty vehicles/engines are concerned, there are many differences in test procedures specified in Japanese, American and European regulations. The main

differences for gaseous emission and particulate measurements are:

a) transient test in the USA, steady speed tests in Japan and ECE,
b) pollutant concentrations are measured in the sample of diluted exhaust gas in the USA, but in the directly taken, undiluted one in ECE,
c) although both (new) Japanese and ECE tests are 13 - mode tests there are essential differences between them in terms of engine speed and load, as well as weighting factors,
d) Japanese regulation allows for tests to be conducted either with the engine placed on an engine test bench or with the vehicle placed on a chassis dynamometer.

In spite of the above many differences, the correlation between results, measured according to particular procedures seems to be better than in the case of petrol cars (Fig.2).

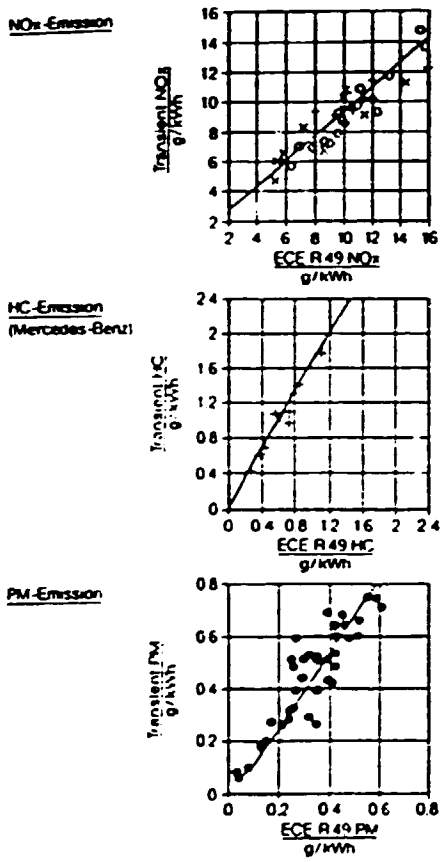


Fig.2 Correlation of emission results obtained in accordance with ECE Regulation 49/02 and US transient test [17]

There are also differences in smoke test procedures used in the USA, Japan and ECE. The main ones are:

a) full load steady speeds in Japan (3 points) and ECE (usually about 6 points), but full load transient conditions (acceleration and lugging modes) in the USA,
b) opacimeters in the USA and ECE, but filter-type smokemeters in Japan.

As regards evaporative emissions the test procedure is well harmoninized. SHED method is specified in the majority of current regulations (Annex 2, point 1.5.3., Annex 3, point 3.3.3.). Japanese regulation permits the use of trap method as well (Annex 4, point 5.6.).

4.4. Control procedures

Modern motor vehicles have to satisfy several requirements with regard to safety, energy consumption, pollutant emission etc. Test procedures for the determination of the full compliance are very complex, time consuming and expensive. They often impose very hard conditions with regard to equipment and manpower. In addition, some of them are destructive. Consequently, it is practically not possible to check all, or at least a significant percentage of, new vehicles for full compliance with the requirements, those with regard to emissions included. As a result, control procedures in which the compliance with the requirements in force is checked "collectively" for some, larger or smaller, vehicle groups, but not separately, individually for each unit, have been developed.

In some countries requirements with regard to emissions were introduced later than those for safety. In addition, different authorities are often in charge of emission control and safety control. As a result, two extreme main models of new vehicle control systems have evolved:

a) "combined" system in which control with regard to all requirements, i.e. safety, emissions etc., is combined and in which control with regard to emissions is part of an overall roadworthiness control system (in the majority of countries),
b) control with regard to safety and control with regard to environmental requirements, in particular emissions, are separate, to some extent independent and run by different authorities, vehicles having to pass both of them (e.g. in USA, Korea).

In some countries, a model which can be classified as mixed one is used (e.g. in Hong Kong). It is to note that there is an essential difference between ECE and EC systems despite the fact that the same, to some extent, harmonized emission regulations are used in both of them. An important feature of the EC system is that the intention is there for complete vehicles to be approved with regard to all requirements. On the other hand, the ECE system applies to separate individual requirements, among others those for emissions.

For each of them a separate procedure is provided.

Beyond standards alone, actual emissions from vehicles can be considerably affected by the manner in which the requirements are enforced (enforcement or control procedure). The existing control procedures are formed from the following main elements:

a) vehicle certification in the USA or type approval (TA) in ECE/EC, Japan, Indonesia, India etc.,
b) verification of the conformity of production (COP),
c) durability surveillance of in-use vehicles (recall).

The above elements play different roles and have different functions. Not all of them are included in systems used in individual countries, even in countries leading in the area of vehicle emission control e.g. EC.

Vehicle certification or type approval means the procedure by which the competent authority empowered by the legislation in force in a given country (or in a group of countries) certifies that vehicles satisfy the relevant technical requirements. For the purpose of certification/approval, vehicles are divided into groupings which are expected to have similar emission characteristics. These groupings are defined "types" (ECE/EC, Japan), "engine families" (USA). To be classified in the same grouping, vehicles must be identical in all the respects defined in great detail in regulations (Annex 2, point 1.3.1. or Annex 3, point 2.). It is to note that the meaning of the term "vehicles with the same engine family" used in USA regulations is usually different than that of "vehicle type" in ECE/EC regulations. Several European types may be covered by a US family. However, ECE regulations/EC directives allow for the extension of type approval on further vehicles which are expected to have similar emission characteristics. It considerably reduces the number of tests.

Tests of one or a few vehicles are conducted in order to check the compliance of the type/family with the emission requirements. The certification/approval is granted if these vehicles pass the test and if additional requirements are satisfied. Such additional requirements may be, for instance, the ability of the manufacturer to ensure the effective control of the conformity of production. If the certification/approval is granted the manufacturer obtains a certificate of conformity (or approval) covering the specific grouping of vehicles. The manufacturer has to guarantee that all manufactured vehicles covered by the certificate are technically equal to the tested one(s) and comply with the regulations.To this end, every vehicle should be labelled by the manufacturer or accompanied by a document stating its compliance with the regulations in force (manufacturer's certificate).

The certification/approval procedure is conducted before the new vehicle family/type is offered for sale and introduced into operation. All modifications to the vehicles should be notified to the authority which have issued the certificate. This authority decides whether the modified vehicles are still covered by the certificate in effect or new certification/approval process is required.

It is worth pointing out some differences between the European type approval and American certification. In the former case, the approval process is mainly conducted by the approval authority and authorised technical service. The certificate is issued on the basis of their own tests and verifications. In the American procedure, most of the actual conduct of the certification process is usually done by the manufacturer. He has, to some extent, to supply the evidence that vehicles conform to the requirements. There is in it a degree of selfcertification for emission compliance. Moreover, in the ECE/EC system the certificate is valid for the vehicle type life unless a new, more stringent standard is laid down. The American certificate is issued for a specific period.

The specific form of approval procedure is that used in some countries of the region (e.g. Hong Kong, Singapore). In those procedures, the actual emission tests are not conducted. The applicant for approval should submit a certificate of conformity issued either by the vehicle manufacturer or by an authorized motor testing laboratory, or by approval authority in foreign countries. It is to note that in above countries all new vehicles are, in practice, imported.

In the majority of control systems, the competent authority is empowered to verify that vehicles covered by the certificate of conformity actually satisfy the emission requirements. This verification of the conformity of production (COP) may have different forms:

a) without actual emission tests:
   - verification that control methods used by the manufacturer are capable of ensuring the required conformity of production and that the control is actually conducted (ECE/EC),
   - checks that manufactured vehicles conform to the description as given in the certificate (ECE/EC),
   - functional test i.e. checks that the emission control systems function according to specifications,

b) with actual emission tests:
   - tests performed by the manufacturer on a limited number of production vehicles at the end of production line, the results of which have to be periodically reported to the certification/approval authority (e.g. in Quality Audit Tests in California, the tests should comprise 2% of production and the results should be reported every 3 months),
   - tests performed by the certification/approval authority itself or under its supervision on randomly selected vehicles (Selective Enforcement Audit in the USA or COP verification in ECE/EC, India).

Tests in the latter case are conducted on new vehicles intended for sale, usually selected at the end of production line (USA, ECE/EC). However, the provisions of some regulations e.g. of those used by Stockholm Group, make it possible to select a sample from among

vehicles newly sold. The maximum distance covered by such vehicles should be less than 15000 km.

The regulations in force do not usually require that emissions from every single manufactured vehicle should not exceed the specified limits. The statistical approach is used for the verifications of conformity of production. ECE Regulations specify two kinds of limits: lower for type approval and higher for conformity of production. Emissions from a single vehicle in the sample taken from the series and subjected to the test are not limited at all. They may exceed the COP limits providing that the statistical average of the sample meets the requirements. In American Selective Enforcement Audit, the series is deemed conform if not more than 40% of production exceed the limits. Japanese regulations prescribe two limits: mean and maximum. The mean limits are applicable to the average emissions of a sample tested during each quarter of a year. Individual vehicles in the sample should not exceed the maximum limits (Annex 4, point 4).

Many research works have shown that deterioration factors established on the basis of durability tests conducted for certification/type approval do not represent the actual deterioration occurring on real vehicles used under real driving conditions. In some cases, the actual deterioration may be even up to 3-6 times worse than that predicted on the basis of tests. It shows the importance of checking the durability on the basis of real in-use vehicles. This was one of the reasons for the introduction of durability surveillance of in-use vehicles. Some regulations (e.g. American ones for all vehicle categories, those laid down in Stockholm Group countries and Korea for cars and LDV) require that every vehicle put into operation, properly maintained and used, should conform to the requirements, when in actual use, for a specified period of use or driven distance. For cars, the useful life is usually defined as a period of 5 years or 80000 km whichever first occurs. The regulations require that the useful life should be covered by the emission device defect and emission performance warranty. Defects of emission-related devices should be reported for this period to the certification authority (California). A report has to be filed when a number of defects on an individual component exceeds the specified rate. The current rate in California is 4%. It will drop to 2% in 1994. The report consists of the specification of the defective components, analysis of the effect on emissions and description of corrective measures to be taken by the manufacturer.

A sample of in-use vehicles may be tested for compliance with the requirements (Korea, Stockholm Group). Only vehicles properly maintained and used are selected for this purpose. If the number of defects or the share of vehicles which fail the test of the sample is substantial, the certification authority may decide upon a recall. The manufacturer is required to correct all in-use vehicles falling into the family/type which does not conform to the requirements. In California, if the manufacturer voluntarily agrees to recall their defective vehicles, he has to ensure that at least 60% of them come in and get fixed. However, if the recall is orde-

red by the authority, the required rate is 80%. On the other hand, the federal regulation does not specify any mandatory rate for recalls.

Unlike American regulations, ECE Regulation 83/01 which also specifies durability test, does not lay down any limits for in-use vehicles. The only provision in this respect is that the emissions of air polluting gases should be effectively limited throughout the normal life of the vehicle and under normal conditions of use. The term "normal life" is, however, not defined. Nevertheless, Holland takes advantage of this provision and conducts a recall process.

The recall process affects the total emissions not only by causing defects and malfunctions of in-use vehicles being repaired. Many manufacturers, when designing vehicles, take into consideration real traffic deterioration and set their design targets well below the legal certification/type approval limits (or conformity of production limits) to account for possible unexpected deterioration.

4.5. Technologies

For many years, emission reduction programmes in the leading countries concentrated on cars equipped with SI engines. They contributed to very fast advances in emission technologies, which, in turn, resulted in the considerable reductions of emissions. Since the end of the seventies when the very stringent exhaust emission standards were introduced in Japan (at that time probably the most stringent in the world) and California, and when US Congress revised the Clean Air Act setting standards to achieve a 90% HC, 90% CO and 75% NO_x reduction in 1980/1981 as compared with 1970 level the dominant technology for exhaust emissions has become that of three way catalyst combined with electronic engine management.

It is interesting to note that at that moment when the very stringent emission standards were introduced in the USA and Japan, there were several other technical alternatives to solving the problems. They include, among the others, CVCC engines developed by Honda, Lean-Rich engine concept developed by Mitsubishi etc. However, all these alternatives have been abandoned.

The catalyst technology has been continually improved. Improvements are the results of, among others, better air fuel management systems, more precise electronic control, better and more durable catalysts with improved coatings. In addition, the reduction of oil consumption and better fuels have also contributed to the improvements of catalyst performance.

As a result of continual amendments of exhaust emission legislation in order to adopt it to the progress in technology and vice versa, a current new "high-tech" vehicle emits on the average under test conditions only 5-15% of CO, HC and NO_x amounts exhausted to the atmosphere by its uncontrolled predecessor from the sixties (Table 1). The progress in terms of the exhaust emission reduction under real driving conditions is lower, but still spectacular.

Table 1

Percentage reductions of exhaust emission standards in ECE Regulations for cars (estimate for vehicles with a reference mass of 1250 kg)

Control stage	Reduction (%)	
	CO	HC + NO_x
Uncontrolled	-	-
Regulation 15/00	34	11
Regualtion 15/01	48	17
Regulation 15/02	48	22
Regulation 15/03	58	33
Regulation 15/04	68	44
Regulation 83/00	85	78
Regulation 83/01	95	89

It is worth pointing out that the emission of modern vehicles even without catalytic converter or λ - probe are relatively low, many times lower than those of uncontrolled or reduced-emission vehicles (Table 2).

Table 2

Effect of emission control devices on emission level

	Emission control	Emission (g/km)		
		CO	HC	NO_x
1	With converter and λ - probe	2.14	0.26	0.17
2	With converter, without λ - probe	5.70	0.50	0.61
3	Without converter, with λ - probe	8.18	1.10	1.11
4	without converter and λ - probe	7.85	1.19	1.29

Parallelly with exhaust emission, a considerable progress has been made in the area of crankcase and evaporative emissions. Crankcase emission controls, basically consisting of connecting, directly or indirectly, the crankcase vent port to the engine inlet system are used on almost 100% of currently produced vehicles in the world. Control of this emission source is no longer regarded as a technical problem. The technology for evaporative losses was developed at the beginning of the seventies and its basic concept has remained unchanged. Their control consists in feeding them back into the engine to be burned. When the engine is switched off, fuel vapours are stored, usually in charcoal canisters and then draw into the cylinders after the engine has been started. The current level of evaporative losses from a low-emission vehicle under test conditions represents an about 60 - 75% reduction as compared with an uncontrolled vehicle.

The technological concept of a low-emission petrol car is, to some extent, standardized and consists of the above exhaust, crankcase and evaporative controls. However, actual devices used in

individual vehicle types/families differ very much in respect of their specific design, efficiency etc.

It applies also to catalytic converters. They differ in such respects affecting emissions as the size and shape, the type of substrate (ceramic, metal foils), washcoat structure and composition, applied noble metals (Pt, Rh, Pd) and their loading etc. In addition, the design is, to some extent, adopted to test procedures. It happens that vehicles designed for one of the markets, e.g. EC, do not comply with requirements of another market, e.g. American one, and vice versa. One of the reasons for such non-compliance is presented in Fig. 1 (point 4.3. above). Technologies developed for petrol cars have been gradually taken advantage of for the reduction of emissions from other vehicle categories equipped with SI engines: LDV, M/HDV (in particular in the USA) and, to some extent, motorcycles and even mopeds.

The rule of equal treatment of vehicles, irrespective of their design, has contributed to the gradual development of the state of the art technology for diesel cars and LDV. After the introduction of PM standards more and more of them are equipped with oxidation catalytic converters.

While the considerable progress in the field of cars has been achieved, it has become more and more evident that reductions from these vehicles alone are not sufficient to solve the air pollution problems in many areas. Therefore, another main category medium - - and heavy - duty diesel vehicles has been receiving increased attention as significant source of NO_x and PM. Although the first emission standards for M/HDV were introduced as early as in 1970 the technological progress for this category has not been as spectacular as in the case of petrol-fueled cars. It has mainly consisted of engine modifications including combustion chamber configuration, fuel ignition timing and pattern, the use of turbocharging and EGR. The current levels of NO_x and PM emissions from M/HDV measured under test conditions represent on the average a 50 - 70% reduction as compared with uncontrolled vehicle.

The new standards set in the USA at the end of the eighties and in Japan and EC at the beginning of nineties are aimed at fostering technological advances similar to those which have been achieved for petrol cars. Up till now no dominant technology has emerged for diesel M/HDV. Oxidation catalytic converters, traps, trap-oxidisers and EGR combined with electronically controlled fuel injection and diesel fuel modifications, including composition, properties and additives, are regarded as the most promising for this purpose. It is expected that the progress for this category will be extended on the other vehicles using diesel engines, for instance agricultural tractors, construction plants etc. in a similar way as that for petrol cars was extended on light-duty vehicles etc. A regulation for agricultural tractors setting roughly similar requirements to those specified in ECE Regulation 49/02 is already under discussion in ECE.

5. TERMS FOR REGIONAL COOPERATION IN THE AREA OF NEW VEHICLE EMISSION CONTROL

5.1. Current situation

Today, The Asia-Pacific region as a whole has the most rapid growth in the motor vehicle population in the world. In Korea, for instance, the total number of registered motor vehicles rose from 1.1 mln in 1985 to 3.4 mln in 1990 which corresponds to an increase rate of 25% per year. The projected vehicle population is about 8.5 mln in 1996 and more than 10.0 mln in 2000. In other countries of the region, the growth has not been so spectacular, but nevertheless considerable on the average, e.g. in Sri Lanka the total number of registered motor vehicles rose from 0.34 mln in 1980 to 0.95 mln in 1992 i.e. almost tripled. This growth has its specific characteristics. One of them is that the distribution of vehicles is not uniform over the country. They are, first of all, concentrated in big cities, in particular capital cities. Moreover, the vehicle kilometrage driven (VKT) per year is very high. It is reported to be more than 35000 km for cars in Korea. Also other countries report very high VKT (e.g. in India about 20000 km [1]). The growth in vehicle population and the progress in technologies are not accompanied by a sufficient improvement in vehicle maintenance which usually lags behind. As a result, despite a relatively low degree of motorisation measured, for instance, in terms of vehicle population per capita and despite the fact that a great deal of progress (Annex 1) has occurred in recent years in the emission control, many cities of the region e.g. Bangkok, Manila, Bombay, Teheran have already started to experience severe air pollution problems. Given the very rapid projected growth in vehicle population, the number of areas with unacceptable air quality will rise very fast if more effective measures to address motor vehicle emissions are not taken in the relatively near future. One of the main reasons for severe, and worsening, air pollution problems in the region as a whole is that the motor vehicle emission reduction programmes conducted in particular countries are usually not sufficiently comprehensive and effective.

Experiences of many countries have shown that the best efficiency of the emission reduction can be achieved if all measures taken up for this purpose are not conducted separately but form a comprehensive and uniform motor emission control system. In such a system the vehicle emission control consists in:

- new vehicle control,
- in-use vehicle inspection,
- fuel quality control.

The system is formed by the following elements:

- legislation empowering competent authorities to carry out control and to introduce emission standards,
- standards (regulations) for new - and in-use vehicles and standards for fuel quality, specifying limits and test methods,

- control procedures for new and in-use vehicles, as well as for fuel quality,
- network of test centres and inspection stations,
- supportive and enforcement elements such as vehicle registration system, economic measures: e.g. taxation, custom-duties, incentives etc., enforcing measures: e.g. sanctions and penalties, maintenance and repair network.

In the majority of countries participating in the project, motor vehicle emission reduction programmes do not include all required elements. It applies in the first place to the new vehicle control which is affectively conducted only in a few countries (point 5.3. below). The most comprehensive and effective is the programme carried out in Korea (Annex 1, point 5). After the introduction of requirements with regard to particulate emissions from new light- and heavy-duty vehicles equipped with diesel engines which is scheduled to go into effect from 1996, it will comprise all the elements which are necessary for the effective control of air pollutionin Korea. As a whole, the Korean programme can serve as a reference for all countries participating in the project. By taking example by this programme, it is possible to effectively address the motor vehicle problems in the region.

5.2. Outline of the motor vehicle emission control system for countries participating in the project.

The outline of the motor vehicle emission control system for countries participating in the project, comprising all elements required for the effective control and reduction of emissions, is shown in Fig. 3. This is the ultimate model to be aimed at. This system was reviewed in great detail and adopted as serving a purpose at the Expert Group Meeting in Seoul in October 1992 held under the project [2].

In this system, the vehicle influx into a given country for the first registration is divided into two streams called for the purpose of the present "Guidelines:

a) vehicles subjected to type approval,
b) vehicles exempted from type approval.

The group a) includes new vehicles supplied in larger quantities:

- produced by local manufactures,
- imported by companies/dealers.

The other group includes:

- new vehicles imported by companies/dealers in small quantities and by private persons,
- second-hand vehicles imported by companies/dealers/private persons,

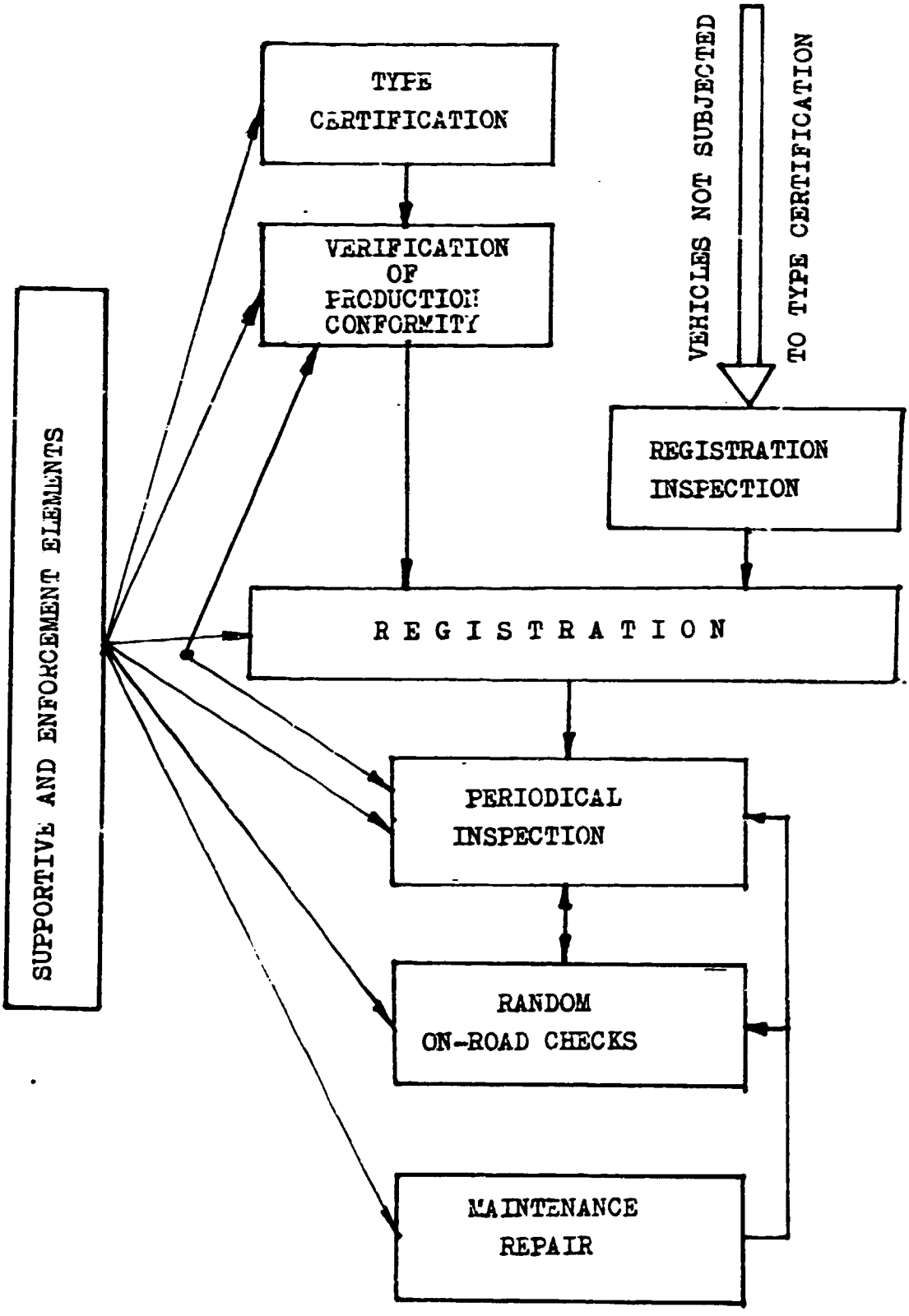


Fig. 3 . Motor vehicle emission control system

- vehicles assembled locally in small quantities (e.g. from spare parts).

Therefore, the system takes into account the specific of those countries in which vehicles, both new and second-hand ones, imported in small quantities for sale or by individual persons for their own use account for a considerable share of the total registration.

The group a) of vehicles is subjected to the type approval which is granted when the requirements specified in regulations/ /standards are complied with. It is also subjected to the production conformity verification.

The compliance of every vehicle of group a) with the requirements with regard to emissions has to be certified by the manufacturer. Vehicles of this group are not subjected to registration inspections. On the other hand, every vehicle of group b) is to be inspected or individually emission tested, if necesasary, prior to the registration and its registration can be granted only if it meets the emission requirements.

The new vehicle control is the cornerstone of the whole system. Provisions in this respect, in particular emission standards, affect considerably those for fuels and for in-use vehicles. Moreover, they have much effect on pre-registration inspection procedure (point 7.2. below).

5.3. Actions to be taken for new motor vehicle emission control

The situation with regard to new motor vehicle emission control in the region varies from country to country. Seven of the countries participating in the project have started some sort of such control (Annex 1). In other 4 countries no requirements with regard to new vehicle emissions have been laid down and/or implemented.

Two main aspect should be taken account of when the situation in the first group of countries is compared:

- severity of standards,
- kind of control procedure.

As regards the first aspect, the severity ranges from low-emission requirements to requirements with regard to idle concentrations only (chapter 6 below). The applied control procedures can be divided as follows:

a) comprising both type approval and COP verification based on own tests (Korea, India),
b) comprising only type approval based on own tests (Indonesia),
c) comprising only type approval based on tests conducted by foreign laboratories (Hong Kong, Singapore).

As it can be seen, the emission control programmes for new vehicles applied in the region differ very much from that described in point 5.2. below.

It is possible to considerably reduce the emissions by upgrading these programmes. The control system to be aimed at should be implemented:

a) partly on regional levels in the framework of the cooperation among countries participating in the project,
b) partly on country levels.

There is a room and need for genuine regional cooperation in the area of new motor vehicle emission control. It should be based on the following common elements of the control programmes:

- common, harmonized emission standards,
- uniform conditions of approval,
- reciprocal recognition of approval granted in other participating countries.

The cooperation among the participating countries based on the above terms will have many advantages for the region as a whole and for individual countries. In this respect much can be learned from experiences of ECE. Countries applying ECE Regulations, like those of the Asia-Pacific region, differ very much with regard to conditions affecting emissions. Despite these differences, it has been possible to set up a harmonized control system, including common limit values, test procedures and conditions of approval.

The cooperation among countries of the region will assist in the reduction of motor vehicle emissions by:

- increasing the market volume and, as a result reducing the development and investment costs for the vehicle manufacturers and thus making it easier for them to meet common requirements,
- increasing the market power and thus making it easier to force the vehicle suppliers to comply with the standards in force, individual markets being too small to dictate requirements,
- making it easier to introduce fuels satisfying common requirements, e.g. with regard to lead content in petrol and sulphur content in diesel fuels,
- adding the credibility to country programmes,
- supporting compliance programmes in countries, which, for economic reasons, are not in a position to conduct control especially when extensive testing is involved requiring complex and sophisticated test equipment,
- decreasing the implementation costs.

The remaining portion of the new vehicle emission control is implemented on country basis. It is entirely left to the discretion and initiative of each of participating countries. The actions on country levels include the following elements (Fig. 3):

- conformity of production verification,
- control of vehicles which are not subjected to type-approval,
- other elements if their application is deemed necessary for the reduction of emissions in individual countries, e.g.

durability surveillance of in-use vehicles (recall).

Given differences among countries in the current status of new vehicle emission control, in particular in the severity and scope of coverage of emission standards, as well as in economic situation, the introduction of harmonized, stringent low-emission standards in all of them does not seem to be realistic in the near future. It is also to note that the degree of urgency for such standards is different. Therefore, two kinds of standards differing in terms of severity are recommended for the first phase of implementation of regional cooperation (chapter 6):

a) reduced-emission standards,
b) low-emission standards.

The implementation of these standards should be conducted selectively, the following main factors being taken into account:

- air quality in the country,
- projections of motor vehicle population and emission growth,
- contribution of motor vehicles as a whole and individual vehicle categories to air pollution, both local (e.g. in great cities) and nation-wide,
- efficiency of control,
- cost effectiveness of control and costs to vehicle manufacturer and motorists,
- availability of low-emission technology to the domestic manufacturer.

The ultimate goal is, however, to introduce low-emission standards for vehicle categories which account for the considerable share of emissions in a given country. Reduced-emission standards should be regarded as some sort of a waiver, granted in order to make it possible to handle transitional problems connected with the introduction and absorption of advanced, state of the art technologies. In contrast to low-emission technologies which are at present mainly available to Korean manufacturers, reduced-emission ones are within reach of the majority of manufacturers in the region. Reduced-emission standards ensure the equal treatment to all of them in the first phase of cooperation.

A fundamental question which has usually to be answered before any specificationswith regard to emissions are laid down is whether to adopt the requirements of one of the existing programmes or to set a unique programme with new test procedure. However, in the case of the region and regional cooperation this question is not relevant any longer. The majority of countries participating in the project has already taken an approach of adopting one of the existing programmes as far as possible as the basis for their new vehicle emission control.

Such an approach is also used in the present "Guidelines". However, the unique situation of participating countries is also taken account of in the recommendations with regard to emission standards and control procedures. The main problem to be solved is which of the existing programmes is the most suitable for the

region as a whole and should be applied in the framework of the regional cooperation (chapter 6 below).

The recommended cooperation and harmonization of the emission control is conducted on a purely voluntary basis. Its form may be different. The simplest initial case is that of two neighbouring countries coming to an agreement with regard, for instance, to the control of one category of vehicles. The most desirable form and the ultimate goal is, however, the regional network on emission control including the majority of countries of the region. To this end, groups of countries having similar conditions may initially proceed on their own time-table, gradually expanding the scope of cooperation.

6. ACTIONS ON REGIONAL LEVELS

6.1. Common emission standards

6.1.1. Scope of cooperation

Irrespective of differences in vehicle population, scope of coverage of current standards etc. priority in all countries participating in the project should be given to the control with regard to emissions from the following categories:

a) vehicles equipped with SI engines:
   - cars,
   - light-duty,

b) diesel vehicles:
   - light-duty,
   - medium/heavy-duty.

For the above categories, two level (i.e. reduced - and low emission) harmonization including the majority of countries participating in the project is possible in the first place. Moreover, common standards for motorcycles seem to be of interest for a small group of countries as well.

6.1.2. Cars and light-duty vehicles

The current situation with regard to this category is summarized below:

a) Korea has introduced low-emission standards and announced their further tightening from 1996 and 2000, FTP-75 procedure being used for testing and certification being conducted on the basis of own tests,

b) Hong Kong and Singapore have just started the application of low-emission standards, approval being conducted on the basis of documents certifying the compliance, issued by foreign laboratories/authorities; USA FTP-75 and Japanese 10-mode test are specified in Hong Kong; compliance with Japanese regulations or ECE Regulation 83/00 is required in Singapore; legislation in both countries is being amended to incorporate EC Directive 91/441/EEC or equivalent ECE

Regulation 83/01 (Approval B and C),

c) Thailand has announced the introduction of low-emission requirements; test procedure of ECE Regulation 83/00 is supposed to be used,
d) reduced-emission standards (only for CO and HC) are in force in India; test procedure based on ECE Regulation 15/04 (with the exception of driving cycle) is used; tighter requirements, but still at reduced-emission level, are announced to be effective from 1995 and low-emission standards from 2000,
e) standards specifying only pollutant concentrations at idle or smoke level at free acceleration are in use in China and Indonesia for new vehicles; reduced-emission mass standard based on ECE Regulation 15/04 being on "trial implementation" in China,
f) the introduction of requirements based on Directive 91/441/EEC (equivalent to ECE Regulation 83/01) is now under consideration in Malaysia.

The requirements in terms of mass emissions are dependent on driving cycle. Consequently, the driving cycle most suitable for the region as a whole must be selected before any common limits are set. Four different cycles are used around the world at present:

a) ECE cycle(s) (Annex 2, point 1.5),
b) American cycle (Annex 3, point 3.3),
c) Japanese cycle (Annex 4 point 5),
d) Indian cycle (Annex 1, point 3).

The last two are used only in countries where they were developed. They are not "international", as they have not spread to other countries and as a result, they do not seem suitable as the basis for a common regional driving cycle. Therefore, the selection should be made out of first two of above four cycles, e.g. ECE or American (FTP) one.

Both cycles have advantages and defects. As regards the American one, its main disadvantage is that the acceleration rate, average and maximum speeds are too high and the share of idle too low as compared with actual average urban driving condition in the region. In addition, there are no current limits for reduced--emission vehicles tested over the American cycle in the region. Consequently, such vehicles are not available and have to be especially developed.

As regards ECE, there are in practice two cycles: one used for the testing of reduced-emission vehicles and the other one for low-emission ones. Countries of the region in which reduced-emission standards are in force apply or intend to apply ECE Regulation 15/04 (or its derivative). Therefore, it is advisable to recommend the limit values and test procedures specified in this Regulation as common reduced-emission standards for the region.

The situation is more complicated in the case of low-emission standards. To be consequent and by analogy, ECE Regulations 83/01 should be recommended. However, the test cycle specified in this Regulation, or to be exact, its extra urban part with maximum speed

of 120 km/h does not seem to be representative of actual highway driving conditions in the region. The solution to this problem would be the use of the cycle for so called low-powered vehicles specified also in ECE Regualtion 83/01. In this cycle, the maximum speed is 90 km/h which is regarded as more suitable for the majority of countries participating in the project. It is to note that emissions from vehicles tested over the cycle with 120 km/h maximum speed are usually higher, in particular in terms of NO_x, than those tested over lower-speed one. Therefore, vehicles satisfying ECE Regulation 83/01 (Approval B and C) could be used in the region without any problems if the maximum speed is set at 90 km/h. A disadvantage of ECE cycles results also from the fact that no limits for low-emission LDV have been laid down up till now.

It seems to be reasonable to apply the same, or at least very similar, cycle for cars and LDV on one hand and for motorcycles on the other. For motorcycles, American cycle has the same as mentioned above, or even higher disadvantages of high speeds and accelerations. ECE urban one seems to be more suitable for motorcycles in the region.

It is however to note, that the pollution is the net result of numerous individual emissions occurring under specific conditions. The existing test cycles represent a compromise which is only roughly representative of traffic conditions even in the country for which they were developed. There are examples that countries with very different traffic conditions and vehicle use pattern adopted with success one of the existing standards, including driving cycles. A good example for it is Stockholm Group that uses US standards.

To sum it up, it is recommended to use either the American cycle or ECE one as the common, harmonized cycle for the region. Consequently, two options of limit values are also suggested (Table 3, 4 and 5).

As regards reduced emission vehicles (Table 3), the recommended limits apply only to exhaust gaseous emissions. When tested over ECE cycle, the limits are equal to those specified in Regulation 15/04. For FTP-75, limits used in Brazil, not widespread in the region, are given as the option. They roughly correspond to US 1973 limits.

As regards low-emission vehicles (Table 4 and 5), the specified limits apply to:

- gaseous exhaust emissions;
- particulate exhaust emission (only for diesel vehicles),
- evaporative emissions (only for vehicles equipped with SI engines).

For cars, they correspond to current US and ECE limits. For LDV only US current ones are given. In addition to exhaust and evaporative standards, crankcase emissions should be nil for both reduced - and low-emission vehicles.

All the low-emission standards are applicable for vehicle useful life of 80000 km.

Table 3

Options for common reduced-emission standards for cars and LDV in the Asia-Pacific region

Test procedure	Reference mass rw [kg]	Limit value [g/km]							
		CO		HC		NO_x		HC + NO_x (1)	
		TA	COP	TA	COP	TA	COP	TA	COP
ECE Regulation 15/04 or ECE Regulation 83/01 Approval A	< rw ≤ 1020	14.3	17.3					4.69	5.87
	1020 < rw ≤ 1250	16.5	19.7					5.05	6.32
	1250 < rw ≤ 1470	18.8	22.5					5.43	6.79
	1470 < rw ≤ 1700	20.7	24.9					5.80	7.26
	1700 < rw ≤ 1930	23.0	27.6					6.17	7.72
	1930 < rw ≤ 2150	24.9	29.9					6.54	8.17
	2150 < rw	27.1	32.6					6.91	8.64
FTP 75		24.0		2.1		2.0			

(1) For LDV, HC + NO_x limits are as given in Table above multiplied by a factor of 1.25

Table 4

Options for common low-emision standards for cars in the Asia-Pacific region.

Test procedure	Exhaust emission (g/km)					Evaporative emissions (g/test)
	CO	HC	NO_x	HC+NO_x	PM	
ECE Regulation 83/01						
TA	2.72			0.97	0.14	2.0
COP	3.16			1.13	0.18	2.0
FTP 75	2.11	0.25	0.62		0.12	2.0

Table 5

Options for common low-emision standards for LDV in the Asia-Pacific region.

Test procedure	Exhaust emission (g/km)					Evaporative emissions (g/test)
	CO	HC	NO_x	HC+NO_x	PM	
ECE Regulation(1) FTP 75	6.21	0.50	0.75/ 1.10(2)		0.31	2.0

(1) Limits are not specified, it is recommended to wait for a decision of GRPA and WP29 in Geneva,
(2) the first figure for light LDV (LVW ≤ 1700 kg), the other for heavy LDV (1700 < LVW ≤ 2600 kg) (LVW - loaded vehicle weight).

6.1.3. Diesel medium - and heavy-duty vehicles

The situation in the region concerning this category with regard to gaseous and particulate emissions is as summarized below:

a) Korea has gradually tightened its standards over the last 9 years, but they are still at reduced-emission level; more stringent requirements are announced to go into effect from 1996, ECE 13-mode test being specified,
b) India has introduced the reduction-emission standards equivalent to ECE Regulation 49/00,
c) the introduction of reduced emission standards based on ECE Regulation 49 are under consideration in China.

As regards the smoke, the status is as follows:

a) in Korea, a limit of 4.0°B is in force from 1993; test method being 3-mode Japanese test,
b) in India, national standard based on ECE Regulation 24 is in force with a little lower limits (Annex 1, point 3.),

c) in China, a national standard has been introduced specifying limits 4.0 - 4.5°B; measurements are carried out by means of filter-type smokemeter; operating conditions being similar to specified in ECE Regulation 24,
d) in Hong Kong, vehicles have to conform to one of the following standards: ECE Regulation 24, BS AU 141a 1971 or Australian design Rule No. 30,
e) in Indonesia, the limit is 5.0°B, measurements being conducted by means of filter type smokemeter at free acceleration,
f) in the Philippines, requirements similar to those in Hong Kong are in force (item d), but not implemented,
g) in Singapore, ECE Regulation 24/03 is applied and, in addition, a limit of 50 HSU at free acceleration should be met.

It is proposed to harmonize the gaseous and particulate emission standards on the basis of one of 13-mode tests, either European or Japanese. Their advantage is that they may be performed on the majority of existing engine test benches which is not the case for American transient test which imposes hard conditions with regard to equipment. Out of the two 13-mode tests, European one is better known in the region as it was developed about 10 years ago. The Japanese test has been just introduced and consequently has not been able to spread so far. In this connection, limits and test procedures specified in ECE Regulation 49 are recommended as common harmonized standards for the participating countries (Table 6).

Table 6

Common reduced-emission and low-emission limits for diesel medium- and heavy-duty vehicles/engines in the Asia-Pacific region.

Emission level	Limits (g/kWh)				Test procedure
	CO	HC	NO_x	PM	
Reduced-emission					ECE Regulation 49/01
TA	11.2	2.4	14.4	-	
COP	12.3	2.6	15.8	-	
Low-emission					ECE Regulation 49/02
TA	4.5	1.10	8.0	0.36	
COP	4.9	1.23	9.0	0.40	

As regards smoke, ECE Regulation 24/00 - 24/03 is wide-spread in the region. Therefore, it is suggested to use it as common smoke standards for reduced- emission vehicles (Annex 2, point 1.7.).

The Expert Group Meeting held in October 1992 in Seoul [3] adopted very stringent requirements with regard to smoke level for low-emission in -use vehicles. The adopted limit is the value measured and approved during the type approval increased by a lump figure of 10 HSU (0.4 m^{-1}) but not higher than 40 HSU (1.18 m^{-1}).

Consequently, it is necessary to introduce adequate requirements for new vehicles. In this connection, two separate requirements with regard to smoke are suggested for new low-emission vehicles:

a) under steady speed condition - the limit value 40 HSU or $1.18m^{-1}$,
b) at free acceleration - 35 HSU or 1.00 m^{-1}.

In both the cases, the procedure of ECE Regulation 24/03 is recommended for testing. It is to note that after the introduction of particulate standards the measurement of smoke has become secondary to PM control.

6.1.4. Motorcycles

The situation with regard to this category is summarized below:

a) India has introduced reduced-emission mass standards based on ECE Regulation 40/01 (tests over Indian driving cycle and therefore slightly different limits),
b) Singapore has specified that all motorcycles should meet current American requirements,
c) Korea, Indonesia and China have only specified requirements with regard to CO and HC concentrations at idle (different with regard to limits),
d) introduction of a national standard based on ECE Regulation 40/00 will be implemented in 1993 in China.

As it is desirable to use the similar driving cycles for motorcycles on one hand and for cars and LDV on the other requirements based on ECE and US regulation are proposed for motorcycles. The are only of reduced-emission level, two stages of different severity being specified:

- stage I - relatively lenient requirements,
- stage II - more stringent requirements.

As regards stage I, the requirements specified in ECE Regulation 40/01 (Annex 2, point 1.8) are recommended as common for the region.

For stage II, two options are given:

i) current limits in force in Switzerland, test method being that specified in ECE Regulation 40/01 (Annex 2, point 3),
ii) current US standards (Annex 3, point 2.5).

The recommended limits are given in Tables below.

Table 7

Common stage I reduced-emission standards for motorcycles in the Asia-Pacific region

Test procedure	Type of engine	Type of tests	Vehicle category (1)	Limits (g/km)	
				CO	HC
ECE Regulation 40/01	Two-stroke	TA	R < 100	12.8	8
			100 ≤ R < 300	$12.8+19.2\cdot\frac{R-100}{200}$	$8 + 4\cdot\frac{R-100}{200}$
			300 ≤ R	32.0	12.0
		COP	R < 100	16.0	10.4
			100 ≤ R < 300	$16 + 24\cdot\frac{R-100}{200}$	$10.4+ 6.4\cdot\frac{R-100}{200}$
			300 ≤ R	40.0	16.8
	Four-stroke	TA	R < 100	17.5	4.2
			100 ≤ R < 300	$17.5+17.5\cdot\frac{R-100}{200}$	$4.2+ 1.8\cdot\frac{R-100}{200}$
			300 ≤ R	35.0	6.0
		COP	R < 100	21.0	6
			100 ≤ R < 300	$21 + 21\cdot\frac{R-100}{200}$	$6 + 2.4\cdot\frac{R-100}{200}$
			300 ≤ R	42.0	8.4

(1) R - reference mass (kg),

Table 8

Options for common stage II reduced-emission standards for motorcycles in the Asia-Pacific region

Test procedure	Type of engine	Limits (g/km)		
		CO	HC	NO_x
ECE Regulation 40/01	Two-stroke Four-stroke	8.0 13.0	3.0 3.0	0.1 0.3
US procedure (modified CVS-2)	All	12.0	5.0	-

6.2. Common type approval procedure

In countries of the region, the product range supplied by a single manufacturer or dealer is usually more limited than in the USA. In this connection, the ECE - like approval procedure seems to be more suitable than US certification. The procedures used in the majority of countries conducting approval have usually some features of that specified by ECE e.g. tests are conducted by technical services authorized by the approval authority, classification of vehicles in groupings is closer to that used in ECE etc. It is suggested that ECE - like procedure be used even in case the US driving cycle were selected for the region.

In the recommended procedure, the vehicle manufacturer or his representative apply to the competent authority (administrative department) for the approval of a vehicle type with regard to limitation of emissions. "Vehicle type" means motor vehicles which do not differ in such respects as:

- engine characteristics: main technical data, intake system, fuel system, ignition system, exhaust system, additional anti-pollution devices, engine performances etc.,
- vehicle characteristics: main technical data, transmission etc.

The full definitions of the "vehicle type" for particular categories selected for regional cooperation i.e. cars, LDV, M/HDV (with diesel engines) and motorcycles are given in Annexes 1 to respectively ECE Regulation 83/01, 49/02 and 40/01.

A vehicle representative of the vehicle type to be approved is submitted to technical services responsible for conducting the approval tests. It should be accompanied, among others, by:

- description of the vehicle type,
- owner's manual.

The authorized technical services:

- check that the submitted vehicle conforms to the supplied description,
- conduct emission tests in accordance with the emission standard(s),

- identify vehicle components that are liable to affect emissions and that should be checked during periodical inspections,
- check that the owner's manual comprises all information necessary for proper vehicle maintenance with regard to emissions.

The technical service prepares a test report and, if all the requirements, both formal and technical, are met, the competent authority grants the type approval and issues an approval certificate. Every modification of the vehicle type should be notified by the holder of type approval, i.e. manufacturer or dealer to the authority which approved the type. The authority may either:

- consider that the modification is unlikely to have an appreciable adverse effect and that in any case the type still complies with the requirements or,
- require a modified vehicle to be subjected to one or more tests specified in the relevant regulations in order to check the compliance.

Approval of a vehicle type may be extended on vehicle types which differ from the type already approved. The conditions for the extension are also specified in great detail in respective ECE Regulations.

6.3. Reciprocal recognition of type approval

The cornerstone of the recommended new vehicle control is that the vehicle should be physically tested in accordance with the agreed procedure in one of the participating countries. The competent authority of such a country communicates the approval (or refusal of approval) to the concerned authorities in all other countries participating in the cooperation by means of a special communication form. Documents permitting the full identification of the vehicle type, i.e. description of the type with all necessary drawings, diagrams and photographs should be annexed to the communication form. The approval of modifications or the extension of approval should also be communicated in a similar way.

Any country participating in the cooperation should not refuse the registration, permit for sale or entry into service of new vehicles on grounds relating to their emission levels if they are covered by a valid certificate of approval issued in another participating country.

7. ACTIONS ON COUNTRY LEVELS

7.1. Verification of conformity of production

The type approval procedure alone is insufficient to ensure that vehicles entering into traffic comply with the construction

requirements. Therefore, all countries are recommended to conduct the verification of conformity of vehicles with the approved type. Provisions in this respect should be made in relevant legislation.

The basis for the verification of COP results from provisions that every manufactured vehicle should conform to the type approved with regard to components affecting emissions and should meet the emissions requirements. The holder of type approval, either the manufacturer or dealer, certifies this conformity by affixing to the vehicle an approval mark or by issuing a written certificate.

The exact COP procedure may vary from country to country depending on local conditions and legislation. The distinction should be made between vehicles manufactured in a given country and those imported. In the case of domestic production, the recommended approach is to concentrate resources to assess, by factory inspections, the manufacturer's quality assurance system i.e. whether the manufacturer is capable of continuous production of vehicles or emission affecting components that conform to the type approval specification and performance requirements. The manufacturer should supply documented details of the quality assurance systems. Once the system has been found satisfactory by the authority, checks are made during the inspection that the stated system is being operated, including supplier's quality assurance arrangements.

The manufacturer of the approved vehicle type should, among others:

- conduct functional tests with regard to emission affecting components and systems,
- perform emission quality audit tests on a limited number of production vehicles,
- take all necessary steps to reestablish the conformity of production if vehicles have failed tests.

The competent authority which has granted the type approval is empowered to verify the conformity of production. The verification is made by:

- checking that the manufacturer is conducting functional and quality tests,
- checking that vehicles conform to the type description,
- conducting emissions tests on a number of randomly-selected serially-manufactured vehicles (surveillance tests).

As regards imported vehicles, the verification consists of the last two of the above items, i.e:

- checking that vehicle conform to approval description,
- conducting emission tests.

The production vehicles for testing may be selected from vehicles intended for sale in a given country, stored, for instance, at the port of entry, manufacturer's premises, dealer's premises. At the request of the competent authority, the holder of approval should supply, without charge, a number of run-in vehicles randomly selected by the authority.

Given the small volume of the market in some countries of the

region, the sampling plan specified in current ECE Regulations (Annex 2, point 1.3.3.) seems to be suitable for the COP emissions tests. A single vehicle is sampled for initial evaluation. If it fails to meet the requirements, the manufacturer/dealer has two choices:

a) to accept the results and declare his full commitment to correct all faulty vehicles to be sold in the future,
b) to request further testing at his expense by selection of a final sample of test vehicles.

In the last case, the "pass" decision is made when the statistical average of emissions of all pollutants does not exceed and the "fail" decision when the average for any pollutant is higher than COP limits.

In the event of failure, the competent authority may withdraw the type approval certificate if it originally issued that certificate. In other cases, it investigates the non-compliance with the authority of the other participating country which granted the type approval.

The decision as to whether to conduct any COP verification, its scope, testing frequency etc. are left entirely to the decision of the authority in a given country and any common terms are not specified. It depends, among others, on existing test facilities. In addition, conditions such as production/sale volume, the performance margin over the emission type-approval limits, reports from in-use testing, complains from user et. should be taken account of. The checking of a least 1% of vehicles is, however, recommended.

7.2. Registration inspection

As mentioned above in point 5.2, new (first registered) vehicles are divided into two groups, depending on whether they are subjected to type approval (group a) or not (group b).

The national administration can affect the share and structure of both the groups, when needed, for instance by:

- specifying the quantity of the same type vehicles above which the certification is required,
- limiting the age of imported second-hand vehicles or taxing them in a function of their age,
- imposing stringent technical requirements for the group b).

Vehicles of group b) (Fig. 3) should undergo the (pre-first) registration inspection. Its extent depends on emission standards in force.

If the requirements set in the standards are of "reduced-emission" level, vehicles should be subjected to the same tests and satisfy the same requirements as specified for in-use periodical inspections (for reduced-emission vehicles). After the introduction of "low emission" standards, it is suggested to differentiate the inspection depending on whether vehicles:

i) belong under types approved,
ii) belong to types not approved.

Vehicles referred to in i) are to undergo the tests specified for in-use periodical inspection (for low-emission vehicles). Vehicles referred to in ii) should be tested in accordance with the procedure specified for type approval/conformity of production (individual approval). Such a procedure is necessary to limit the influx in the country of reduced-emission or even uncontrolled vehicles, considerably cheaper and therefore overcompetitive in terms of price.

The recommended test procedure and limits for both reduced-and low-emission vehicles are specified in chapter 6 of "Guidelines" for in-use vehicle inspection for emission control in the Asia-Pacific region" [3].

8. PREREQUISITES FOR THE IMPLEMENTATION OF NEW MOTOR VEHICLE EMISSION CONTROL

8.1. Development of administrative and technical services

To implement the effective control of emissions from new motor vehicles, irrespective of whether they are reduced or low-emission ones, it will be necessary for the majority of countries of the region to develop:

- administrative services,
- technical services (test centres).

The setting up of administrative services capable of effectively handling the control procedures may require introducing changes to organizational structure of the authority in charge of vehicle emission programmes, redefining its functions, responsibilities and competencies, and empowering it to levy suitable penalties, sanctions etc. The extent of required changes with regard to organizational structure varies from country to country and general recommendations can not be given. Some of the problems related to organizational structures will be included in the guidelines devoted to practical policy measures for the reduction of vehicle emissions and strategy for their implementation to be worked out under the project.

To implement the recommended emission control for new motor vehicles, technical services (test centres) should be developed. They should be capable of handling the below specified tasks:

a) to conduct vehicle type approval procedure with regard to emissions under authorization of the competent authority in charge of vehicle emission control (usually environment protection or transport department):
   - to conduct emission tests,
   - to identify systems/devices to be checked during in-use vehicle inspection,
   - to inspect whether the manufacturer is able to ensure the conformity of production with the approved type,
   - to prepare a technical report for the competent authority;

b) to carry out the verification of production conformity:
   - to select vehicles which should be subjected to the verification, among others, on the basis of in-use inspection results,
   - to check the compliance with the type description approved during the type certification,
   - to select serially-manufactured vehicles to be subjected to full emission tests and to conduct such tests,
   - to check that the vehicle manufacturer performs quality control, uses proper equipment, methods, etc.;
c) to assist the competent authority(ies):
   - in formulating policy with regard to emission control,
   - in preparing emission standards for new vehicles, for in-use vehicles and fuel quality standards,
   - in promoting emission control,
   - in improving the efficiency of emission control;
d) to improve, update and implement new existing emission test procedures.

To be capable of performing its duties the test centre has to possess necessary test facilities. The equipment required for testing in accordance with recommended procedures and their technical characteristics are specified in relevant regulations. Its main components are as follows:

a) for cars and LDV (as well as for motorcycles):
   - chassis dynamometer(s) with accessories such as driver's aid, devices for the determination and setting of road load (e.g. fifth wheel, torquemeter); two dynamometers of different size or a single one with a special attachment are required for cars and LDV on one hand and motorcycles on the other,
   - CVS unit,
   - analytical equipment for gaseous pollutants (exhaust gas analysers) with gases necessary for calibration and operation,
   - dilution tunnel and system for the collection of particulates (filters, pumps etc.),
   - weighing chamber and microbalance for particulate filter weighing (the same may be used for M/HDV),
   - SHED enclosure with accessories,
   - reference fuels (petrols for reduced - and low-emission vehicles and diesel fuels),
b) for M/HD vehicles/engines:
   - engine tests benches (two different sizes to cover the whole power range),
   - analytical equipment (exhaust gas analysers) with suitable gases,
   - dilution tunnel and system for the collection of particulates,
   - smokemeters,

- gas flowmeters,
- reference diesel fuel (the same as for cars and LDV).

The only type-approval test centre in the region which has the required facilities is National Institute for Environmental Research in Seoul. In other centres in the region, i.e. in India, China and Indonesia (Annex 1) facilities for testing reduced-emission vehicles are only available. In addition, they are often not in fully good technical conditions.

The cost of full facilities for emission testing is dependent on their sophistication.A set of manually-operated equipment of older design can be purchased at a price of about 0.6 - 0.8 mln US$. On the other hand, a modern, sophisticated, fully computerized set costs about 1.5 - 2.0 mln US$. The cooperation in the region and reciprocal recognition of type approval reduces the number of required centres, however, even in this case, the development of test facilities is necessary in order to conduct effective vehicle emission control. Manufacturer's facilities, when available, may be used also for testing.

The harmonization of limits, test method and control procedures requires a good cooperation among institutions dealing with vehicle emission-related problems in individual countries, in particular technical services. Research works are often necessary to implement test methods and to clarify their technical details. In addition, skillful and competent personnel is required to conduct emission tests and operate sophisticated equipment. To solve all these problems it is suggested to establish close cooperation among existing test centres in the region and, if it turns out not to be suffucient, to set up a common regional test and training centre. Its main functions would be to assist the operational regional network on emission control in solving specific technical problems, to conduct the training of senior technical men from participating countries not only in the area of new motor vehicle control, but also in other areas, for instance, in-use vehicle inspection [2], [3].

8.2. Preconditions for the introduction of low-emission standards

The number one precondition for the introduction of the state of the art emission technolcgies is the availability of suitable fuels, in particular, but not only, unleaded petrol. This problem will be presented in separate guidelines and, therefore, is not discussed below.

Experience with low-emission vehicles collected up till now shows that potential of the state of the art technology is taken full advantage of if the enhanced in-use inspection is introduced parallelly with the introduction of such vehicles into service. This inspection should include:

- visual checks of anti-pollution devices,
- checks of pollutant concentrations in the exhaust gas.

The standards for in-use low-emission vehicles should be considerably more stringent than for reduced-emission ones. Details

in this respect are given in "Guidelines for in-use motor vehicle inspection for emission control in the Asia-Pacific region" [3].

The necessity of such an enhanced in-use inspection results from some specific features of low-emission vehicles, especially those equipped with three way catalytic converters. In such vehicles, defects of some anti-pollution devices, e.g. λ - probe or catalytic converters, may increase many times emissions of all pollutants (Table 2, point 4.5.). On the other hand, they do not affect any other vehicle performances. As a result, the driver can operate the defected vehicle without even knowing that anti-pollution devices are out of order. In this respect, low-emissions vehicles differ very much from reduced-emission ones in which a noticeable increase in emissions resulting from failures of some components/systems is usually accompanied by a deterioration in other vehicle parameters e.g. driveability or fuel economy. The enhanced inspection is particularly important in the transition period when two grades of petrol, leaded and unleaded, are parallelly available in the market. It is an important factor to deter drivers to misfuel, deliberately or accidentally, their vehicles and also to temper or modify vehicles in a way which adversely affects emissions. The introduction of special inspection for in-use low-emission venicles is especially justified in countries of the region in view of poor vehicle maintenance standard.

8.3. Impacts on costs

Costs of the implementation of the new vehicle emission control in line with the recommendations of the present "Guidelines" result from:

a) the setting up and operation of the control structure,
b) increase of fuel production cost,
c) increase of vehicle production costs.

The group a) must be often incurred, at least partially, by the state budget. Fees for type-approval and COP verification paid by vehicle suppliers (manufacturers/dealers) do not usually cover the costs of initial investments and operation (point 8.1 above), in particular when the market volume is small. The group b) will be presented in the guidelines devoted to fuel control.

In spite of low-emission technological advances, many countries in the world have only been able to make limited progress in reducing vehicle emission. The main reason for it is the high cost of such technologies. The cost increase is dependent on the initial technological state of a given vehicle. It is to note that in order to meet the current low-emission standards for petrol vehicles, not only the introduction of catalytic converter and λ - probe, but also modifications of the engine itself (e.g. the replacement of carburetors with electronic fuel injection, electronic engine management) and sometimes even a modification to vehicle body are required. On the average, the introduction of the state of art technology adds about 10 - 15% to the production cost of small cars

(with an engine capacity of less than 1000 cc), 7 - 12% for those with an engine capacity of 1000-1400 cc and 5 - 10% for others. On the other hand, however, the above modifications not only reduce emissions, but give better overall vehicle performances, lower fuel consumption included, better reliability and higher durability of components and vehicle as a whole.

References

1. UNIDO. Report of the expert group meeting on control and regulatory measures concerning motor vehicle emissions in the Asia-Pacific region. Seoul, 21 - 24 August 1990.
2. UNIDO. Report of the expert group meeting on in-use motor vehicle inspection for emission control in the Asia-Pacific region. Seoul, 20 - 22 October 1992.
3. UNIDO. Guidelines for in-use motor vehicle emission control in the Asia-Pacific region. January 1993.
4. ECE. Agreement concerning the adoption of uniform conditions of approval and reciprocal recognition of approval for motor vehicle equipment and their parts. 20 March 1958.
5. ECE Regulation No.15, Revision 3 "Uniform provisions concerning the approval of vehicles equipped with a positive-ignition engine or with a compression-ignition engine with regard to the emission of gaseous pollutants by the engine. Method of measuring the power of positive-ignition engines. Method of measuring the fuel consumption of vehicles" (doc. E/ECE/324, E/ECE/TRANS/505, Rev.1/Add.14/Rev.3 of 2 February 1982) as amended by Revision 3 - Amendment 1 (doc. Rev.1/Add.14/Rev.3/ /Amend.1 of 1 June 1984) and
   Revision 3 - Amendment 1 - Corrigendum 1 (doc. Rev.1/Add.14/ /Rev.3/Amend.1/Corr.1 of 16 May 1989).
6. ECE Regulation No. 24, Revision 2 "Uniform provisions concerning:
   I. The approval of compression ignition (C.I.) engines with regard to emission of visible pollutants.
   II. The approval of motor vehicles with regard to the installation of C.I. engines of an approved type.
   III. The approval of motor vehicles equipped with C.I. engines with regard to the emission of visible pollutants by the engine.
   IV. The measurement of power of C.I. engines"
   (doc. E/ECE/324, E/ECE/TRANS/505, Rev.1/Add.3/Rev.2 of 25 April 1986).
7. ECE Regulation No.40 "Uniform provisions concerning the approval of motorcycles equipped with a positive-ignition engine with regard to the emission of gaseous pollutants by the engine" (doc. E/ECE/324, E/ECE/TRANS/505, Rev.1/Add.39 of 7 May 1979) as amended by Amendment 1 (doc. E/ECE/324, E/ECE/TRANS/505, Rev.1/Add.39/Amend.1 of 18 May 1988) and Corrigendum 3 (doc. E/ECE/324, E/ECE/TRANS/505, Rev.1/Add.39/ /Corr.3 of 29 August 1989).
8. ECE Regulation No.47 "Uniform provisions concerning the approval of mopeds equipped with a positive-ignition engine with regard to the emission of gaseous pollutants by the engine" (doc. E/ECE/324, E/ECE/TRANS/505, Rev.1/Add.46 of 28 August 1981).

9. ECE Regulation No.49 "Uniform provisions concerning the approval of compression ignition (C.I.) engines and vehicles equipped with C.I. engines with regard to the emission of gaseous pollutants by the engine" (doc. E/ECE/324, E/ECE/TRANS/505, Rev.1/Add.48/Rev.1 of 9 October 1990) as amended by "Draft 02 series of amendments to Regulation No. 49" (doc. TRANS/SC1/WP29/340 of 2 march 1992).
10. ECE Regulation No.83 "Uniform provisions concerning the approval of vehicles with regard to the emission of gaseous pollutants by the engine according to fuel requirements" (doc. E/ECE/324, E/ECE/TRANS/505, Rev.1/Add.82 of 9 April 1990) as amended by "Draft 01 series of amendments to Regulation No. 83" (doc. TRANS/SC1/WP29/339 of 2 march 1992).
11. ECE. Consolidated resolution on the construction of vehicles (R.E.3) (doc. TRANS/SC1/WP29/78/Amend.3 of 12 June 1991).
12. Official Journal of the European Communities. Council Directive No. 92/53/EEC of 18 June 1992 amending Directive 70/156/EEC on the approximation of the laws of the Member States relating to the type approval of motor vehicles and their trailers. L225, vol.35, 10 August 1992.
13. Code of Federal Regulations. Protection of Environment 40. Parts 86 to 99. Revised as of July 1, 1991.
14. Automobile type-approval handbock for Japanese certification. Japan Automobile Standards Internationalization Centre. June 1991.
15. International Expert Meetings in Stockholm on Air Pollution by Motor Vehicles. Control of air pollution from motor vehicles. General Provisions for emission regulations for light motor vehicles. Master Document. 1987-09-25.
16. F.F. Pischenger: Technology for ECE Step 2 (1996) and further possibilities. Paper presented at European Symposium Auto Emissions 2000. Bruxelles, 21 - 22 September 1992.
17. G. Fränkle, W Hase, F. Scherer, D. Woschée: Modern Mercedes-Benz heavy-duty engines (series 300 and 400) to meet the future Euro I exhaust emission standards. Proceedings of the International Seminar "The diesel engine-energy state and environmental constraints" Cologne, 22 - 23 May 1991.
18. M. Walsch, J. Karlsson: Motor Vehicle pollution Control in Asia: the lessons of Europe.SAE Paper 900613.

Status of new motor vehicle emission control in countries participating in the project

1. China

In China, new motor vehicles undergo two-stage control with regard to pollutant emissions:

i) on manufacturer's side (before sale),

ii) on owner's side (after sale).

In the case i), there is a difference in control procedures for vehicles of domestic production and those imported. Domestic in-production vehicles are subjected to the control in accordance with automotive product quality assessment method carried out by manufacturers themselves and research institutes of automotive industry. As regards imported vehicles, they should undergo a type approval before the import licence is issued. The type approval procedure as a whole is conducted by National Import and Export Commodity Inspection Bureau, actual tests being run by authorized test centres.

Before the first registration in China, every vehicle should undergo an initial (pre-registration) inspection in a pointed inspection station licenced by Ministry of Public Security. The purpose of such an inspection is to verify whether the vehicle is produced by a licenced manufacturer and meets requirements laid down in the vehicle safety and emission standards.

The following emission standards for new vehicles are in force in China:

i) for vehicles equipped with SI (petrol) engines:
   a) standard GB 3842-83 specifying limits for CO and HC concentrations in the exhaust gas at idle (Table A1/1) and standard GB 3845-83 specifying the measurement method for all vehicle categories,
   b) standard GB 11641-89 specifying exhaust mass emission limits for CO, HC and NO_x and standard GB 11642-89 specifying measurement method for light duty vehicles with gross vehicle weight up to 3500 kg (the scope, limits and method are very similar to those laid down in ECE Regulation 15/04, test I),
   c) standard GB 11340-89 specifying crankcase emission measurement method and limit (similar to those laid down in ECE Regulation 15/04, test III);

ii) for diesel vehicles:
   a) standard GB 3843-83 specifying smoke limits at free acceleration (Table A1/2) and standard GB 3846-83 specifying the measurement method,
   b) standard GB 3844-83 specifying smoke limits at full load (Table A1/2) and standard GB 3847-83 specifying measurement method.

Table A1/1

Limits for CO and HC concentrations at idle for new vehicles equipped with SI engines in China

Vehicle category	Limits	
	CO [% vol.]	HC [ppm]*
domestic production	5.0	2500
imported	4.5	1200

* as n-hexane

Table A1/2

Smoke limits for new diesel vehicles in China

Measurement method	Vehicle category	Limit [°B]
free acceleration	all	5.0
full load *	domestic production - new type engines	4.0
	imported	4.0
	domestic production - in-production engines	4.5

* Engine operating conditions similar to specified in ECE Regulation 24/03; measurement by means of filter-type smokemeter.

The standards listed above under i)a) and ii)a) are used for the control of new vehicles both before and after sale. On the other hand, the standards i)c) and ii)b) are applied only for the control before sale. The standards i)b) is on "trial implementation" in automotive industry. Its provisions are mainly used for the type approval of imported vehicles.

The standard i)a) is being amended. More stringent limits are going to be laid down. Moreover, it is planned to draw up standards for diesel gaseous and particulate emissions, evaporative emissions and gaseous emissions from vehicles with gross vehicle mass above 3500 kg equipped with SI engines.

Test facilities for measurement of vehicle mass emissions on chassis dynamometer in driving cycle or on engine test bench exist or are being set up in:

- Beijing Automotive Research Institute,
- Automobile Research Institute in Changchun,
- automobile research centres in Nanjing and Hubei.

2. Hong Kong

In Hong Kong, the first regulations with regard to new motor vehicle emission came into force:

- for vehicles equipped with SI engines - on 1 November 1974,
- for diesel vehicles - on 1 September 1976.

The requirements were specified in Road Traffic (Construction and Maintenance of Vehicles) Regulations. According to these Regulations vehicles were to conform to one of the following standards:

- vehicles equipped with SI engines: ECE regulation 15/00, EC Directive No. 70/220/EEC or Australian Design Rules No. 27,
- diesel vehicles (smoke level): British Standard BS AU 141a 1971, ECE Regualtion 24/00, EC Directive No. 72/306/EEC or Australian Design Rule No. 30.

More stringent requirements for vehicles equipped with SI engines came into force on 1 October 1978. These vehicles were to conform to one of the following standards: ECE Regulation 15/01, EC Directive No. 74/290/EEC or Australian Design Rules 27A.

The above regulations applied to all motor vehicles with the exception of:

- motorcycles,
- vehicles whose design speed does not exceed 50 km/h.

New, very stringent motor vehicle emission standards came into force on 1 January 1992. They are specified in Air Pollution Control (Vehicle Design Standards)(Emission) Regulations 1991 issued in accordance with the provisions of Air Pollution Control Ordinance. They apply to cars (including taxis) and light duty vehicles with gross vehicle weight not exceeding 2500 kg. The standards from 1976/1978 are still in force for other vehicles.

According to the aforementioned Regulations, cars and light duty vehicles should comply with either American or Japanese standards listed in Table A1/3. The regulations are being amended to incor-porate the latest EC Directive 91/441/EEC. In addition, every motor vehicle belonging under the above mentioned categories should be designed to operate on unleaded petrol. Provisions of Air Pollution Control (Vehicle Design Standards)(Emissions) Regulations 1991 apply to vehicles registered in Hong Kong on or after 1 January 1992 i.e. to both new and used imported ones. These vehicles must be either type approved or individually certified by Transport Department.

An application for type approval should comprise, among others, emission documentation including:

- certificate of compliance of vehicle type (Attachment A1/1),
- description of vehicle and engine,
- emission test report,
- diagrams of emission control system, exhaust system and additional anti-pollution devices.

Certificates of compliance issued either by an authorized motor vehicle emission testing laboratory or by an authority vested to grant the approval by a national or international body are accepted.

For vehicles, e.g. used imported ones, which have not been type-approved in Hong Kong, individual emission testing is required. A certificate of compliance issued by testing laboratory approved by Transport Department is accepted. This certificate should state the following:

- make, model, vehicle identification number and engine number,
- method of testing (US FTP 75 or Japanese test),
- test results.

There are no motor vehicle emission testing facilities in Hong Kong at present, therefore the documentary evidence issued by foreign laboratories or authorities must be produced.

Table A1/3

Emission standards for motor vehicles registered in Hong Kong on or after 1 January 1992.

Vehicle category	Emission limits [g/km]				Test method
	CO	HC	NO_x	PM	
I	2.10 2.70	0.26 0.39	0.63 0.48		US FTP 75 Japanese 10-mode
II	2.10 2.70 2.70	0.26 0.62 0.62	0.63 0.72(a) 1.26(b)	0.12	US FTP 75 Japanese 10-mode ,,
III	6.20 2.70	0.50 0.39	0.75 0.48		US FTP 75 Japanese 10-mode
IV	6.20 2.70	0.50 0.62	0.75 1.26	0.16	US FTP 75 Japanese 10-mode
V	6.20 17.00	0.50 0.70	1.10 0.98		US FTP 75 Japanese 10-mode
VI	6.20 9.80	0.50 6.70	1.10 3.50(c) 5.00(d)	0.28	US FTP 75 Japanese 6-mode(e)

I. cars equipped with SI engines,
II. cars equipped with diesel engines,
III. light duty vehicles equipped with SI engines and having a gross weight of not more than 1700 kg,
IV. light duty vehicles equipped with diesel engines and having a gross weight of not more than 1700 kg,
V. light duty vehicles equipped with SI engines and having a gross weight exceeding 1700 kg but not more than 2500 kg,
VI. light duty vehicles equipped with diesel engines and having a gross weight exceeding 1700 kg but not more than 2500 kg,

a) vehicle curb weight of not more than 1265 kg,
b) vehicle curb weight exceeding 1265 kg,
c) indirect injection engines,
d) direct injection engines,
e) limits expressed in ppm.

3. India

In India, Central Pollution Control Board is responsible for development of emission requirements for new motor vehicles. These requirements are notified in:

- Central Motor Vehicles Rules, 1990 made under Motor Vehicle Act, 1988,
- Environment (Protection) Rules, 1990 made under Environment (Protection) Act.

The requirements in both aforementioned documents are identical.

As regards vehicles equipped with SI engines, the following standards are in force:

a) CO concentration in the exhaust gas at idle (the same limits and test method as for in-use vehicles, see [3]):
   - vehicles with four wheels - 3% vol.,
   - vehicles with two and three wheels - 4.5% vol.,

b) mass emission standards (different limits are specified for type approval and conformity of production tests):
   - light duty vehicles (the full definition of this category is not given) - Table A1/4,
   - vehicles with two and three wheels - Table A1/5.

It is to note that limits for only CO and HC are laid down for LDV and no requirements with NO_x are specified. The requirements concerning CO at idle came into in March 1990 and those for mass emissions in April 1991.

The mass emission tests are conducted using so called "Indian driving cycle" specified in Table A1/6. Test methods are similar to those set in ECE Regulation 15/04 (for light duty vehicles) and Regulation 40 (for vehicles with two and three wheels).

Table A1/4

Emission standards for light duty vehicles in India.

Type of test	Reference Mass, R(kg)	CO(g/km)	HC(g/km)
Type approval	R ≤ 1020	14.3	2.0
	1020 < R ≤ 1250	16.5	2.1
	1250 < R ≤ 1470	18.8	2.1
	1470 < R ≤ 1700	20.7	2.3
	1700 < R ≤ 1930	22.9	2.5
	1930 < R ≤ 2150	24.9	2.7
	2150 < R	27.1	2.9
Conformity of production	R ≤ 1020	17.3	2.7
	1020 < R ≤ 1250	19.7	2.7
	1250 < R ≤ 1470	22.5	2.8
	1470 < R ≤ 1700	24.9	3.0
	1700 < R ≤ 1930	27.6	3.3
	1930 < R ≤ 2150	29.9	3.5
	2150 < R	32.6	3.7

Table A1/5

Emission standards for vehicles with two and three wheels in India

Type of test	Reference Mass, R(kg)	CO(g/km)	HC(g/km)
Type approval	R ≤ 150	12	8
	150 < R ≤ 350	$12 + \frac{18(R-150)}{200}$	$8 + \frac{4(R-150)}{200}$
	350 < R	30	12
Conformity of production	R ≤ 150	15	10
	150 < R ≤ 350	$15 + \frac{25(R-150)}{200}$	$10 + \frac{5(R-150)}{200}$
	350 < R	40	15

Table A1/6

Breakdown of Indian driving cycle

No. of Operation	Acceleration (m/sec^2)	Speed (km/h)	Duration of each operation(s)	Cumulative time (s)
01. Idling	-	-	16	16
02. Acceleration	0.65	0-14	6	22
03. Acceleration	0.56	14-22	4	26
04. Deceleration	-0.63	22-13	4	30
05. Steady speed	-	13	2	32
06. Acceleration	0.56	13-23	5	37
07. Acceleration	0.44	23-31	5	42
08. Deceleration	-0.56	31-25	3	45
09. Steady speed	-	25	4	49
10. Deceleration	-0.56	25-21	2	51
11. Acceleration	0.45	21-34	8	59
12. Acceleration	0.32	34-42	7	66
13. Deceleration	-0.46	42-37	3	69
14. Steady speed	-	37	7	76
15. Deceleration	-0.42	37-34	2	78
16. Acceleration	0.32	34-42	7	85
17. Deceleration	-0.46	42-27	9	94
18. Deceleration	-0.52	27-14	7	101
19. Deceleration	-0.56	14-00	7	108

Table A1/7

Smoke limits in India

Nominal Flow G(l/s)	Absorption Coefficient K(m^{-1})	Nominal Flow G(l/s)	Absorption Coefficient K(m^{-1})
42	2.00	120	1.20
45	1.91	125	1.17
50	1.82	130	1.15
55	1.75	135	1.13
60	1.68	140	1.11
65	1.61	145	1.09
70	1.56	150	1.07
75	1.50	155	1.05
80	1.46	160	1.04
85	1.41	165	1.02
90	1.38	170	1.01
95	1.34	175	1.00
100	1.31	180	0.99
105	1.27	185	0.97
110	1.25	190	0.96
115	1.22	195	0.95
		< 200	0.93

An exception is reference fuel which is representative of petrol used in India and consequently different from those specified in the aforementioned ECE Regulations.

As for diesel vehicles, the following standards are in force:

a) smoke level at free acceleration not exceeding 2.3m^{-1} or 65HSU (the same as for in-use vehicles, see [3]),
b) smoke level under full load conditions - test method similar to specified in ECE Regulation 24 (Annex 2, point 1.7); limits given in Table A1/7 ,
c) emission of gaseous pollutants - limits (CO-14g/kWh, HC-3.5g/kWh, NO_x-18g/kWh) and test method as specified in ECE Regulation 49/00 (Annex 2, point 1.6).

The standard under a) came into force in March 1990, that under b) in April 1991 and that under c) - in April 1992.

In order to check that vehicles meet the above requirements with regard to emissions two types of control are performed:

- type approval,
- conformity of production (COP)tests.

Every vehicle type should undergo the type approval in order to verify its compliance with provisions of Motor Vehicles Act and Central Motor Vehicle Rules, including provisions with regard to emissions, and to obtain a type approval certificate. The following agencies are authorized to perform the type approval procedure:

a) Vehicle Research and Development Establishment of Ministry of Defence, Ahmednagar,
b) Automotive Research Association of India, Pune,
c) Central Machinery Testing and Training Institute, Budni,

d) Indian Institute of Petroleum, Dehradun.

Facilities for vehicle mass emission testing exist in the agencies listed under b) and d).

Each motor vehicle coming within the approval type should be certified by the manufacturer to be conforming to the provisions of Motor Vehicle Act and rules made under the Act. Moreover, the manufacturer should certify that the components liable to affect the emissions of pollutants are so designed, constructed and assembled as to enable the vehicle to comply with the emission requirements.

The aforementioned testing agencies are empowered to conduct COP tests on vehicle drawn from the production line of the manufacturer. These tests are conducted when the annual production of a given vehicle type exceeds:

- 50000 for vehicles with two wheels,
- 25000 for other vehicles.

If the sample of drawn vehicles fails the COP tests, the production of a given vehicle type may be stopped and its recertification demanded.

The introduction of more stringent emission standards has been already announced. Details are given in Attachment A1/2 to this Annex.

4. Indonesia

According to Traffic and Road Transport Law No. 14 of 1992 all motor vehicles operated on the road should be type-approved. The type approval certificate is issued by Directorate General of Land Transport on the basis of approval tests conducted by Board of Motor Vehicle Testing for Roadworthiness and Certification.

Approval tests for motor vehicle type comprise 12 items, including the following emission related checks:

- CO and HC concentrations in the exhaust gas at idle for vehicles equipped with SI engines,
- smoke at free acceleration for diesel vehicles.

Vehicle type means vehicles which do not differ among others in respects affecting the emissions such as:

- engine basic design,
- engine displacement, in cm^3,
- fuel supply system,
- valve arrangement,
- power and torque,
- type of fuel.

The emission standards to be complied with are specified in Decree of Minister of Communications No. KM8 of 1989. The limits are as follows:

a) for vehicles equipped with SI engines fuelled with "premium" petrol (RON at least 87):
   - CO concentration - 4.5% vol.,
   - HC concentration (as n-hexane) - 1200 ppm,

b) for diesel vehicles fueled with diesel fuel (having cetane number at least 45):
   - smoke - 50% measured by means of filter-type smoke-meter.

It is to note that no special limits with regard to HC are specified for motorcycles with two-stroke engines which are also subject to type approval.

Test methods are specified in Decree No. AJ.402/8/5 of 1990 issued by Director General of Land Transport. Both limits and test methods for type approval are identical to those used for in-use vehicle inspection [2], [3].

No mass emission standards are in force in Indonesia. The Minister of Population and Environment issued in 1988 basic guidelines for emission standards from different sources, among others from motor vehicles, where the following limits are specified for passenger cars:

- CO - 24.6 g/km,
- HC - 3.6 g/km.

These standards have not been implemented and used for type approval. Board of Motor Vehicle Testing for Roadworthiness and Certification has some basic facilities for testing of mass emissions from motor vehicles:

- chassis dynamometers for motorcycles, light duty vehicles and medium/heavy duty vehicles,
- CVS equipment,
- exhaust gas analysers and smokemeters.

5. Korea

A comprehensive and effective control system has been set up in Korea in order to check that motor vehicles comply with roadworthiness standards being in force. The control procedure consists of two, separately conducted parts:

a) control with regard to safety and performance carried out by the Ministry of Transport,
b) environment-related control carried out by the Environment Protection Administration (EPA).

The environment-related control includes the following items:

- pollutant emissions,
- noise,
- fuel economy.

Previous, current and future already announced emission standards are shown:

- for vehicles equipped with SI engines (petrol - and LPG-fuelled) - in Table A1/8,
- for diesel vehicles - in Table A1/9.

The control of new motor vehicles for the compliance with the aforementioned emission standards consists of:

- certification,
- surveillance procedure,
- recall procedure.

Every motor vehicle subject to certification should be covered by a certificate of conformity stating that emission requirements provided for in the standards are complied with. The certificate is issued by EPA for engine family-vehicle configuration combination. Actual emisson tests are conducted by National Institute of Environmental Research (NIER).

In order to determine whether vehicles manufactured by the manufacturer, who has obtained the certificate, conform to the emission standards in respect to which the certification was conducted, EPA is empowered to conduct surveillance tests on samples of vehicles randomly drawn from the manufacturer's line. 1-2 samples are usually drawn every year for each engine family. A sample is composed of 3-5 vehicles. If a sample fails the tests, the certificate of conformity may be suspended or revoked.

The aforementioned emission standards for cars and light duty vehicles apply to the emissions of vehicles for their useful life which is set to 80000 km or 5 years. In order to guarantee required performance for the useful life the recall programmes were introduced in 1990. The following procedure is used for this purpose:

- a sample for the recall tests consists of 5 vehicles of the same engine family,
- vehicles are randomly selected from the register file,
- vehicle owners are requested by mail to submit their vehicles for testing,
- technical condition of selected and submitted vehicles is checked,
- emission tests are usually conducted at NIER facilities and arithmetical average is taken as the test results,
- if the sample fails the tests, the vehicle manufacturer may request a repetition of recall tests,
- if the sample fails the tests, components affecting emissions to be replaced /repaired are listed in the test report,
- EPA decides whether and which components should be replaced in the in-use vehicles.

The test procedure currently used for cars and LDV emission testing is similar to US FTP 75 (CVS 75). As regards heavy-duty vehicles, the test procedure is similar to that specified in ECE 13-mode test. Emisson standards for gasoline and LPG vehicles which came into force in 1987 (transient test) have not been implemented.

Table A1/8

Emission standards for new gasoline and LPG vehicles in Korea

Type of Vehicle	Model Year	Test Procedure	CO	NO_x	HC		Smoke %
					Exhaust	Evaporative (g/test)	
Small Car [1]	1987. 7. 1.	CVS-75(g/km)	8.0	1.5	2.1	4.0	-
	2000. 1. 1.	CVS-75(g/km)	2.11	0.62	0.25	2.0	-
Passenger Car	1980. 1. 1.	10-Mode(g/km)	26.0	3.0	3.8	-	-
	1984. 7. 1.	10-Mode(g/km)	18.0	2.5	2.8	-	-
	1987. 7. 1.	CVS-75(g/km)	2.11	0.62	0.25	2.0	-
	2000. 1. 1.	CVS-75(g/km)	2.11	0.25	0.16	2.0	-
Light-Duty Truck	1987. 7. 1.	CVS-75(g/km)	6.21	1.43	0.50	2.0	-
	2000. 1. 1.	CVS-75(g/km) [2]	2.11	0.62	0.25	2.0	-
		CVS-75(g/km) [3]	6.21	1.43	0.5	2.0	-
Heavy-Duty Vehicle	1980. 1. 1.	6-Mode (ppm)	1.6%	2200	520	-	-
	1987. 7. 1.	Transient (g/b.hp-hr)	15.5	10.7	1.3	4.0	-
	1991. 2. 1.	G-13 Mode (g/kWh)	33.5	11.4	1.3	-	-
	2000. 1. 1.	G-13 Mode (g/kWh)	33.5	5.5	1.3	-	-
Motorcycle	1991. 8. 1.	Idling (%)	5.5	-	1.1/0.45 [4]	-	-
	1993. 1. 1.	Idling (%)	4.5	-	1.1/0.45 [4]	-	-
	1996. 1. 1.	Idling (%)	3.6	-	0.45/0.45 [4]	-	-

1) Engine displacement less than 800 cc
2) Trucks adn passenger cars capable of seating 15 persons or less with loaded mass exceeding 1.5 ton
3) Light duty trucks except 2)
4) 2 stroke/4 stroke engines

Table A1/9

Emission standards for new diesel vehicles in Korea

Type of Vehicle	Model Year	Test Procedure	CO	NO_x	HC	Particulate	Smoke %
Passenger Car	1980. 1. 1.	Full Load	-	-	-	-	50%
	1984. 7. 1.	6-Mode(ppm)	980	1000/590 [1]	670	-	50%
	1988. 1. 1.	6-Mode(ppm)	980	850/450 [1]	670	-	50%
	1993. 1. 1.	CVS-75(g/km)	2.11	1.25	0.25	0.25	-
	1996. 1. 1.	CVS-75(g/km)	2.11	0.62	0.25	0.12	-
	2000. 1. 1.	CVS-75(g/km)	2.11	0.62	0.25	0.05	-
Light-Duty Truck	1980. 1. 1.	Full Load	-	-	-	-	50%
	1984. 7. 1.	6-Mode(ppm)	980	1000/590	670	-	50%
	1988. 1. 1.	6-Mode(ppm)	980	850/450	670	-	50%
	1993. 1. 1.	6-Mode(ppm)	980	750/350	670	-	40%
	1996. 1. 1.	CVS-75(g/km)	6.21	1.43	0.5	0.31	-
	2000. 1. 1.	CVS-75(g/km) [2]	2.11	0.62	0.25	0.05	-
		CVS-75(g/km) [3]	6.21	1.43	0.5	0.16	-
Heavy-Duty Vehicle	1980. 1. 1.	Full Load	-	-	-	-	50%
	1984. 7. 1.	6-Mode(ppm)	980	1000/590	670	-	50%
	1988. 1. 1.	6-Mode(ppm)	980	850/450	670	-	50%
	1993. 1. 1.	6-Mode(ppm)	980	750/350	670	-	40%
	1996. 1. 1.	D-13Mode(g/kWh)	4.9	11.0	1.2	0.9	40%
	2000. 1. 1.	D-13Mode(g/kWh)	4.9	6.0	1.2	0.25 [4] (0.10)	25%

1) Direct injection/Indirect injection engines
2) Trucks and passenger cars capable of seating 15 persons or less with loaded mass not exceeding 1.5 ton
3) Light duty truck except 2)
4) ( ) City bus

6. Philippines

The control system for emissions from new motor vehicles is specified in "Rules and Regulations for the Prevention, Control and Abatement of Air Pollution from Motor Vehicle (1979)" issued by National Pollution Control Commission pursuant to the provisions of Presidential Decree No. 1181.

According to the above mentioned "Rules and Regulations" all non-registered (i.e. new) light-duty vehicles equipped with SI engines should be certified as to conformity with prescribed crankcase, evaporative and exhaust emission standards as a condition for sale and/or use. The following standards were laid down:

a) the exhaust emissions for 1982 and later models should not exceed the values given in Table below as a function of gross vehicle weight (GVW):

Table A1/10

Emission standards for gasoline-fuelled light duty vehicles in the Philippines

GVW [kg]	Limits [g/km]	
	CO	HC
1000 or less	25	2.5
1001 - 1500	30	3.0
1501 - 3000	35	3.5

b) fuel evaporative emissions for 1985 and later models should not exceed 2.0 g/test.

The specified test procedures are similar to US FTP 75 and US evaporative test.

As regards non-registered diesel vehicles separate provisions apply to:

- vehicles with new engines,
- vehicles with reconditioned engines.

The conformity with the provisions is a condition for registration after 1 January 1982.

Vehicles with new engines should be covered by a certificate to one of the following standards with regard to smoke level:

- British Standards BU AU 141(a), 1971,
- EC Directive 72/306/EEC,
- Australian Design Rule No. 30,
- ECE Regulation No. 24,
- US Federal Regulations Part 86.

Vehicles with reconditioned engines must not emit smoke in excess of 2.5 m^{-1} measured at free acceleration from low idle speed.

The provisions of the aforementioned "Rules and Regulations" have never been fully implemented. Only a few vehicle models were granted a certificate of conformity in the early 1980's. At present, vehicles not covered by a certificate are registered without any problems.

7. Singapore

Emission standards for new motor vehicles in force in Singapore are given in Table below.

Table A1/11

Motor vehicle emission standards in Singapore

Vehicle category	Standard	Date of entry into force
Petrol-driven vehicles except motorcycles (cars, goods vehicles, engineering plants)	ECE Regulation 15/04 ECE Regulation 83/00 or Japanese Safety Regulations for Road Vehicles, article 31	1 October 1986 1 July 1992
Motorcycles	US CFR 86.410-80	1 October 1991
Diesel vehicles (goods vehicles, engineering plants)	ECE Regulation 24/03	1 January 1991-for new vehicles 1 January 1992-for second-hand vehicles

ECE regulation 83/01 (EC Directive 91/441/EEC) is now under consideration to replace ECE regulation 83/00. In addition to the above standards, all petrol-driven vehicles, motorcycles included, are required to be able to operate on unleaded petrol. This requirement is effective from 1 July 1991.

Compliance with the aforementioned standards is ensured through type approval inspection conducted by Registrar of Vehicles (ROV). As there are no testing facilities for type approval with regard to emissions, the compliance is checked on the basis of documents. The following documents are required:

i) A certificate of compliance stating that the vehicle type meets the respective emisson standards. The certificate has to be endorsed by either the vehicle manufacturer or an authorized foreign emission testing laboratories,

ii) A detailed test report of the vehicle to be registered.

The list of authorized laboratories includes German, Italian, French, British and Japanese vehicle emission testing laboratories.

8. Thailand

In Thailand, requirements with regard to motor vehicle emissions are specified in Thai Industrial Standards. Two standards have been laid down up till now:

- for cars and light duty vehicles - equivalent to ECE Regulation 83/00,
- for motorcycles - equivalent to ECE Regulation 40/01.

According to Announcement of Minister of Industry issued on 8 October 1991 petrol-driven vehicles have to be equipped with catalytic convertors. This requirement is effective from:

- 1 January 1993 - for engine displacement 1600 cm^3 or more,
- 1 September 1993 - for engine displacement less than 1600 cm^3.

Emissions Certification	REGULATION	Attachment 1	Page 1
			Date
	VEHICLE TYPE	Revision No	Date

CERTIFICATE OF COMPLIANCE

The Vehicle Type described below, offered for sale in Hong Kong, comply with the Standards for exhaust emissions as laid down in the Air Pollution Control (Vehicle Design Standards) (Emissions) Regulations 91.

Vehicle Make :
Series Identifier (Sales Designation) :
Vehicle Type :

Exhaust emissions testing in support of this application was carried out in accordance with the procedures specified in :-

The attached documents, duly completed, are an essential part of this certificate.

This approved laboratory used for the generation of test data used in this application was :

Laboratory Certified by :
(Name National Authority)

.....

Principal Engineer
Emissions

A) **MASS EMISSION STANDARD FOR PETROL DRIVEN VEHICLES EFFECTIVE FROM 1.4.1995.**

I TYPE APPROVAL TESTS

i) Passenger cars

Reference mass R(Kg)	CO g/km	HC + NO_x g/km
R < 1020	5.0	2.0
1020 < R < 1250	5.7	2.2
1250 < R < 1470	6.4	2.5
1470 < R < 1700	7.0	2.7
1700 < R < 1930	7.7	2.9
1930 < R < 2150	8.2	3.5
R > 2150	9.0	4.0

Note

1. The test will be as per Indian driving cycle with cold start.
2. There should be no cranckcase emission. (To be implemented from 1.1.1994)
3. Evaporative emission should not be more than 2.0 g/test. (To be implemented from 1.1.1994)

ii) Two wheelers (For all categories)

CO - 3.75 g/km
HC - 2.40 g/km

Note
The test will be as per Indian driving cycle with cold start.

iii) Three wheelers(For all categories)

CO - 5 6 g/km
HC - 3.6 g/km
Note
The test will be as per Indian driving cycle with cold start.

II CONFORMITY OF PRODUCTION TESTS

i) Passenger Cars (For all categories)
A relaxation of 20% for CO & 25% for combined HC+NO_x for the corresponding values of Type Approval Test given above would be permitted.

ii) Two & Three Wheelers (For all categories)
A relaxation of 20% for CO and 25% for HC for the values of Type Approval Test given above would be permitted.

MASS EMISSION STANDARD FOR DIESEL VEHICLES EFFECTIVE FROM 1.4.1995.

I TYPE APPROVAL TESTS

Vehicle category	HC* (g/KWH)	CO* (g/KWH)	NO_x (g/KWH)	Smoke
Medium & Heavy over 3.5 Ton/GVW	2.4	11.2	14.4	***
Light diesel upto 3.5 Ton GVW	2.4	11.2	14.4	***

OR

Reference mass R(Kg)	CO** g/km	HC + NO_x** g/km
R < 1020	5.0	2.0
1020 < R < 1250	5.7	2.2
1250 < R < 1470	6.4	2.5
1470 < R < 1700	7.0	2.7
1700 < R < 1930	7.7	2.9
1930 < R < 2150	8.2	3.5
R > 2150	9.0	4.0

Note

* The test cycle is as per 13 mode cycle on dynamometer.

**1) The test should be as per Indian driving cycle with cold start.

*** The emissions of visible pollutants(smoke) shall not exceed the limit values to smoke density, when expressed as light absorption coefficient given at Page 2 of Annexure II for various nominal flows when tested at constant speeds over full load.

I CONFORMITY OF PRODUCTION TESTS

A relaxation of 10% for the values of Type Approval Test given above would be permitted .

Nominal Flow G(l/s)	Light Absorption Coefficient ($K(m^{-1})$)
42	2.00
45	1.91
50	1.82
55	1.75
60	1.68
65	1.61
70	1.56
75	1.50
80	1.46
85	1.41
90	1.38
95	1.34
100	1.31
105	1.27
110	1.25
115	1.22
120	1.20
125	1.17
130	1.15
135	1.13
140	1.11
145	1.09
150	1.07
155	1.05
160	1.04
165	1.02
170	1.01
175	1.00
180	0.99
185	0.97
190	0.96
195	0.95
200	0.93

Annexure III

MASS EMISSION STANDARD FOR PETROL DRIVEN VEHICLES EFFECTIVE FROM 1.4.2000

I TYPE APPROVAL TEST

i) Passenger cars(for all categories)

CO - 2.72 g/km
HC + NO_x - 0.97 g/km

Note

1. The test should be as per Indian driving cycle with cold start.

ii) Two wheelers(for all categories)

CO - 2.0 g/km

HC - 1.5 g/km

Note

1. The test should be as per Indian driving cycle with cold start.

iii) Three wheelers(for all categories)

CO - 4.0 g/km

HC - 1.5 g/km.

Note

1. The test should be as per Indian driving cycle with cold start.

II CONFORMITY OF PRODUCTION TESTS

i) Passenger Cars (For all categories)
A relaxation of 16% for CO & combined HC + NO_x for corresponding values of Type Approval Test given above would be permitted.

ii) Two & Three Wheelers (For all categories)
A relaxation of 20% for CO as well as HC for the values of Type Approval Test given above would be permitted.

MASS EMISSION STANDARD FOR DIESEL VEHICLE EFFECTIVE FROM 1.4.2000

I TYPE APPROVAL TESTS

Vehicle category	HC*	CO* (g/KWH)	NO_x*	PM*	Smoke
Medium & Heavy over 3.5 ton GVW	1.1	4.5	8.0	0.36	***
Light diesel upto 3.5 ton GVW	1.1	4.5	8.0	0.61	***

OR

CO ** g/km	HC + NO_x** g/km	PM**
2.72	0.97	0.14

Note

* The test should be as per 13 mode cycle.

**1) The test should be as per Indian driving cycle with cold start.

*** The emission of visible pollutants (smoke) shall not exceed the limit values of smoke density , when expressed and light absorption coefficient given at Page 2 of Annexure IV for various nominal flows when listed at constant speed, over full load.

I CONFORMITY OF PRODUCTION TESTS

A relaxation of 10% for the values of Type Approval Test given above would be permitted for Conformity Of Production Test for all vehicles.

Annexure IV
(Page 2 of 2 Pages)

Nominal Flow G(l/s)	Light Absorption Coefficient (K(m^{-1})
42	2.00
45	1.91
50	1.82
55	1.75
60	1.68
65	1.61
70	1.56
75	1.50
80	1.46
85	1.41
90	1.38
95	1.34
100	1.31
105	1.27
110	1.25
115	1.22
120	1.20
125	1.17
130	1.15
135	1.13
140	1.11
145	1.09
150	1.07
155	1.05
160	1.04
165	1.02
170	1.01
175	1.00
180	0.99
185	0.97
190	0.96
195	0.95
200	0.93

Emission legislation in Europe

1. Regulations of Economic Commision for Europe

1.1. General

The emission legislation concerning pollutant emissions from new motor vehicles in force in the majority of European countries is based on Regulations issued by Economic Commission for Europe (ECE) in the framework of "Agreement concerning the adoption of uniform conditions for approval and reciprocal recognition of approval for motor vehicle equipment and parts" done at Geneva in 1958 (Geneva Agreement 1958) [4]. The following Regulations are in force as of 1 January 1993:

a) Regulation 15, 04 series of amendments (15/04) "Uniform provisions concerning the approval of vehicles equipped with a positive-ignition engine or with a compresion-ignition engine with regard to emission of gaseous pollutants by the engine"; date of entry into force - 20 October 1981 [5],

b) Regulation 24, 03 series of amendments (24/03) "Uniform provisions concerning:
   I. The approval of compression ignition (C.I) engines with regard to the emission of visible pollutants,
   II. The approval of motor vehicles with regard to the installation of C.I. engines of an approved type,
   III. The approval of motor vehicles equipped with C.I. engines with regard to the emission of visible pollutants by the engine,
   IV. The measurement of power of C.I. engines";
   date of entry into force - 20 October 1981 [6],

c) Regulation 40, 01 series of amendments (40/01) "Uniform provisions concerning the approval of motorcycles equipped with a positive-ignition engine with regard to the emission of gaseous pollutants by the engine"; date of entry into force - 31 May 1988 [7],

d) Regulations 47, original version (47/00) "Uniform provisions concerning the approval of mopeds equipped with a positive-ignition engine with regard to the emission of gaseous pollutants by the engine"; date of entry into force - 1 November 1981 [8],

e) Regulations 49, 02 series of amendments (49/02) "Uniform provisions concerning the approval of compression ignition (C.I.) engines and vehicles equipped with C.I. engines with regard to the emission of pollutants by the engine"; date of entry into force - 1 January 1993 [9],

f) Regulation 83, 01 series of amendments (83/01) "Uniform provisions concerning the approval of vehicles with regard to the emission of gaseous pollutants by the engine according to engine fuel requirements"; date of entry into force - 1 January 1993 [10].

All ECE Regulations are formulated through technical body - Group of Rapporteurs on Pollution and Energy (GRPE). Each Regulation is issued as an addendum to Geneva Agreement 1958. It is to note that Regulation 15/04 is still in force only in a few European countries (Yugoslavia, Romania, Russian Federation). The majority of countries has already ceased to apply it and adopted Regulation 83. ECE has no power to enforce the compliance with issued Regulations. They are applied on a voluntary basis by contracting parties to Geneva Agreement 1958. The fact of application should be notified to the Secretary General of UN. Countries applying a given Regulation may not prohibit any vehicles which comply with its provisions to be registered, marketed etc. However, they may also accept vehicles which do not comply if their national legislation does not require mandatory conformity.

1.2. ECE classification of motor vehicles

The full ECE classification of motor vehicle is given in [11]. The following is a simplified outline of this classification including only vehicles covered by the aforementioned emission Regulations and necessary for better understanding of the scope of application of particular Regulations.

A. Category L - motor vehicles with less than four wheels:

a) categories L1 and L2 - two wheeled (L1) and three-wheeled (L2) vehicles with an engine capacity not exceeding 50 cm^3 and maximum design speed not exceeding 50 km/h (this category is often referred to as "mopeds"),

b) categories L3, L4 and L5 - two-wheeled (L3) and three-weeled (L4, L5) vehicles with an engine cylinder capacity exceeding 50 cm^3 or a maximum design speed exceeding 50 km/h (motorcycles).

B. Category M - motor vehicles having at least four wheels and used for the carriage of passengers:

a) category M1 - vehicles comprising not more than eight seats in addition to the driver's seat (cars),

b) category M2 - vehicles comprising more than eight seats in addition to the driver's seat and having a maximum mass not exceeding 5000 kg,

c) category M3 - vehicles comprising more than eight seats in addition to the driver's seat and having a maximum mass exceeding 5000 kg.

C. Category N - motor vehicles having at least four wheels and used for the carriage of goods:

a) category N1 - vehicles having a maximum mass not exceeding 3500 kg,

b) category N2 - vehicles having a maximum mass exceeding 3500 kg but not exceeding 12000 kg,

c) category N3 - vehicles having a maximum mass exceeding 12000 kg.

D. Category T - agricultural and forestry tractors.

1.3. Control system

1.3.1. Kinds of control procedure

The control system with regard to emissions specified in all ECE emission Regulations consists of:
- vehicle/engine type approval (TA),
- verification of conformity of production (COP) i.e. conformity of vehicles/engines with the approved type.

Vehicle/engine means a category of vehicles/engines which do not differ in such respects as:

a) engine characteristics:
- make, trade mark, etc.,
- main technical data (cycle, cylinder capacity, bore, stroke, number and layout of cylinders etc.),
- cooling system,
- intake system,
- fuel feed,
- valve timing,
- ignition,
- exhaust system,
- lubrication system,
- additional anti-pollution devices,

b) vehicle characteristics:
- make, trade name, etc.,
- main technical data (category, masses, transmision type, transmission ratio, wheel drive etc.).

1.3.2. Type approval

Type approval means a procedure whereby the approval authority certifies that a type of vehicle/engine complies with the requirements specified in the Regulation. In order to check the compliance, a vehicle/engine representative of the type to be approved is subjected to specified tests run by technical services authorized by the approval authority. The type approval is granted if the tested vehicle/engine meets all relevant provisions. Moreover, before granting, the approval authority should verify the existence of satisfactory arrangements for ensuring the effective control of the conformity of production. Every vehicle/engine belonging to the approved type should be either marked with an international approval mark or accompanied by a document stating its compliance with the Regulation in force.

Every modification of the vehicle type should be notified to the approval authority. This authority may:
- either consider that the introduced modifications are unlikely to have an appreciable adverse effect on emissions and that the vehicle type still complies with the requirements,
- or require new tests in order to prove the compliance.

1.3.3. COP verification

Every vehicle/engine belonging to the approved type should be so manufactured as to conform to the approved type with regard to characteristics affecting emissions. In order to verify the conformity suitable inspections of the production are conducted. The approval authority is empowered to conduct such inspections at any time. As a general rule, the conformity with the approved type is verified on the basis of the type description, however, if necessary, vehicles may be subjected to some of the tests specified in the Regulation. Usually, with a few exceptions (e.g. Regulation 49/00 or 49/02 B), the limits prescribed for COP are more lenient than those for type approval.

The following procedure for testing in the framework of COP is prescribed in the emission Regulations. A vehicle/engine is randomly taken from the series and subjected to tests. If the vehicle meets the requirements, the series is deemed to conform. However, if the requirements are not complied with, the manufacturer may ask for tests to be performed on a sample of the determined size including the vehicle/engine originally taken. The production of the series is regarded to conform if the following condition is met for each pollutant:

$$\bar{X} + kS \leq L$$

where:

$\bar{X}$ - the arithmetical mean of the result with the sample,
S - standard deviation,
L - limit prescribed for COP,
k - statistical factor depending on the size n, given in Table below.

Statistical factor used for COP verification Table A2/1

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

$$k = \frac{0.860}{\sqrt{n}}$$

if $n \geq 20$

The approval authority may withdraw the granted type approval if manufactured vehicles/engines do not conform to the approved type.

1.4. Regulation 15/04

1.4.1. Scope of application

Regulation 15/04 applies to the emission of gaseous pollutants (CO, HC, NO_x) from positive-ignition engined vehicles and from compression-ignition engined vehicles of categories M1 and N1. Compression ignition engined vehicles of category N1 need not comply with the provisions of Regulation 15/04 providing that they comply with the provisions of Regulation 49.

Regulations 15/04 specifies 3 types of test:

- type I test for the verification of the average emissions of CO, HC and NO_x after a cold start (conducted only on vehicles whose maximum mass does not exceed 3500 kg),
- type II test for the verification of CO emission at idle (conducted on positive-ignition engined vehicles),
- type III test for the verification of crankcase emissions from positive-ignition engined vehicles.

1.4.2 Type I test

The limit values for emissions determined in type I test are specified separately for CO mass and combined mass of HC and NO_x as a function of the vehicle reference mass. The reference mass means an unladen mass of the vehicle increased by a lump figure of 100 kg. The limits to be complied with in the type approval and COP verification are given in Table below.

Table A2/2

Limit values for emissions in type I test as specified in Regulation 15/04.

Reference mass rw [kg]	Limits [g/test]			
	CO		HC + NO_x	
	TA	COP	TA	COP
rw ≤ 1020	58	70	19	23.8
1020 < rw ≤ 1250	67	80	20.5	25.6
1250 < rw ≤ 1470	76	91	22	27.5
1470 < rw ≤ 1700	84	101	23.5	29.4
1700 < rw ≤ 1930	93	112	25	31.3
1930 < rw ≤ 2150	101	121	26.5	33.1
2150 < rw	110	132	28	35.0

The limit values for the combined mass of HC and NO_x specified in Table A2/2 are applicable only to vehicles of M1 category designed to carry not more than 6 occupants (including a driver). All vehicles other than mentioned above covered by Regulation 15/04 should conform to the limit values obtained by multiplying those listed in Table A2/2 by 1.25.

The type I test is conducted on the vehicle placed on a chassis dynamometer. The dynamometer must be capable of simulating the road load and for this purpose equipped with means of load and inertia simulation.

Two types of chassis dynamometer are specified:

- dynamometer with fixed load curve, i.e. a dynamometer whose design provides a fixed load curve (e.g. equipped with a hydraulic brake),
- dynamometer with adjustable load curve, i.e. if at least two road load parameters can be adjusted to shape the load curve.

The operating cycle on the chassis dynamometer is so called "European urban cycle" depicted in the graph in Fig A2/1. The test consist of 4 cycles conducted without interuption. The characteristics of the cycle are given in Table A2/3.

Before the test, the vehicle should be conditioned for at least 6 hours in a room in which the temperature remains reasonably

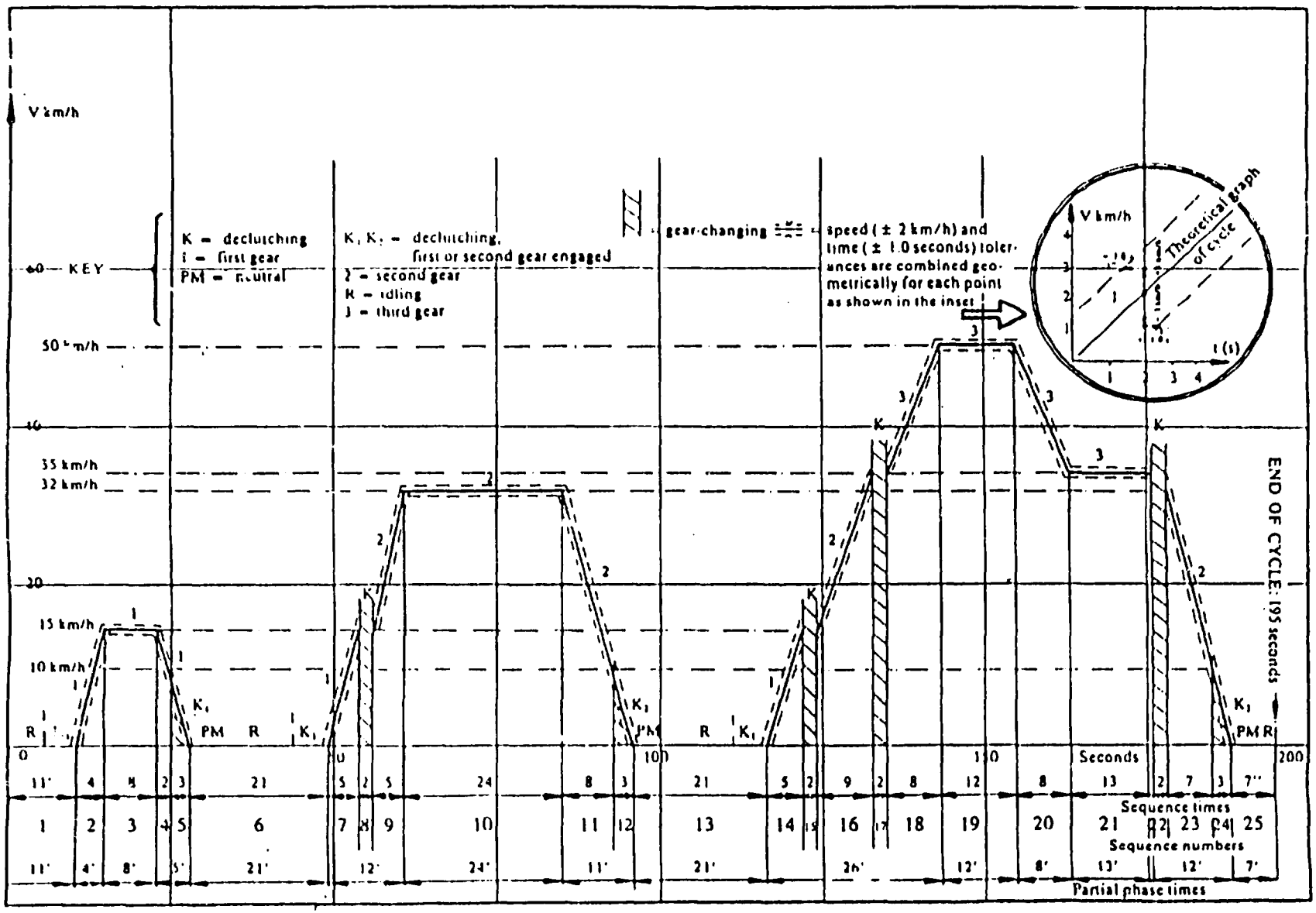


Fig. A2/1 European urban test cycle

constant between 20°C and 30°C. After the engine is started, it is kept idling for a period of 40s. This period is not included in the emission measurement. The first cycle begins at the end of the 40s idling period.

Table A2/3

Breakdown of the operating cycles specified in Regulations 15/04 (83) and 83/01

Parameter	Urban cycle	Extra-urban cycle
Average speed (km/h)	19.0	62.6
Running time (s)	4x195 = 780	400
Theoretical distance (km)	4x1.013 = 4.052	6.955
Maximum speed (km/h)	50	120
Share of (%):		
- idling	35.4	10.0
- gear shift	4.1	1.5
- accelerations	18.5	25.8
- steady-speed periods	29.2	52.2
- decelerations	12.8	10.5

The exhaust gas sampling system (CVS), the analytical system and the method of emission mass calculation specified in Regulation 15/04 are similar to that used in FTP 75 (Annex 3, point 3.3.2). The main exception is that two sampling bags are usually used: one for the collection of diluting air sample and the other one - - for the diluted exhaust gas sample.

1.4.3. Type II test.

The CO concentration in the exhaust gas emitted with the engine idling must not exceed 3.5% vol. at the settings specified by the manufacturer (used for type I test). In addition, this concentration within the range of adjustments obtained by means of controls for changing the idling conditions of the engine should not be higher than 4.5% vol.

The aforementioned limits apply:

a) to the corrected CO concentration (CO_{corr}) calculated by means of the formula:

$$CO_{corr} = CO_m \frac{15}{CO_m + CO_{2m}} \quad [\% \text{ vol.}]$$

when the total of measured CO and CO_2 concentrations is lower than 15,

where:
CO_{corr} - corrected CO concentration, in % vol.,
CO_m - measured CO concentration, in % vol.,
CO_{2m} - measured CO_2 concentration, in % vol.,

b) to the actually measured CO concentration (CO) when this total is at least 15.

For the measurement of concentrations, the exhaust gas is directly sampled from vehicle exhaust system.

1.4.4. Type III test

The engine crankcase ventilation system should not allow any emission of the crankcase gas into the atmosphere.

The measurements to check the compliance with the above provision are conducted in 3 sets of conditions of vehicle operation specified in Table below.

Table A2/4

Operating conditions for crankcase emission test

Conditions No.	Vehicle speed (km/h)
1	idling
2	50 ± 2
3	50 ± 2
Conditions No.	**Power absorbed by brake**
1	Nil
2	That corresponding to the settings for type I tests
3	That for conditions No. 2, multiplied by a factor of 1.7

The checking consists of measurement of the pressure in the crankcase. If this pressure does not exceed the atmospheric one, the vehicle is deemed satisfactory. However if this requirement is not met, an additional test by means of a flexible bag connected to the dipstick hole can be conducted. The vehicle passes the test if no visible inflation of the bag occurs during 5 minutes of vehicle operation under each of specified conditions.

1.5. Regulation 83/01

1.5.1. Scope of application

Regulation 83/01 applies to the pollutant emissions from all vehicles of category M1 and N1 equipped with positive-ignition engines or equipped with compression-ignition engines. It does not apply to vehicles with a design speed not exceeding 50 km/h.

Regulation 83/01 divides vehicles into 3 main groups according to fuel requirements. Different emissions levels and tests are required for each of them. The specified groups are as follows:

A. vehicles fueled with leaded petrol (Approval A),
B. vehicles fueled with unleaded petrol (Approval B),
C. vehicles fueled with diesel fuel (Approval C).

Vehicles coming within the groups B and C are further divided into two subgroups:

1. vehicles of category M1:
   - with a maximum mass not exceeding 2500kg,
   - designed to carry not more than 6 occupants, including the driver,

2. vehicles other than specified in item 1 i.e.:
   - vehicles of category M1 with a maximum mass exceeding 2500kg or designed to carry more than 6 occupants or off-road type,
   - vehicles of category N1.

Regulation 83/01 does not specify the classes of vehicles that must be fuelled with unleaded petrol. This specification is supposed to be done in the framework of national regulations.

The following five tests are specified in Regulation 83/01:

I.	type I test	- verification of the average exhaust emissions after a cold start,
II.	type II test	- verification of CO concentration in the exhaust gas at idle,
III.	type III test	- verification of crankcase emissions,
IV.	type IV test	- determination of evaporative emissions,
V.	type V test	- durability of pollution control devices (if applies only to components which control and/or limit exhaust emissions).

Tests to which individual groups and subgroups should be subjected are listed in Table A2/5.

1.5.2. Approval A

For vehicles fuelled with leaded petrol (Approval A) Regulation 15/04 and Regulation 83/01 are identical and therefore an approval granted according to Regulation 15/04 can be automaticly converted into an approval pursuant to Regulation 83/01.

Approval A was introduced to make it possible for countries which do not require stringent emission standards to use Regulation 83/01 instead of 15/04.

1.5.3. Approval B

Regulation 83/01 specifies different exhaust emission limits and different test procedures for subgroups 1 and 2 of vehicles for which Approval B is required.

For the subgroup 1 the limits are expressed in g/km and not in g/test like in Regulation 15/04. The limits apply to the mass of CO and combined mass of HC and NO_x (Table A2/6).

Table A2/5

Approval system specified in ECE Regulation 83/01

Type--Approval Test	Vehicles fuelled with leaded petrol Approval A	Vehicles fuelled with unleaded petrol Approval B		Vehicles fuelled with diesel fuel Approval C	
	(identical to Regulation 15/04) Category M1, N1	Subgroup 1	Subgroup 2	Subgroup 1	Subgroup 2
Type I:	YES PART I	YES PART I & PART II	YES (mass ≤ 3.5 tonnes PART I	YES PART I & PART II	YES (mass ≤ 3.5 tonnes) PART I
Type II:	YES	...	YES	...	...
Type III:	YES	YES	YES	...	...
Type IV:	...	YES	...	...	...
Type V:	...	YES	...	YES	...

The limit values for vehicles of subgroup 1 subject to Approval B and C

Table A2/6

	Limit values [g/km]		
	CO	HC + NO_x	PM^x
TA	2.72	0.97	0.14
COP	3.16	1.13	0.18

x only for Approval C

In order to check the compliance with the above limits vehicles should be subjected to type I test. The obtained results are multiplied by detorioration factors determined in type V test. The resulting masses of pollutants should not exceed the limits.

The measurement of emissions in type I test is carried out over a driving cycle ilustrated in Fig. A2/2. It comprises two parts (Table A2/3 above):

- part I - 4 urban cycles as specified in Regulation 15/04 (so called "European urban cycle"),
- part II - extra urban cycle.

The extra urban cycle was introduced to the test due to the fact that the urban cycle gives unrealisticaly low figures for NO_x emissions.

The type V test represents a durability test of 80000 km driven in accordance with a specified programme. Every 10000 km, or more frequently, exhaust emissions are measured according to the provisions for type I test. All emission data are plotted as a function of driving distance and the best fit straight lines are drawn. The exhaust emission detorioration factor is calculated for each pollutants by the formula:

$$DEF = \frac{M_{i2}}{M_{i1}}$$

where:

M_{i1} - mass emission of the pollutant i interpolated to 6400 km, in g/km,

M_{i2} - mass emission of the pollutant i interpolated to 80000 km, in g/km,

Table A2/7

Optional detorioration factors for vehicles fuelled with unleaded petrol and diesel fuel

Vehicles	Detorioration factor for		
	CO	HC + NO_x	PM
fuelled with unleaded petrol (Approval B)	1.2	1.2	---
fuelled with diesel fuel (Approval C)	1.1	1.0	1.2

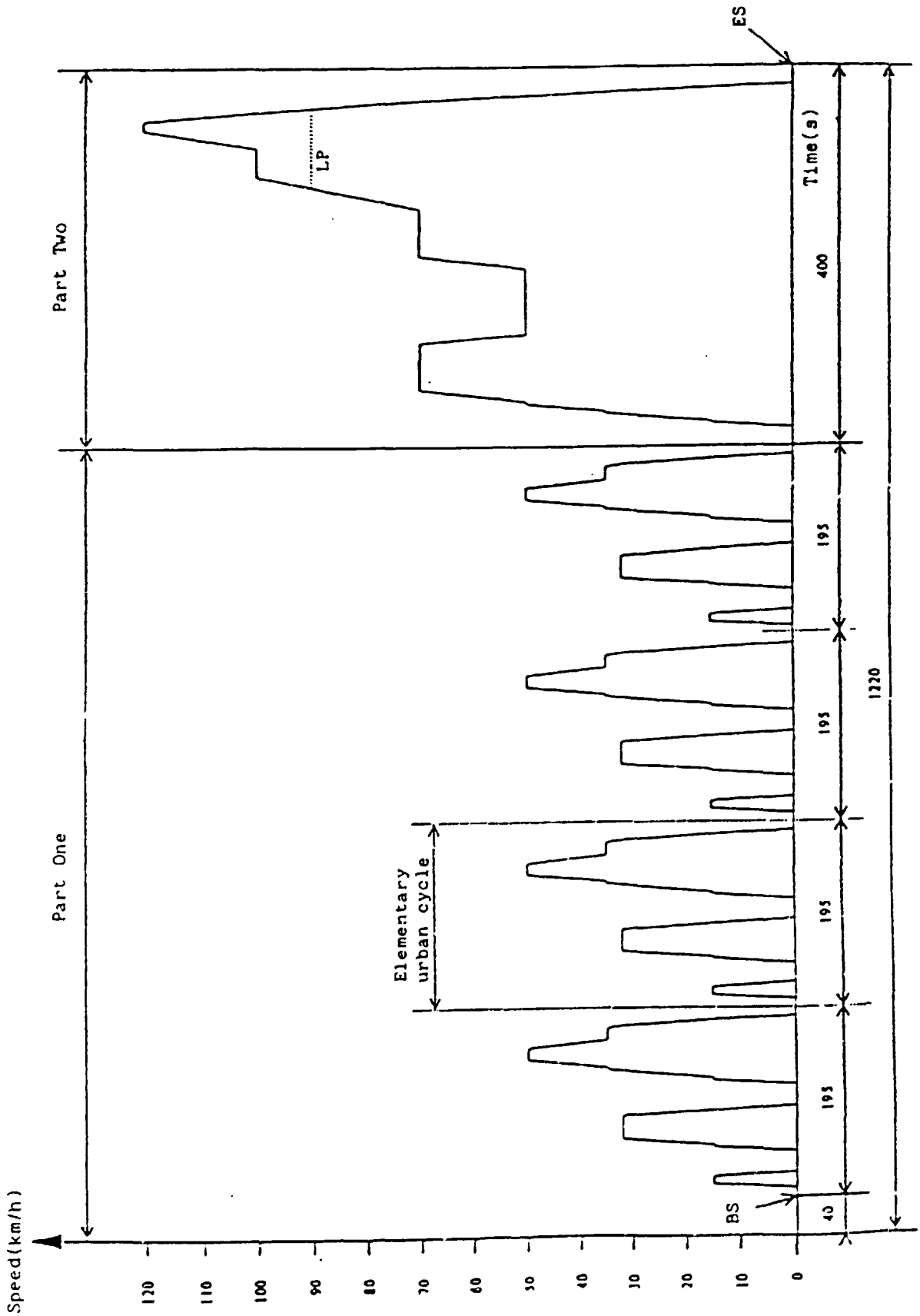


Fig. A2/2 European test cycle specified in ECE Regulation 83/01 for cars

For vehicles subject to Approval B but belonging to the subgroup 2 (Table A2/5), the type I test is similar to that specified in Regulation 15/04. The respective limits are specified in Table A2/2 (point 1.4.2. above). The main difference is that the combined mass of CH and NO_x for N1 category is not multiplied by a lump factor 1.25.

Regulation 83/01 requires for vehicles subject to Approval B that their inlet orifice for the fuel tank should be so designed as to prevent the tank being filled from a delivery nozzle of external diameter of 23.6 mm or greater. This provision need not be met if:

- the vehicle is so designed that devices designed to control the emissions are not adversely affected by leaded petrol,
- the vehicle is marked with the symbol for unleaded petrol.

The type 2 test (for subgroup 2) and type 3 test as well as respective requirements are identical to those specified in Regulation 15/04 (point 1.4.3. and 1.4.4. above).

The evaporative emissions measured in accordance with type IV test (only for subgroup 1) should not exceed 2g/test. The test procedure is similar to that presented in detail in Annex 3, point 3.3.3.

1.5.4. Approval C

Vehicles fuelled with diesel fuel belonging to group 1 should comply with the exhaust emission requirements specified in Table A2/6. Emissions of CO, HC + NO_x and PM are limited for this subgroup. The test procedure is similar to that described above for Approval A, subgroup 1 (with the exception of HC and particulate emission measurement). Detorioration factors to be used when the type V test is not conducted are given in Table A2/7 above.

The type I test for vehicles falling within subgroup 2 is identical to specified in Regulation 15/04. The particulate emissions are not limited. The limits for CO and HC + NO_x are given in Table A2/2. It is to note that the limits for HC + NO_x should not be multiplied by 1.25 for N1 category.

1.6. Regulation 49/02

1.6.1. Scope of application

Regulation 49/02 applies to the emissions of pollutants from compression-ignition engines used for driving motor vehicles of categories M1 (but only having a maximum mass exceeding 3500kg), M2, M3, N1, N2 and N3. However, engines used by M2, N1 and N2 categories are not subject to Regulation 49/02 provided that they are approved according to Regulation 83.

1.6.2. Limits

Regulation 49/02 specifies requirements for both gaseous and particulate emissions. The previous versions (i.e. original, unamended and 01 series of amendments) limited only gaseous emissions. In order to show the development of Regulation 49 all limit values are given below (Table A2/8). Regulation 49/02 specifies two sets of limits:

A) limits A with the date of entry into force:
   - for type approval - 1 January 1993,
   - for COP - 1 October 1993,

B) limits B with the date of entry into force:
   - for type approval - 1 October 1995,
   - for COP - 1 October 1996.

Table A2/8

Emission limit values specified in ECE Regulation 49

Version of Regulation		Limits [g/kWh]			
		CO	HC	NO_x	PM
00	TA	14.0	3.5	18.0	--
	COP	14.0	3.5	18.0	--
01	TA	11.2	2.4	14.4	--
	COP	12.3	2.6	15.8	--
02 A	TA	4.5	1.1	8.0	0.36[x]
	COP	4.9	1.23	9.0	0.40[x]
02 B	TA	4.0	1.1	7.0	0.15
	COP	4.0	1.1	7.0	0.15

[x] In the case of engines with net power not exceeding 85 kW, the limit values for particulate emissions are obtained by applying a coefficient of 1.7 to the above specified values.

1.6.3. Test procedure

The test is carried out with the engine installed on an engine test bench. The prescribed sequence of warmed up engine operating conditions consists of 13 speed and power modes which span the typical range of CI engines operation (Table A2/9). For the determination of gaseous emissions (CO, HC, NO_x), the concentration of each pollutant, exhaust gas flow and power output are measured during each mode. The measured values are weighted by means of weighting factors (Table A2/9) and used to calculate the emission in g/kWh.

Table A2/9

13 - mode cycle specified in ECE Regulation 49

Mode No.	Engine speed	Percent load	Weighting factor
1	idle	--	0.25/3
2	intermediate	10	0.08
3	,,	25	0.08
4	,,	50	0.08
5	,,	75	0.08
6	,,	100	0.25
7	idle	--	0.25/3
8	rated	100	0.10
9	,,	75	0.02
10	,,	50	0.02
11	,,	25	0.02
12	,,	10	0.02
13	idle	--	0.25/3

The analytical system for the determination of gaseous pollutant concentration include:

- NDIR analyser for CO,
- heated FID analyser for HC,
- heated or unheated CL analyser for NO_x with an NO_2 - NO converter.

A schematic diagram of the analytical and sampling system using heated CL analyser is shown in Fig. A2/3.

The following methods may be used for determination of the exhaust gas flow:

- direct measurement of the exhaust flow e.g. by flow nozzle,
- measurement of the air flow and fuel flow, and calculation of the exhaust flow.

The emissions are calculated by means of the formulas of the following type:

$$E_i = \frac{\sum_{j=1}^{13} M_{ij} \cdot WF_j}{\sum_{j=1}^{13} P_j \cdot WF_j}$$

where:

E_i - emission, in g/kWh,
M_i - mass flow rate, in g/h,
P_i - power output, in kW,
WF - weighting factor (Table A2/9),
i - subscript indicating the pollutant (CO, HC, NO_x),
j - subscript indicating the number of mode.

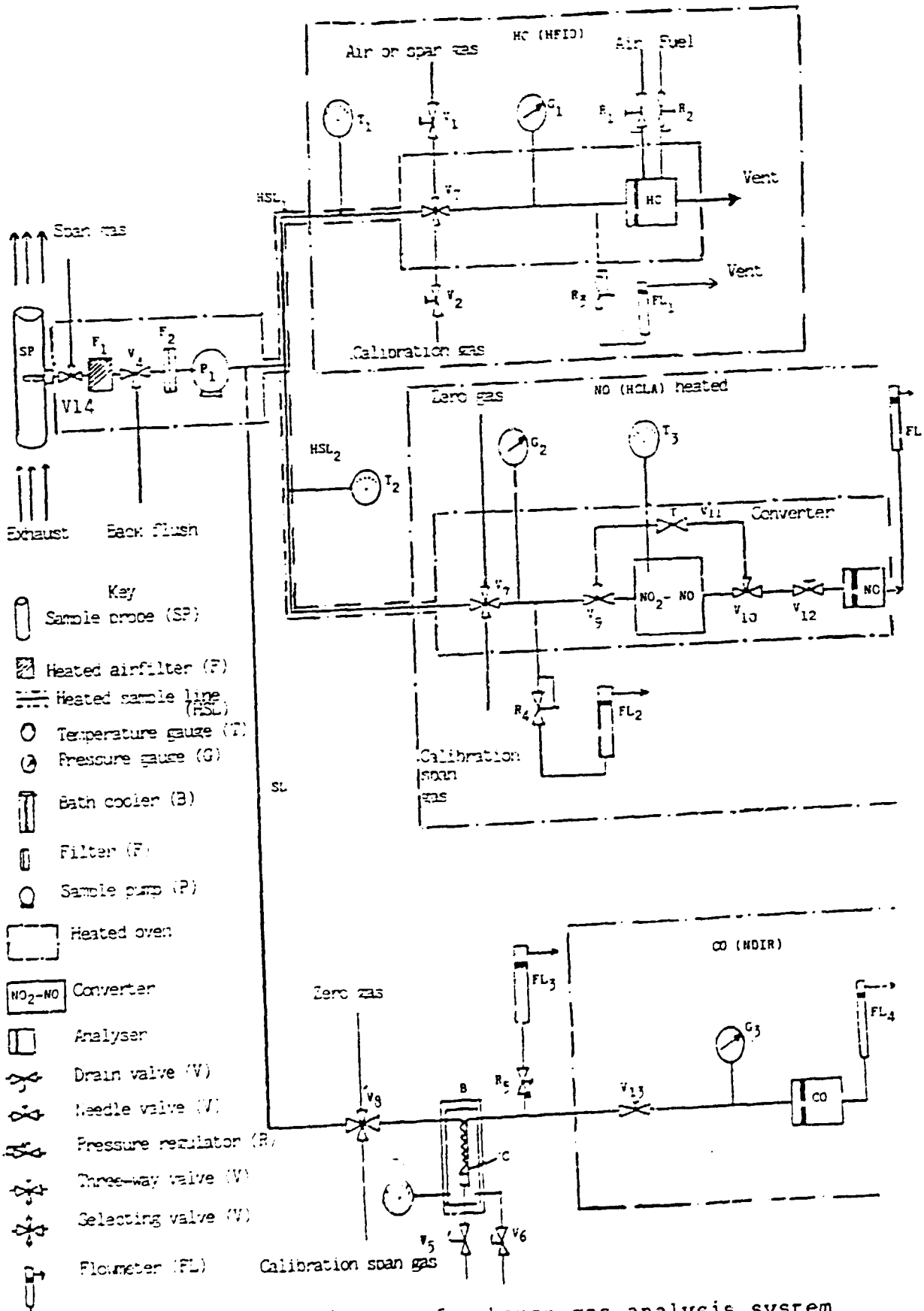


Fig. A2/3 Schematic diagram of exhaust gas analysis system

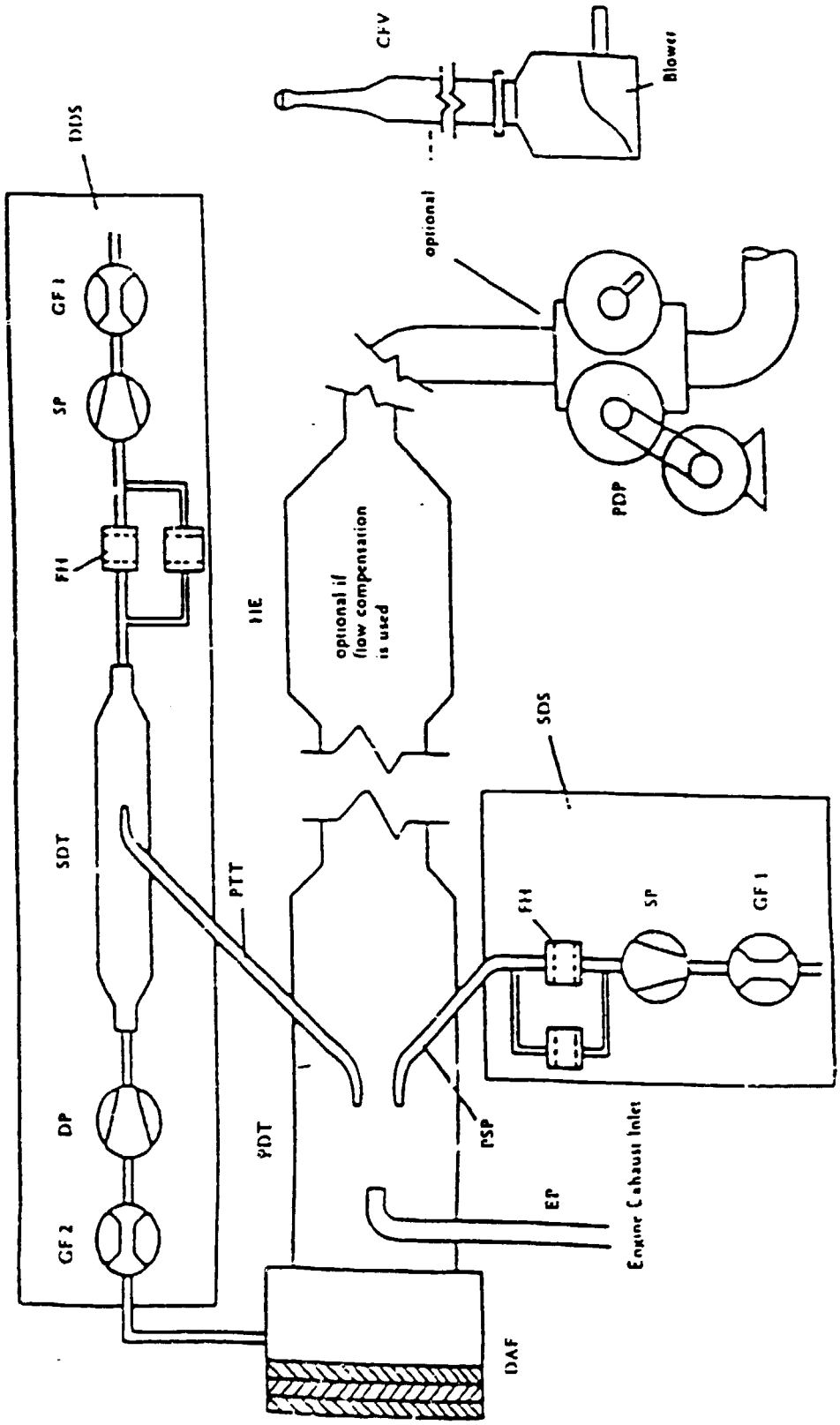


Fig. A2/4 Full-flow system for measurements of particulate emissions

Particulates mean any material collected on fluorocarbon-coated glass fiber filters or fluoro-carbon based (membrane) filters after diluting exhaust gas with clean filtered air so that the mixture temperature does not exceed 325 K (52°C). Different measurement systems may be used for measurement, however the full flow system is recognized as the reference one (Fig. A2/4). One sample over the complete 13 - mode test cycle is taken. The sample flow drawn through the filters should be so adjusted that the effective weighting factor in each mode corresponds to that specified in Table A2/9.

For the determination of particulate emissions the following variables are measured:

- sample mass or volume in each mode,
- flow rate of diluted exhaust gas in each mode,
- power output in each mode,
- particulate sample mass over the entire 13 - mode test cycle.

1.7. Regulation 24/03

1.7.1. Scope of application

Regulation 24/03 is applicable to the emissions of visible exhaust pollutants from compression-ignition (CI) engines. It is divided into 3 parts:

Part I. The emission of visible pollutants from CI engines which are intended for installation into road vehicles,

Part II. The installation into road vehicles of CI engines that has been type approved pursuant to Part I,

Part III. The emission of visible pollutants from motor vehicles that are fitted with CI engines not type approved to Part I.

1.7.2. Limit values

Regulation 24/03 specifies two types of tests:

- test at steady speeds over the full-load curve,
- test at free acceleration.

The limit values for both the tests are expressed as light absorption coefficient k (point 1.7.3. below). For the test at steady speeds they are specified as a function of nominal gas flow rate G in dm^3/s.

The emission of visible pollutants measured during the type approval at steady speeds should not exceed the limits specified in Table A2/10.

5.4. 3-mode smoke test

The test is conducted at full-load under the following speed conditions:

a) 40% of the maximum rated speed (or at 1000 rpm if this speed is lower),
b) 60% of the maximum rated speed,
c) 100% of the maximum rated speed.

The smoke level is measured by means of filter-type smokemeters and expressed in "Bosch" percent. Measured smoke values are corrected to standard ambient conditions using the formula:

$$\text{corrected value} = \text{measured value} - 0.24(t - 20) + 0.16(P - 760)$$

where:
t - ambient temperature, in °C,
P - atmospheric pressure, in mm Hg.

5.5. Idle test

Before the test, the vehicle is warmed up for about 15 min by driving at a constant speed of 40 km/h. Afterwards, the concentrations CC, HC and CO_2 are measured at idle. The exhaust gas is sampled directly from the exhaust pipe.

If the test vehicle is equipped with an exhaust control device using the secondary air, the CO and HC concentrations are corrected by means of the formula:

$$\text{corrected value} = \text{measured value} \cdot \frac{14.5}{1.8 \cdot 6 \cdot 10^{-4}HC + 0.5CO + CO_2}$$

where:
CO, CO_2, - measured CO and CO_2 concentrations, in % vol,
HC - measured HC concentration, in ppm.

5.6. Evaporative emission test

The measured losses consist of:
- running losses,
- hot soak losses.

The following procedure is used:
- warming up the vehicle on a chassis dynamometer at a constant speed of 40 km/h for 15 min,
- filling the fuel tank to 40% of capacity with the reference fuel,
- measuring the running losses which occur during the vehicle operation at a constant speed of 40 km/h for 40 min (trap method),
- hot soak losses measurement in the SHED enclosure or by the trap method for one hour.

The SHED and traps methods are similar to those specified in USA regulation (Annex 3, point 3.3.3.).

Table A2/10

Smoke limits specified in ECE Regulation 24/03

Nominal flow G litres/second	Absorption coefficient k m^{-1}
42	2.26
45	2.19
50	2.08
55	1.985
60	1.90
65	1.84
70	1.775
75	1.72
80	1.665
85	1.62
90	1.575
95	1.535
100	1.495
105	1.465
110	1.425
115	illegible
120	1.37
125	1.345
130	1.32
135	1.30
140	1.27
145	1.25
150	1.225
155	illegible
160	1.19
165	1.17
170	1.155
175	1.14
180	1.125
185	1.11
190	1.095
195	1.08
200	1.065

After the test at steady speeds the engine/vehicle is subjected to a test under free acceleration. Regulation 24/03 does not specify any limits for this test in the case of naturally aspirated engines. In the case of turbo-charged engines the absorption coefficient measured under free acceleration should, however, not exceed the limit prescribed in Table A2/10 for the nominal gas flow rate corresponding to the maximum absorption coefficient measured during steady speed test increased by a lump figure of $0.5m^{-1}$. The test values measured during the type approval under free acceleration should be shown in the approval mark affixed to every engine/vehicle conforming to the approved type.

The procedure for the verification of conformity of production is as follows. A vehicle which has not been run in is subjected to the test under free acceleration. It conforms to the type approved and passes the test if the absorption coefficient does not exceed the figure shown in the approval mark by more than $0.5\ m^{-1}$. However, if the requirement is not met, the engine is subjeted to the test at steady speeds. The light absorption coefficient should not exceed the limit values given in Table A2/10.

1.7.3 Test procedures

1.7.3.1. Test at steady speeds

The test may be carried out either with the engine installed on an engine test bench or with the vehicle placed on a chassis dynamometer. The opacity of the exhaust gas is measured with the engine running under full load and at steady speed. The test is carried out for a sufficient number of measurement points ranging between the maximum and minimum rated speeds, usually about 6. The minimum rated spped means:

- either the highest of the following 3 speeds: 45% of maximum net power speed, 1000 rpm, minimum speed permitted by the idling control,
- or such lower speed as the manufacturer may request.

The exhaust gas opacity is measured by means of smokemeters which fall into one of the following two groups:

- partial-flow sampling opacimeters,
- full-flow sampling opacimeters.

The requirements that should be complied with by opacimeters are specified in great detail in [3].

The light absorption coefficient is given by the formula:

$$k = \frac{1}{L} \ln\left(1 - \frac{N}{100}\right)$$

where:

k - light absorption coefficient, in m^{-1},

L - effective length of the light path through the exhaust gas to be measured, in m,

N - reading of the linear 0 - 100 scale.

The nominal gas flow rate is not measured but calculated by means of the following formula:

- for two-stoke engines $G = \frac{V \cdot n}{60}$

- for four-stoke engines $G = \frac{V \cdot n}{120}$

where:

G - nominal gas flow rate, in dm^3/s,

V - cylinder capacity of the engine, in dm^3,

n - engine speed, in min^{-1}.

1.7.3.2. Test under free acceleration

Test may be conducted on a engine installed on an engine test bench or on a vehicle. Both types of smokemeters specified for test at steady speeds i.e. partial flow and full-flow opacimeters may be used for measurements. With the engine at (low) idle speed, the accelerator control is operated quickly, but not violently, so

as to obtain the maximum fuel delivery from the injection pump. This position is maintained until governor comes into action and the maximum cut-off speed is reached. As soon as this speed is reached the control is released. The operation described above is repeated not less than six times in order to clear the exhaust system and make necessary adjustments of the measuring device. The maximum opacity value in each succesive acceleration is read until stabilized values are obtained i.e. four of consecutive values are situated within a band of $0.25m^{-1}$ and do not form a decreasing sequence The arithmetical mean (x_M) of these four values is calculated.

The light absorption coefficient obtained at the time of type approval and shown on the approval mark is given by the smaller of the following two expressions (so called "corrected absorption coefficient"):

$$x_L = \frac{S_L}{S_M} \cdot x_M$$

$$x_L = x_m + 0.5$$

where:

x_M - arithmetical mean determined as specified above,

x_L - corrected value of the absorption coefficient,

S_M - value of absorption coefficient measured at steady speeds which is closest to the prescribed limit corresponding to the same nominal flow,

S_L - value of absorption coefficient prescribed in Regulation (Table A2/10) for the nominal flow corresponding to that which gives the value S_M.

1.8. Regulation 40/01

1.8.1. Scope of application

Regulation 40 is applicable to the emission of gaseous pollutants (CO, HC and NO_x) from motor vehicles of categories L3, L4 and L5 (i.e. two - and three - wheeled vehicles having a maximum design speed exceeding 50 km/h and/or engine cylinder capacity exceeding $50cm^3$) with an unladen mass of less than 400 kg and equipped with positive-ignition engines.

Regulation 40/01 specifies two types of tests:

-type I test: verification of the average emissions in a congested urban area,

-type II test: verification of CO concentration at idling speed.

1.8.2. ype I test

The limit values for type I test are expressed in terms of vehicle reference mass R (Table A2/11).

Table A2/11

Emission limits specified in ECE Regulation 40/01

	LIMITS IN TERMS OF REFERENCE MASS R FOR MOTORCYCLES WITH TWO-STROKE ENGINES	
	Type approval	Conformity of production
Carbon monoxide		
R ≤ 100 kg	CO = 12.8 g/km	CO = 16 g/km
100 kg < R ≤ 300 kg	$CO = 12.8 + 19.2 \frac{R - 100}{200}$	$CO = 16 + 24 \frac{R - 100}{200}$
R > 300 kg	CO = 32 g/km	CO = 40 g/km
Unburnt hydrocarbons		
R ≤ 100 kg	HC = 8 g/km	HC = 10.4 g/km
100 kg < R ≤ 300 kg	$HC = 8 + 4 \frac{R - 100}{200}$	$HC = 10.4 + 6.4 \frac{R - 100}{200}$
R > 300 kg	HC = 12 g/km	HC = 16.8 g/km
	LIMITS IN TERMS OF REFERENCE MASS R FOR MOTORCYCLES WITH FOUR-STROKE ENGINES	
	Type approval	Conformity of production
Carbon monoxide		
R ≤ 100 kg	CO = 17.5 g/km	CO = 21 g/km
100 kg < R ≤ 300 kg	$CO = 17.5 + 17.5 \frac{R - 100}{200}$	$CO = 21 + 21 \frac{R - 100}{200}$
R > 300 kg	CO = 35 g/km	CO = 42 g/km
Unburnt hydrocarbons		
R ≤ 100 kg	HC = 4.2 g/km	HC = 6 g/km
100 kg < R ≤ 300 kg	$HC = 4.2 + 1.8 \frac{R - 100}{200}$	$HC = 6 + 2.4 \frac{R - 100}{200}$
R > 300 kg	HC = 6 g/km	HC = 8.4 g/km

The reference mass means the mass of the vehicle in running order increased by a lump figure of 75 kg. The limits are specified only for CO and HC. They are different for vehicles equipped with two - - and four - stroke engines. NO_x emission is measured for information only. The test is performed with the vehicle placed on a chassis dynamometer equipped with means of load and inertia simulation. The measurement is conducted over the European urban driving cycle similar to that specified in Regulation 15/04 (Fig. A2/1). Four cycles are carried out without interruption. Before the test, the vehicle is conditioned at a temperature between 20°C and 30°C. After the engine has been started, two preparatory complete cycles are effected without collecting the exhaust gas. Unlike in Regu-lations 15/04 and 83, the emissions in Regulation 40/01 are measured after warming-up and not after a cold start.

A modified and simplified CVS system is used for gas sampling and volume measurement. The analytical equipment is similar to that specified in Regulation 15/04. So is the method of emission calculation.

1.8.3 Type II test

Co concentration in the exhaust gas at idle should not exceed 4.5% vol. The gas sample is taken directly from the exhaust pipe. In order to avoid any dilution with air, the sample probe should be inserted in the exhaust pipe at least 60 cm.
The aforementioned limit applies:

a) to the corrected CO concentration (CO_{corr}) calculated by means of the following formulas:

- for vehicles with two-stroke engines:

$$CO_{corr} = CO_m \cdot \frac{10}{CO_m + CO_{2m}}$$

- for vehicles with four-stroke engines:

$$CO_{corr} = CO_m \cdot \frac{15}{CO_m + CO_{2m}}$$

The abbreviations used in the above formulas are defined in point 1.4.3. above;

b) to the actually measured CO concentrations when the total of measured CO and CO_2 concentrations is at least 10 for vehicles with two-stroke engines and 15 for four-stroke engines.

The measurement method is similar to specified in regulation 15/04 (point 1.4.3. above).

1.9. Regulation 47

1.9.1. Scope of application

Regulation 47 is applicable to the emissions of gaseous pollutants (CO, HC, NO_x) from motor vehicles of categories L1 and L2 (i.e. two - and three - wheeled vehicles having a maximum design speed not exceeding 50 km/h and an engine cylinder capacity not exceeding 50 cm^3) with an unladen mass of less than 400 kg and equipped with positive-ignition engines.
Two types of tests are specified:

- -type I test: verification of the average emission of gaseous pollutants in a congested urban area,
- -type II test: verification of the emission of CO and HC at idling speed.

1.9.2. Type I test

The limit values for type I test are different for two- and three wheeled vehicles (Table A2/12). NO_x emissions is measured for information only and no limits are prescribed.

Table A2/12
Emission limits specified for mopeds in Regulation 40

Vehicle type	Type of control	Limits (g/km)	
		CO	HC
Two-wheeled vehicles	TA COP	8 9.6	5 6.5
Three-wheeled vehicles	TA COP	15 18	10 13

The emission measurement is conducted with the vehicle placed on a chassis dynamometer equipped with means of load and inertia simu-lation. The driving cycle differs very much from specified in Regu-lations 15/04 and 40/01 (Fig. A2/5). It lasts 112 s and comprises 7 phases. Four test cycles are performed without interruption. Directly before starting with the first cycle, four preparatory consecutive cycles are run in order to warm the vehicle.

The exhaust gas sampling method (modified and simplified CVS system), analytical method and emission calculation method are similar to specified in Regulation 40.

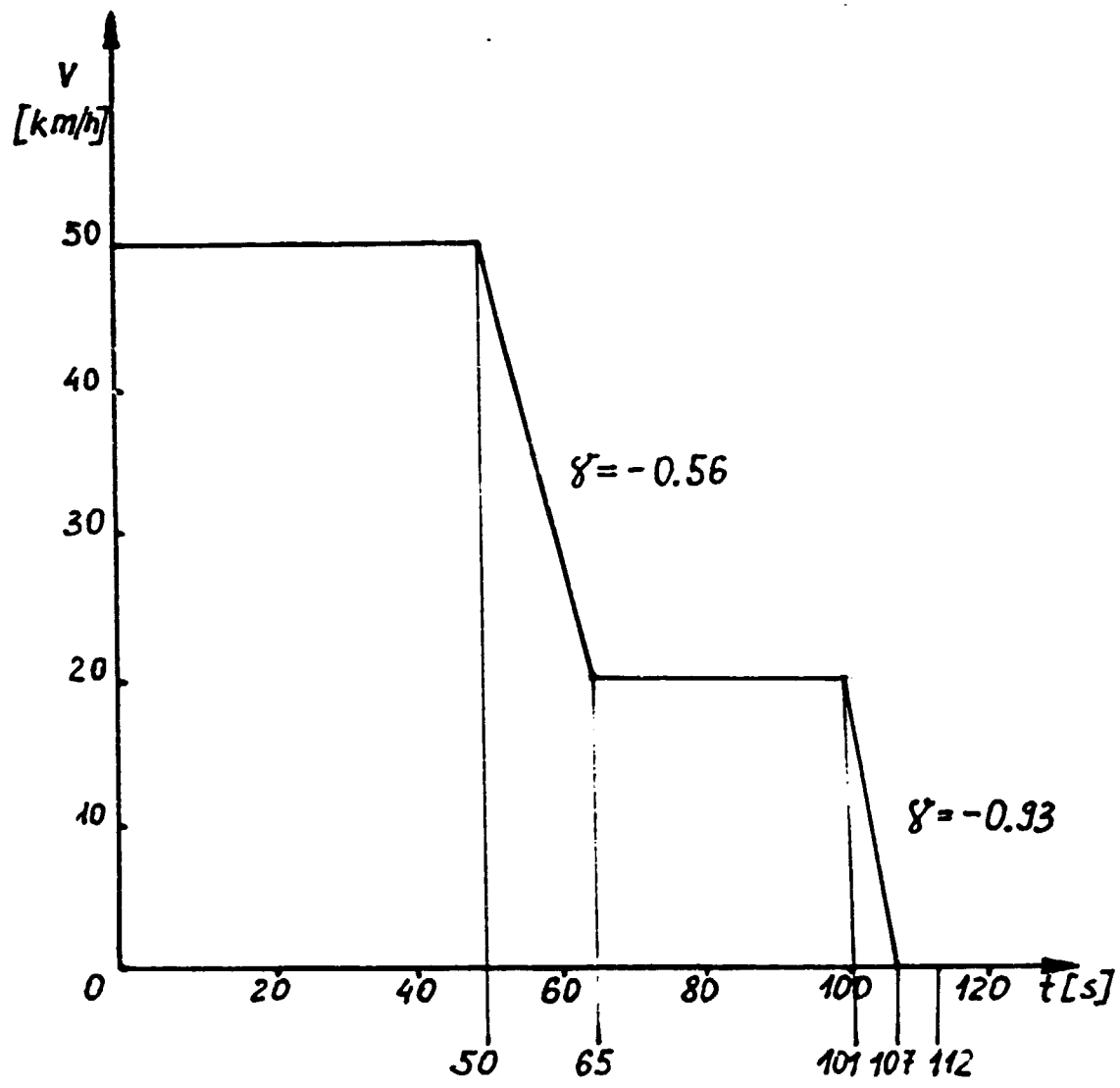


Fig. A2/5 Driving cycle specified in ECE Regulation 47

1.9.3. Type II test

The mass of carbon monoxide and hydrocarbons emitted with the engine running at idling speed during 1 minute should be determined. For this purpose, the exhaust gas is diluted with air. Direct measurements of CO, CO_2 and HC concentrations in the diluted gas as well as in the air are performed. Moreover, the diluted gas flow rate, expressed in cm^3/min, is measured. The mass of CO and HC emitted during 1 minute is calculated by means of the formulas of the following type:

$$E_i = \frac{V \cdot d_i \cdot [c_{ei} - c_{di} (1 - \frac{1}{DF})]}{10^6}$$

where:
E - emission, in g/min,
V - diluted gas flow rate, in m^3/min,
c_e - concentration in the diluted gas, in ppm,
c_d - concentration in the diluted air, in ppm,
DF - coefficient expressed by the formula:

$$DF = \frac{14.5}{CO_2 + 0.5CO + HC}$$

CO_2, CO, HC - concentrations of the respective gas in the diluted exhaust gas, in % vol.,
i - subscript meaning the component (CO, HC).

2. Directives of European Community

In the past, European Community (EC) generally adopted emission Regulations promulgated by ECE and issued them as directives which have the force of law within its member states. Lately, EC has started to play a more active role in formulating requirements. As a matter of fact, the requirements specified in the recent ECE Regulation 83/01 (Approval B and C) as well in Regulation 49/02 were first formulated by EC and issued as Directives and only afterwards adopted by ECE.

According to EC legislation [12], each member state should register or permit the entry into service of new vehicles if, and only if, they are accompanied by a valid certificate of conformity. This certificate is issued by the vehicle manufacturer, in his capacity of the holder of a vehicle type-approval. The type approval is granted by a member state when a type of vehicle complies with the relevant tehnical requirements of all separate Directives, emission Directives include.

ECE and EC try to harmonize their emission Regulations and Directives as far as it is possible. The list of EC Directives equivalent to ECE Regulations is given in Table below. It is to

note that Approval A specified in Regulation 83 and 83/01 for vehicles fuelled with leaded petrol is not included in the respective Directive. Only new vehicles fuelled with unleaded petrol can be type-approved in EC.

Table A2/13

EC Directives equivalen to ECE Regulations

ECE Regulation	EC Directive
15/00 (original)	70/220/EEC
15/04	83/351/EEC
83/00 (original)	88/76/EEC
83/01	91/441/EEC
49/00 (original)	88/71/EEC
49/02	91/542/EEC
24/00 (original)	72/306/EEC
24/03	---
40/00 (original)	---
40/01	---
47/00 (original)	---

3. Stockholm Group

Sweden was the first European country which introduced emission requirements differing from ECE/EC limits. In 1975 Sweden adopted US 1973 regulation for light-duty vehicles. In the eighties, some other European countries (Switzerland, Austria, Norway, Denmark, Finland) decided that ECE Regulations in force at that time were too lenient in particular for cars and consequently not suitable for them from the point of view of environment protection any longer. They revoked some of ECE Regulations and introduced more stringent requirements. In the above mentioned countries, emission regulations equivalent to US 1983 or US 1988 regulations for light-duty vehicles are in force. Some of the above countries (Austria) introduced as early as in 1991 limits equivalent to COP limits specified in Regulation 49/02 for vehicles with a maximum mass exceeding 3500 kg. Moreover, Switzerland and Austria have very stringent emission standards for mopeds and motorcycles (Table A2/14)

Table A2/14

Emission limits for mopeds and motorcycles in Switzerland

Vehicle category	Limits (g/km)			Test Procedure
	CO	HC	NO_x	
Mopeds	0.5	0.5	0.1	Regulation 47
Motorcycles				Regulation 40
- 2-stroke engines	8.0	3.0	0.1	
- 4-stroke engines	13.0	3.0	0.3	

Emission legislation in USA

1. General

This overview of emission legislation in USA covers only national, federal regulations. The federal emission regulations are published in the Code of Federal Regulations, title 40, part 86. [13]

The current (as of 1992) emission federal regulations are applicable to the following motor vehicle or internal combustion engines categories:

- light-duty vehicles,
- light-duty trucks,
- heavy-duty engines and vehicles (both Otto-cycle and diesel),
- motorcycles.

The definition of the above categories are given in the respective paragraphs below.

The survey is limited only to regulations for Otto-cycle vehicles fuelled with petrol and diesel vehicles fuelled with diesel fuel. Methanol fuelled vehicles are not included as for the time being they are not used in countries participating in the project.

2. Control procedures

2.1 Certification

Every new motor vehicle/engine manufactured or imported into the USA for introduction into service, which is subject to any of emission standards, should be covered by a certificate of conformity. This certificate is issued by Environment Protection Agency (EPA) in so called certification process if, after a review of the test reports, data submitted by the manufacturer and data derived from inspections of manufacturer's facility (including among others test facility and facility where construction or assembly processes are taken place), it is determined that vehicles/engines meet the requirements.

The certificate is issued for a period not exceeding one model year and in principle for:

- each engine family - evaporative emission family for light-duty vehicles and light-duty trucks,
- each engine family with respect to exhaust emission and one certificate per manufacturer with respect to evaporative

emissions in the case of petrol-fuelled heavy-duty vehicles,
- each engine family for diesel heavy duty engines,
- engine family - displacement - emission system combination for motorcycles.

Model year means the manufacturer's annual production period which includes 1 January of such calendar year, but, if the manufacturer has no annual production period, it means the calendar year.

The vehicle/engines for which the certification is required are divided into groupings of engines which are expected to have similar exhaust emission characteristics throughout their useful life, defined as "engine family". To be classified in the same "engine family", engine must be identical in all the following main respects:

- cylinder bore - center - to center dimensions,
- cylinder block configuration (air or liquid cooled; in line, vee etc.),
- location of the intake and exhaust valves,
- combustion cycle (2-stroke, 4-stroke; Otto, diesel cycle),
- method of air aspiration,
- catalytic converter or thermal reactor characteristics,
- type of inlet air cooling system (for charged diesel heavy--duty engines),
- number of carburettors and engine displacement class (for motorcycles).

In order to be classified in the same evaporative emission family, vehicles must be similar in the following main respects:

- type of vapour storage device (e.g. canister, air filter),
- basic canister design,
- fuel system.

The exhaust and evaporative emission standards apply to the emissions of vehicles/engines for their useful life. The term "useful life" means one of the following values whichever first occurs:

a) for light duty vehicles - a period of use of 5 years or 50000 miles,
b) for light duty trucks - a period of use 11 years or 120000 miles,
c) for heavy-duty Otto-cycle engines - a period of use of 8 years or 110000 miles,
d) for heavy-duty diesel engines - a period of use 8 years or 110000 - 290000 miles (depending on power output),
e) for motorcycles - a period of use 5 years of 12000 - - 30000 km (depending on engine displacement).

It is to note that the above useful-life period is specified for the purpose of certification. The useful-life period for purposes

of the emissions defect and performance warranty is different (point 2.3 below).

Since it is expected that emission control efficiency changes with distance accumulation, the emission level of a vehicle/engine which has accumulated the useful life distance (or its equivalent) are used as the basis for determining the compliance. For this purpose two types of tests are conducted in the certification process:

- tests for collecting emission data (on emission data vehicles),
- tests for collecting durability data in order to determine deterioration factors (on durability data vehicles).

In principle, two vehicles/engines within each engine family may be subjected to tests for collecting exhaust emission data (emission data vehicles/engines):

- the first one selected based on the specified criteria,
- the other one is the vehicle/engine expected to exhibit the highest emissions.

The selection criteria for the first vehicle/engine to be tested are as follows (in the listed order):

a) for light duty vehicles and light duty trucks:
   - heaviest equivalent test mass (weight),
   - highest road-load power,
   - largest engine displacement,
   - transmission with the highest final gear ratio,
   - highest axle ratio,
   - maximum fuel flow calibration;

b) for heavy-duty Otto cycle engines:
   - largest displacement,
   - highest fuel flow at the speed of maximum torque,
   - most advanced spark timing,
   - lowest EGR flow rate (or no EGR),
   - lowest flow supplied by air pump (or no air pump);

c) for diesel heavy-duty engines (one engine within each engine family - exhaust emission control system combination):
   - highest fuel feed per stroke at the speed of maximum torque,
   - highest fuel feed per stroke at the speed of maximum power;

d) motorcycles:
   - one test vehicle for a configuration (transmission, drive ratio, masses etc.) which is expected to have the greatest probability of exceeding the standards within each engine family - displacement - emission control system combination.

As regards evaporative emissions, the vehicle expected to exhibit the maximum emissions is selected from within each evaporative family to be certified for emission - data collection.

Tests for emission - data collection are usually conducted:

a) for light duty vehicles and light duty trucks - at about 4000 miles,
b) for heavy duty engines - after 125 h of operation.

The main selection criteria of durability - data vehicles are as follows:

a) light duty vehicles (selection by EPA):
   - engine displacement with the largest projected sales volume within each engine family - emission control system ;
b) light duty trucks, heavy duty vehicles:
   - the manufacturer selects the vehicles, engines, subsystems etc. for each engine family - emission control system combination.

The emission values to be compared with the standards are the official emission results for each emission-data vehicle/engine adjusted by applying the appropriate deterioration factors. For light duty vehicles the deterioration factors are determined on the basis of durability - data vehicle tests:

a) for exhaust emissions - deterioration factors are equal to emissions interpolated to 50000 miles divided by emissions interpolated to 4000 miles; the emission - data vehicle results are multiplied by the respective factors,
b) for evaporative emissions - deterioration factor is equal to emission level at 50000 miles minus emission level at 4000 miles; the factor is added to the emission - data vehicle results.

For light-duty trucks and heavy duty engines deterioration factors are supplied by the manufacturer on the basis of his own durability tests. If the total combined sales of the engine family are fewer than 10000 units, the manufacturer may request utilizing deterioration factors prescribed by EPA instead of conducting durability tests. As regards motorcycles each test vehicle is driven the total distance specified in Table below. Four tests should be performed between the minimum and total distances.

Table A3/1

Test distances for motorcycles

Displacement (cm^3)	Total test distance (km)	Minimum test distance (km)
50 - 169	6000	2500
170 - 279	9000	2500
280	15000	3500

Any motor vehicle/engine covered by a certificate of conformity should be marked with a legible label containing, among others, the following information:

- name or trade mark of manufacturer,
- engine family identification,
- engine tune-up specifications,
- statement "This vehicle (engine) conforms to U.S. EPA regulation applicable to 19.., Model Year ...."

Most of the actual conduct of the certification process is usually done by the manufacturer. The approval authority monitors the process and tries to maximize the confidence level in the data and information which are the basis for issuance of a certificate of conformity. EPA may require that test vehicles be submitted to EPA, without charge, for purposes of conducting emission tests. Such tests may be conducted at the manufacturer's facility.

2.2. Selective Enforcement Audits

The conformity of production of vehicles covered by a certificate of conformity may be checked by EPA. The verification process is called Selective Enforcement Auditing (SEA).

The testing is required by means of SEA test order addressed to the manufacturer in which, among others, the vehicle/engine configuration to be selected for SEA is specified. The maximum limit of test orders for a manufacturer during a given model year is determined by dividing the projected sales by 300000. If the projected sales are less than 150000, only one order may be issued. In principle, tests are conducted by the manufacturer under EPA supervision. However, EPA is empowered to conduct tests on its own.

SEA tests are carried out in accordance with the procedure used in the process of certification for emission - data vehicles i.e. no durability tests are conducted. The final SEA test results are determined by multiplying the values obtained on test vehicles by the appropriate deterioration factors derived from the certification process.

The vehicles comprising the test sample are tested until a pass decision or a fail decision is reached. The pass or fail decisions are taken on the basis of the cumulative number of failed vehicles. The criteria are determined at quality level 40% and depends on the annual sales. An example of sampling plan is given in Table A3/2.

A failed vehicle is defined as one whose final test results exceed the emission standard for at least one pollutant. A pass decision is reached when the cumulative number of failed vehicles for each pollutant is less or equal to "pass number" (Table A3/2). A fail decision is reached when the cumulative number of failed vehicles for one pollutant is greater than or equal to "fail number".

Table A3/2

Sampling plan for SEA of light duty vehicles (annual sales of 50 - 99000)

Stage	Pass No.	Fail No.	Stage	Pass No.	Fail No.
1	(1)	(2)	16	6	11
2	(1)	(2)	17	7	12
3	(1)	(2)	18	7	12
4	0	(2)	19	8	13
5	0	(2)	20	8	13
6	1	6	21	9	14
7	1	7	22	10	14
8	2	7	23	10	15
9	2	8	24	11	15
10	3	8	25	11	16
11	3	9	26	12	16
12	4	9	27	12	17
13	5	10	28	13	17
14	5	10	29	14	17
15	6	11	30	16	17

(1) Test sample passing not permitted at this stage
(2) Test sample failure not permitted at this stage

The certificate of conformity may be suspended for a vehicle/engine configuration which does not pass SEA. Once it has been suspended, the manufacturer must take, among others, the following steps for the failed configuration:

- to remedy the non-conformity,
- to demonstrate that the configuration conforms to the standard by retesting vehicles.

The certificate of conformity for a given configuration may be revoked if the remedy for the nonconformity requires a design changes to the engine or emission control system, or if the manufacturer has not remedied the nonconformity.

2.3 Recall process

The US legislation requires the vehicle manufacturers to warrant the emission - related components/systems and the emission performance for the useful life. The useful life for the purpose of warranty usually differs from that for the purpose of certification. It is equal to (whichever first occurs):

a) for light duty vehicles - a period 5 years or 50000 miles (as for certification),
b) for light duty trucks, gasoline fuelled heavy-duty engines - a period of 5 years or 50000 miles,
c) for other heavy-duty diesel engines - a period of 5 years or 100000 miles.

If any defect occurs to emission-affecting components/systems during the useful life, it should be fixed by the manufacturer/ /dealer. Defects of these components/systems have to be reported for a period of 5 years after the end of a model year. A report has to be filled if the number of defects is 25 or more. If the number of defects in a given engine family - emission control configuration is high, the manufacturer may be requested to repair all vehicles of this configuration in service (recall process). The current requirements with regard to emission level for the purpose of performance warranty for in-use vehicles are the same as those for certification. Requirements differing from those for certification are, however, announced for 1994 - 1998 model years.

3. Light duty vehicles and light duty trucks

3.1. Definitions

Light duty vehicles means a passenger car or passenger car derivative capable of seating 12 passengers or less.

Light duty truck means any motor vehicle with a maximum design mass (specified by the manufacturer) of 8500 pounds (3860 kg) or less, with a curb mass of 6000 pounds (2720 kg) or less and having a basic vehicle frontal area of 45 square feet (4.16 m^2) or less, which is:

- designed for purposes of transportation of goods or is a derivation of such a vehicle, or
- designed for transportation of persons and has a capacity of more than 12 persons, or off-road type.

3.2. Emission standards

Emission standards for light-duty vehicles and light-duty trucks are shown in Table A3/3. It is to note that exhaust emissions have been measured by FTP 75 method (point 3.3.2. below) since 1975. As regards evaporative emissions, SHED method was introduced in 1978. Before this year, tests were conducted using the canister method. No crankcase emissions are allowed.

More stringent standards have been already announced. Details are given in Table A3/4.

Table A3/3

Emission standards for light-duty vehicles and light-duty trucks

Date of entry into force (Model year)	CO at idle [% vol.]	Exhaust emissions [g/mile]				Evaporative emissions [g/test]	Remarks
		CO	HC	NO_x	PM		
Light - duty vehicles							
1975		15	1.5	3.1		2.0	canister method
1977		15	1.5	2.0		2.0	
1978		15	1.5	2.0		6.0	SHED method
1980		7	0.4	2.0		6.0	
1981		3.4	0.41	1.0		2.0	
1982		3.4	0.41	1.0	0.6	2.0	
1987		3.4	0.41	1.0	0.2	2.0	
Light - duty trucks							
1975		20	2.0	3.1			
1979		18	1.7	2.3		2.0	
1982		18	1.7	2.3	0.6	2.0	
1985	0.5	10	0.8	2.3	0.6	2.0	
1987	0.5	10	0.8	2.3	0.26	2.0	LVW ≤ 3750 lbs
					0.50		LVW > 3750 lbs
1988	0.5	10	0.8	1.2	0.26		LVW ≤ 3750 lbs GVW ≤ 6000 lbs
	0.5	10	0.8	1.7	0.45		LVW > 3750 lbs GVW ≤ 6000 lbs
	0.5	10	0.8	2.3	0.45		GVW > 6000 lbs
1990	0.5	10	0.8	1.2	0.26		LVW ≤ 3750 lbs
	0.5	10	0.8	1.7	0.45		LVW > 3750 lbs
1991	0.5	10	0.8	1.2	0.26		LVW ≤ 3750 lbs
	0.5	10	0.8	1.7	0.13		LVW > 3750 lbs

LVW - loaded vehicle weight (curb weight + 300 lbs)
GVW - gross vehicle weight

Table A3/4

Announced after 1993 standards for light - duty vehicles and light-duty trucks in USA

Vehicle category	Loaded vehicle weight (6) (lbs)	Durability (miles)	Limits [g/mile]					Required percentage in the model year				
			CO	THC(4)	NMHC(5)	NO_x	PM(2)	1993	1994	1995	1996	after 1966
Light - duty vehicles												
Conventional vehicles		50000	3.4	0.41	-	1.0	0.2	100	60	20	0	0
Vehicles with improved emission control		50000	3.4	-	0.25	0.4 1.0(1)	0.08	0	40	80	100	100
		100000	4.2	-	0.31	0.6 1.25(1)	0.10					
Light - duty trucks												
Conventional vehicles	0 - 3750	120000	10.0	0.80	-	1.2	0.26	100	60	20	0	0
	3751 - 5750		10.0	0.80	-	1.7	0.13		100(3)	60(3)	20(3)	
Vehicles with improved emission control	0 - 3750	50000	3.4	-	0.25	0.4 1.0(1)	0.08					
		120000	4.2	0.80	0.31	0.6 1.25(1)	0.10	0	40 0(3)	80 40(3)	100 80(3)	100
	3751 - 5750	50000	4.4	-	0.32	0.7 - (1)	0.08					
		120000	5.5	0.80	0.40	0.97	0.10					

(1) only for diesel vehicles,
(2) PM limits for conventional vehicles apply only to diesel vehicles; PM limits for vehicles with improved emission control apply to both gasoline-fuelled and diesel vehicles,
(3) for PM,
(4) THC - total hydrocarbons,
(5) NMTC - non-methane hydrocarbons,
(6) LVW - loaded vehicle weight (curb weight + 300 lbs)

3.3. Test procedures

3.3.1. Overview

Light duty vehicles and light duty trucks are currently tested for the following emissions:

a) gaseous exhaust emissions (CO, CO_2, HC, NO_x) for both gasoline fuelled and diesel vehicles,
b) exhaust particulate emissions for diesel vehicles (see note 2) to Table A3/4,
c) evaporative HC emissions for gasoline-fuelled vehicles.

3.3.2. Test procedure for the determination of exhaust emission

The currently used procedure is called Federal Test Procedure 75 (FTP 75). The test is designed to determine exhaust emissions, both gaseous and particulate, while simulating an average trip in an urban area of 17.1 km (7.5 miles). The test consists of vehicle operation on a chassis dynamometer through a specified driving cycle. For gasoline - fuelled vehicles, the exhaust gas is diluted with air. A proportional part of the diluted exhaust is continuously collected using a constant volume sampler (CVS) system. The colle-cted gas is subsequently analysed for CO, CO_2, HC, and NO_x. For diesel vehicles, the exhaust gas is also diluted. However, the diluted gas is continuously analysed for total hydrocarbons. The other gaseous components (CO, CO_2, NO_x) are collected for subse-quent analysis as in the case of gasoline - fuelled vehicles. Simultaneously with the gaseous emission collection, particulates from a proportional part of the diluted exhaust gas are continuou-sly collected on filters. The testing requires a dilution tunnel on top of CVS system.

The chassis dynamometer, like that specified in ECE Regulations 15/04 and 83/01, must be capable of simulating the road load and vehicle inertia. The reference mass classes and consequently the equivalent inertias differ, however, from prescribed in the aforementioned Regulations.

The urban driving cycle is depicted in Fig. A3/1.

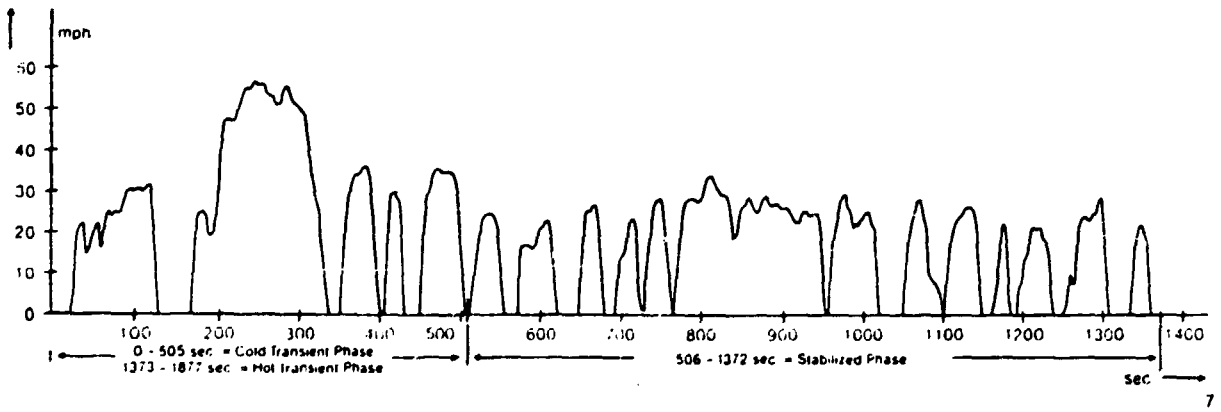


Fig. A3/1. FTP driving cycle

It is divided into two phases:

- phase I (called "transient"): 0 - 505 s,
- phase II (called "stabilized"): 505 - 1370 s.

Before the test, the vehicle is conditioned for at least 12 hours. After a cold start, the phase I ("cold transient") of the cycle is performed. It terminates at the end of the deceleration which is scheduled to occur at 505 seconds of the cycle. The diluted exhaust from this phase is collected in the bag I. Afterwards, without interruption, the phase II, representing the "stabilized" period after the cold start, is conducted. It includes the remainder of the driving cycle including engine shutdown. After a 10 minute hot soak, the "hot start" test begins. The phase I, representing this time the "hot transient" period, is repeated to form a phase III. The second period of the hot start test is assumed to be identical to the phase II of the cold start test and it is not performed.

The diluted exhaust gas is collected, for gaseous pollutant analysis, in three bags, for each phase of the test, i.e:

- bag 1 - phase I of the cold start test,
- bag 2 - phase II of the cold start test,
- bag 3 - phase III of the cold start test (after a 10 minute hot soak).

Parallely, diluting air is also collected. The component concentrations in diluting air are used for correction of concentration in the diluted exhaust gas.

As mentioned above, CVS system is used for exhaust gas sampling. In this system, two main conditions must be satisfied in order to measure the true exhaust mass emissions: the total volume of the mixture of diluted exhaust gas must be measured and a continuously proportional sample of the volume must be collected for analysis. Two versions of the CVS system, meeting the above requirements, are prescribed:

- positive displacement pump - constant volume sampler (PDP-CVS), in which the flow of diluted gas through the pump at constant pressure and temperature is measured by counting the number of pump revolutions (Fig. A3/2),
- critical flow venturi - constant volume sampler (CFV-CVS), in which the diluted gas is sucked by means of a blower through a critical-flow venturi where it is maintained at sonic velocity and continuously measured (Fig. A3/3).

The analytical equipment for measurement of pollutant concentrations in the collecting bags (and direct measurements of HC in the exhaust gas in the case of diesel vehicles) consists of:

- non-dispersive infra-red (NDIR) analysers for CO and CO_2,
- flame ionization (FID) analyser for hydrocarbons (heated to 190 ± 10°C for diesel engines),
- chemiluminescent (CL) analyser for NO_x, with an NO_2 - NO converter.

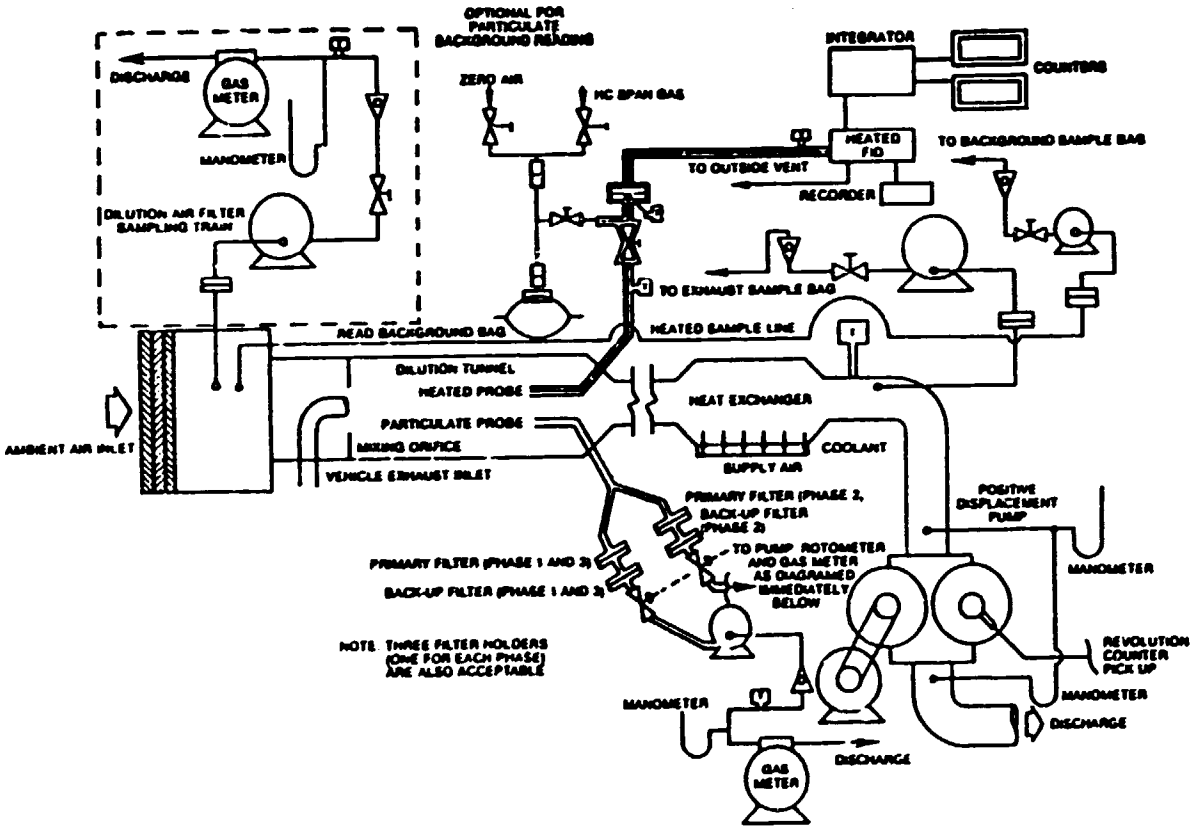


Fig. A3/2. Positive displacement pump - constant volume sampler (PDP-CVS) for diesel vehicles.

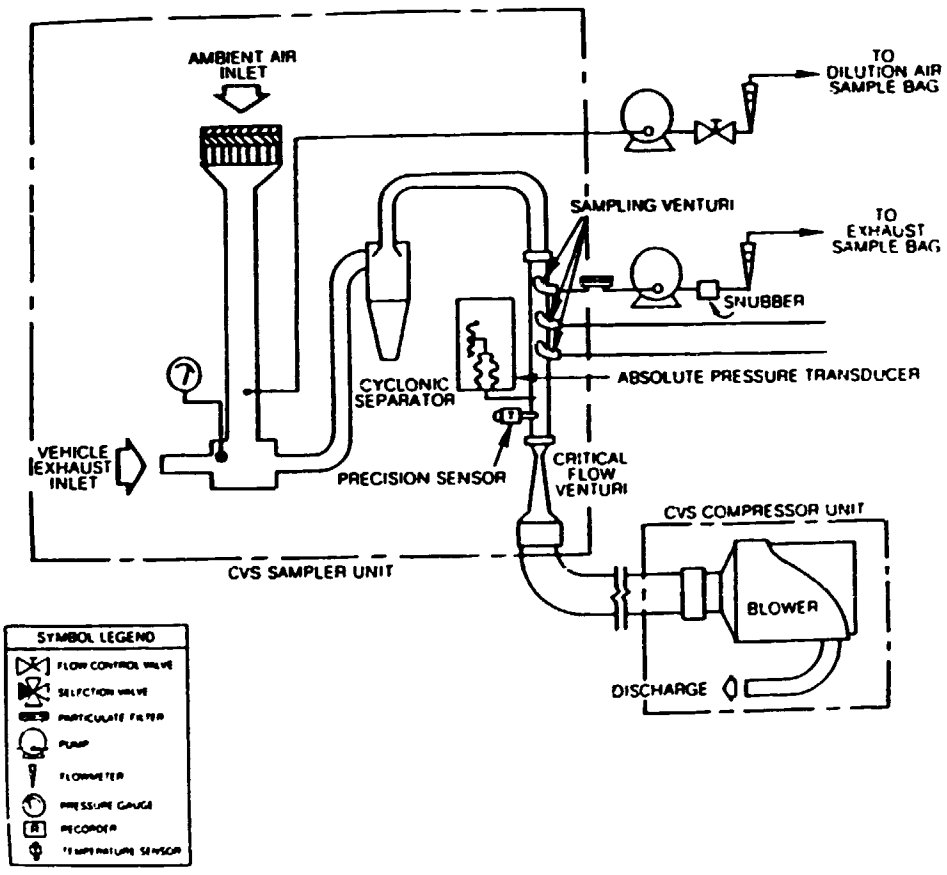


Fig. A3/3. Critical flow venturi - constant volume sampler (CFV-CVS) for gasoline vehicles.

An example of exhaust gas analytical system is shown in Fig. A3/4.

The "particulates" definition is given in Annex 2, point 1.6.3. The particulate sampling system consists of a dilution tunnel, sample probe, filters, pump, flowmeters and flow controls (Fig. A3/2). During each phase of the driving cycle, diluted exhaust particulates are continuously sampled by two filters: primary and back-up one, situated one behind the other. The sampling probe is positioned in the dilution tunnel so as to ensure that a representative particulate sample is taken. A differential weighing is used to determine the mass of the components collected during each test phase. The final tests results are calculated by use of the following formula:

$$M_i = 0.43 \frac{m_{icT} + m_{is}}{S_{CT} + S_s} + 0.57 \frac{m_{iHT} + m_{is}}{S_{HT} + S_s}$$

where:

M_i - mass of component i emitted during the test, in g/km,
m_{icT} - mass of component i emitted during phase I of test (cold transient - CT), in g,
m_{is} - mass of component i emitted during phase II of test (stabilized - S), in g,
m_{iHT} - mass of component i emitted during phase III of test (hot transient - HT), in g,
S_{CT} - measured distance driven during phase I, in km,
S_S - measured distance driven during phase II, in km,
S_{HT} - measured distance driven during phase III, in km,
i - subscript meaning a component (CO, HC, NO_x, PM).

The mass of gaseous pollutants emitted in each test phase is calculated by use of the following formula:

$$m_{ij} = V_{mixj} \cdot S_i \cdot c_{ij} \cdot 10^{-6} \cdot k_H$$

where:

m_{ij} - mass of component i, emitted in phase j, in g,
V_{mixj} - volume of diluted gas in phase j corrected to standard conditions, in dm^3,
S_i - density of component i under standard conditions, in g/dm^3,
c_{ij} - concentration of component i in phase j, in ppm,
k_H - humidity correction factor (only for NO_x).

The test procedure used up to 1975 differed from that used at present. The driving cycle was performed only once i.e. the transient phase was not repeated after hot soak. The total diluted exhaust gas was collected in one bag. This procedure is called FTP 72.

3.3.3. Test procedure for the determination of evaporative emissions.

Evaporative emissions may be divided in three following parts:

a) tank diurnal breathing losses which mainly occur after the vehicle engine has been switched off and are due to emissions of fuel vapours from the tank as a result of temperature changes,

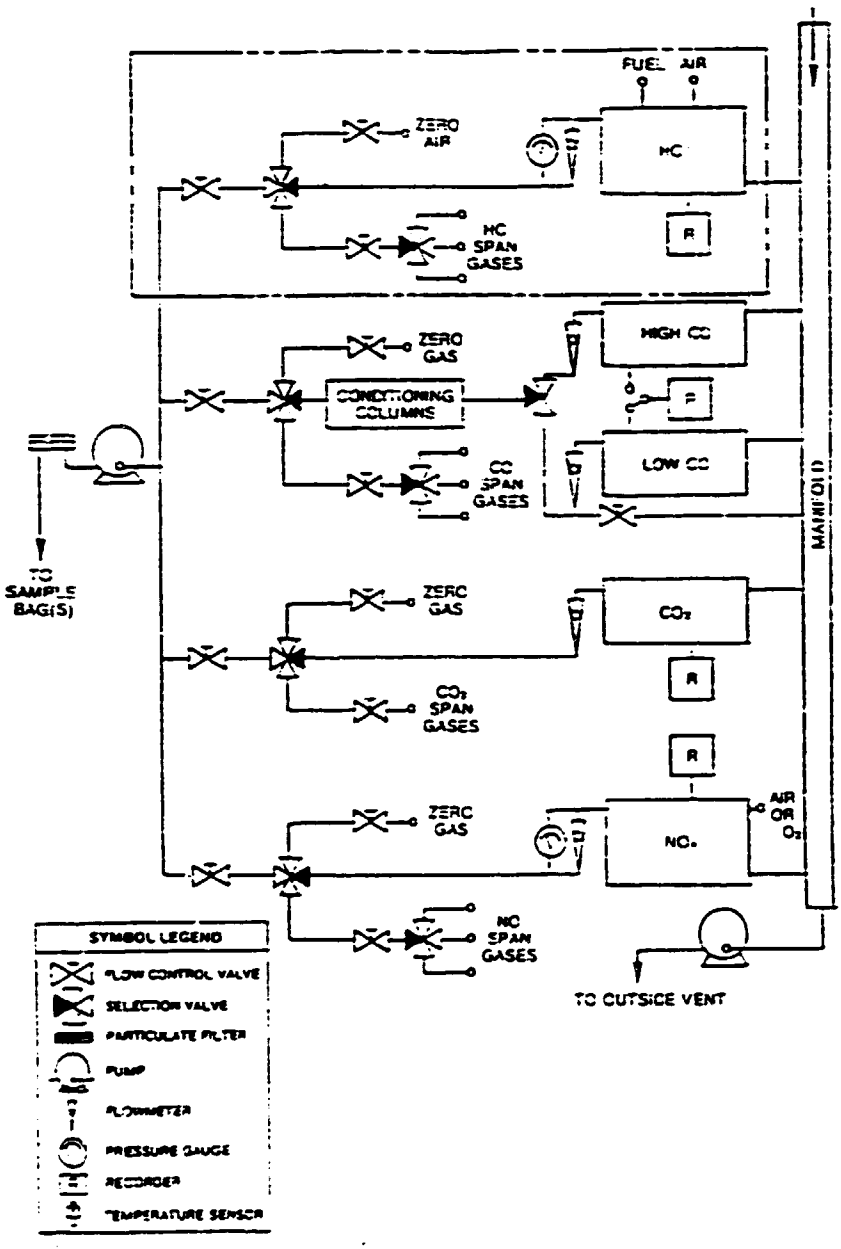


Fig. A3/4. Exhaust gas analytical system

b) hot soak losses, which occur when the warmed-up vehicle is stationary, due to fuel distillation in the fuel system resulting in turn from engine heat transfer to this system,
c) running losses, which occur when the vehicle is being driven.

The measurement of tank diurnal breathing losses and hot soak losses is conducted using so called SHED (Sealed Housing for Evaporative Determination) method. In this method, all evaporative emissions are collected in a sealed enclosure in which the test vehicle is placed. The hydrocarbon concentration in the enclosure is measured by means of FID analyser.

The main phases of the evaporative tests are as follows:
- vehicle preconditioning in driving cycle (1 cycle is performed),
- parking for 11 - 35 hours at a temperature between 20 - 30°C,
- fuel tank filling to 40% ± 2% of capacity,
- diurnal losses measurement in the SHED enclosure during 1 hour at a temperature 15 - 29°C,
- dynamometer exhaust test,
- hot soak losses measurement in the SHED enclosure during 1 hour at a temperature between 20 - 30°C.

The running losses are measured only if it can not be excluded that they may occur during driving operation. The running losses are measured using HC collecting traps. In the trap method, the emission is measured by means of canisters filled with activated carbon. The canisters are installed to the openings that vent fuel vapour to the atmosphere. The mass of collected fuel (vapour) is measured by weighing.

3.4. Heavy duty engines and vehicles

3.4.1. Definitions

Heavy-duty vehicle means any motor vehicle having a maximum design mass exceeding 8500 pounds (3860 kg) or a curb mass exceeding 6000 pounds (2720 kg) or a basic frontal area exceeding 45 square feet (4.16 m^2). Heavy-duty engine means, in turn, any engine which the engine manufacturer expects to be used for motive power in a heavy-duty vehicle.

3.4.2. Limits

Heavy-duty vehicles/engines are tested for the following emissions:
a) exhaust gaseous emissions (CO, CO_2, HC, NO_x) for both gasoline-fuelled and diesel engines,
b) exhaust particulate emissions,
c) evaporative emissions (only for gasoline-fuelled vehicles),
d) smoke.

The limits for tests listed under a), b) and c) are given in Table A3/5. The limits for smoke are given in Table A3/6.

Table A3/5

Exhaust and evaporative emission standards for heavy-duty vehicles/engines

Year	Type of engine	CO at idle [%vol.]	Exhaust emissions [g/kWh]					Evaporative emissions [g/test]	Remarks
			CO	HC	NO_x	HC+NO_x	PM		
1979	all	-	25	1.5	-	10	-		two options
			25	-	-	5	-		
1984	all	0.5	25	1.5	10.7	10	-		
	diesel		15.5	0.5		9			option
1985	gasoline	-	37.1	1.9	10.6	-		3.0	two options
			40.0	2.5	10.7	-		3.0	
	diesel		15.5	1.3	10.7				
1987	gasoline	0.5	14.4	1.1	10.6	-		3.0	GVW < 14400
			37.1	1.9	10.6	-		4.0	GVW ≥ 14400
	diesel		15.5	1.3	10.7				
1988	diesel		15.5	1.3	10.7	-	0.6		} gasoline
1990	diesel		15.5	1.3	6.0				} fuelled
1991	diesel		15.5	1.3	5.0		0.25		engines
1994	diesel		15.5	1.3	5.0		0.10		} as 1987

Table A3/6

Smoke standards for diesel engines

Type of mode	Limit [%]
acceleration	20
lugging	15
peaks in either modes	50

3.4.3. Test procedures for exhaust emissions from heavy-duty engines

Up to 1984 a steady-speed 13-mode tests was used for measurement of exhaust gaseous emissions from heavy-duty engines. The test was conducted on an engine test bench. It was to some extent similar to that specified in ECE Regulation 49, the main difference being in the cycle weighting factors (Table A3/7).

Table A3/7

US 13-mode test for heavy-duty engines

Mode	Speed	Load (%)	Weighting Factor
1	Idle	0	0.06667
2	Intermediate	2	0.08
3	Intermediate	25	0.08
4	Intermediate	50	0.08
5	Intermediate	75	0.08
6	Intermediate	100	0.08
7	Idle	0	0.06667
8	Rated	100	0.08
9	Rated	75	0.08
10	Rated	50	0.08
11	Rated	25	0.08
12	Rated	2	0.08
13	Idle	0	0.06667

In 1985, the new transient test was introduced replacing the steady-speed one. The test is conducted on an automated engine test bench. The cycle contains elements of urban driving in New York and elements of both freeway - and urban driving in Los Angeles (Fig. 3/5). The main reasons for the introduction of transient test were to make the procedure more representative of real driving conditions and improve repeatability and reproducibility. Before the test, the engine is cold conditioned until the oil sump reaches a temperature between 20°C and 30°C. The test consists of a "cold start" part and following it a "hot start" part. In both the parts, one full cycle (Fig. A3/5) is performed, engine torque and speed being continuously recorded. Data points are recorded at least once every second. On the basis of these data points, the engine power is integrated separately for the "cold start" and "hot start" parts.

The exhaust gas is diluted with air and a continuous proportional sample is collected for analysis. It may be analysed either in bags or continuously (for gaseous components). The CVS sampling concept is similar to that used for light-duty vehicles. So is analytical equipment.

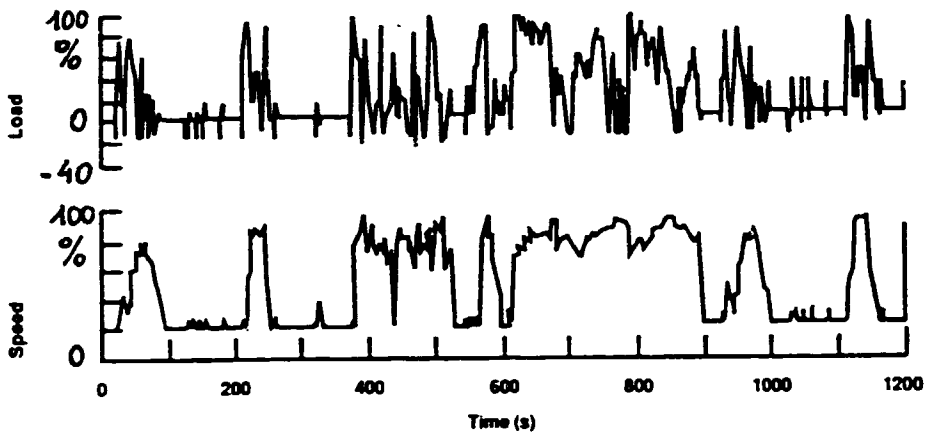


Fig. A3/5 US transient test for heavy-duty engines

The final test results are calculated using the following formula:

$$M_i = \frac{(\frac{1}{7})\, m_{ic} + (\frac{6}{7})\, m_{iH}}{(\frac{1}{7})\, P_c + (\frac{6}{7})\, P_H}$$

where:

M_i - specific weighted mass emission of component i, in g/HPh,
m_{ic} - mass emission of component i during the "cold start" part, in g,
m_{iH} - mass emission of component i during the "hot start" part, in g,
P_c - total brake horsepower, integrated over time, for the "cold start" part, in g,
P_H - total brake horsepower, integrated over time, for the "hot start" part, in g,
i - subscript meaning a component (CO, CO_2, HC, NO_x, PM).

The mass emission m_i are calculated in a way described in point 3.3.2. above. CO emission at idle (for gasoline engines) is measured using CVS method.

3.4.4. Test procedure for evaporative emissions from heavy--duty vehicles

The test is carried out on a vehicle. The procedure is similar to that used for light-duty vehicles and light-duty trucks.

3.4.5. Smoke test procedure

Measurements are carried out with the engine placed on an engine test bench over smoke test cycle shown in Fig. A3/6.

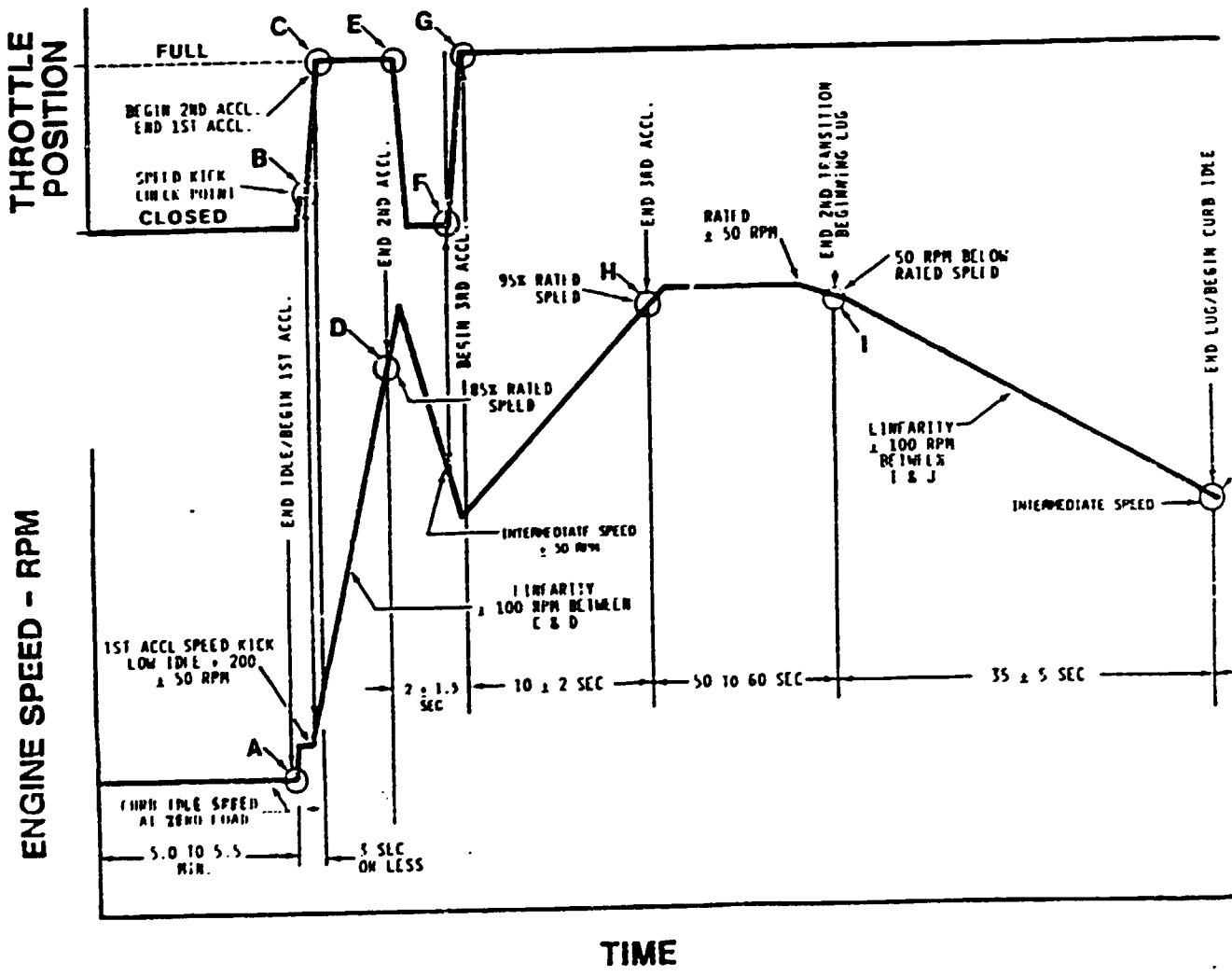


Fig. A3/6 US smoke test cycle

The cycle is repeated three times. It is composed of the following modes:

a) idle mode which begins following the lugging mode at point J and ends at point A marking the beginning of acceleration,
b) acceleration modes which consist of the following sequences of 3 engine accelerations and 1 deceleration:
   - first acceleration represented by points A, B and C,
   - second acceleration beginning at point C and ending at D,
   - deceleration represented by points E, F, G,
   - third acceleration beginning at point G and ending at H,
c) rated speed mode represented by points H and J,
d) lugging mode beginning at point J and ending at J.

The smoke is measured either by means of full flow (in-line) or free-flow (end of line) opacimeters. During the test, the following measurement data should be, among other, recorded: engine speed, throttle position and smoke.

Test values to be compared with the limits (Table A3/6) are determined using the following procedure (Fig. A3/6).

Acceleration smoke value:

The acceleration mode is divided into 2 segments:

- the first one between points A and D,
- the other one between points G and H.

Both of the segments are, in turn, divided into 0.5 s intervals. Average smoke reading is determined during each interval.

15 highest readings during both acceleration segments for each cycle are selected. The acceleration value is equal to the average of 45 readings from the three cycles.

Lug smoke value

The lugging mode is divided into 0.5 s intervals and the average smoke reading during each interval is determined. 5 highest readings during the lugging mode for each cycle are selected. The lug smoke value is the average of 15 readings from the three cycles.

Peak smoke value

3 highest readings are selected for each cycle out of 20 readings determined during the acceleration and lugging modes. The peak value is the average of 9 readings from the three cycles.

3.5. Motorcycles

Motorcycle means any motor vehicle having two wheels or three wheels and a curb mass less than or equal to 680 kg. The following motorcycles are excluded from the requirements of the standards:

- motorcycle with engine displacement less than 50 cm^3,
- motorcycle which, with a 80 kg driver, are not able to start from a dead stop using only the engine or to exceed a speed of 40 km/h.

The prescribed exhaust emission limits are given in Table A3/8. No crankcase emissions should be discharged into the atmosphere.

Table A3/8

Exhaust emission standards for motorcycles

Model year	Limits [g/km]	
	CO	HC
1980 onwards	12	5

The exhaust emissions are tested using the modified CVS sampling (CVS-2 with two bags) and analytical systems similar to those specified for light-duty vehicles. The driving cycle for motorcycles with engine displacements equal to or exceeding 170 cm^3 is identical to urban driving cycle for light-duty vehicles. For motorcycles with lower displacements a simplified cycle (lower accelerations, speeds) is prescribed.

Emission legislation in Japan

1. General

The Japanese regulations with regard to pollutant emission control from new motor vehicles are specified in the following main documents issued pursuant to the provisions of Road Vehicles Act:

a) Safety Regulations for Road Vehicles (Ordinance of Ministry of Transport, No. 67 of July 28, 1951 with subsequent amendments),

b) Type Approval Testing Standards (Circular of Jisha No. 626 and Koshin No. 531 of September 30, 1972 with subsequent amendments),

c) Mean Value Standards for Motor Vehicle Exhaust Emissions (Circular of Chigi No. 129 of April 4, 1985 with subsequent amendments),

d) Type Approval Test Procedures (Circular of Koshin No. 453 of August 24, 1971 with subsequent amendments) in which, in turn, the following emission test procedures have been prescribed:
   - TRIAS 23-1990: Idling, 10-mode, 11-mode exhaust emission test procedure for gasoline-fuelled motor vehicles,
   - TRIAS 23-3-1990: Fuel evaporative emission test procedure for gasoline-fuelled motor vehicles,
   - TRIAS 24-1972: Diesel smoke test procedure,
   - TRIAS 24-2-1974: 6-mode exhaust emission test procedure for diesel-powered motor vehicles,
   - TRIAS 24-3-1990: 10-mode exhaust emission test procedure for diesel-powered motor vehicles,
   - TRIAS 30-1983: Heat-damage test procedure for motor vehicles.

The full texts of the above documents are published in "Automobile Type Approval Handbook for Japanese Certification" [14].

2. Outline of the control system

The Japanese laws require that all motor vehicles should undergo an inspection by the government in order to check that they conform to requirements with regard to safety and environmental protection specified in Safety Regulations for Road Vehicles. Vehicles which have passed the inspection get an inspection certificate. Consequently, all new motor vehicles should undergo so called "initial inspection" conducted at Local Land Transport Offices (LLTO) under the Ministry of Transport.

In order to make the initial inspection procedure more efficient and quicker, the type approval system has been established. In this system, the testing of vehicles belonging to the same type is conducted collectively. Two kinds of the type approval are prescribed:

- type designation system,
- type notification system.

The type designation system is used for vehicles which are manufactured uniformly. The manufacturer/dealer who has received the type designation must bear full responsibility for the compliance with the provisions of Safety Regulations for Motor Vehicles, the quality and uniformity of production. The compliance verification process run by the manufacturer is called "completion inspection". He must possess testing facilities, personnel etc. required to conduct the completion inspection.

In order to receive the type designation, the manufacturer has to submit specified application documents to Regional Transport Bureau (RTB) of the Ministry of Transport and submit motor vehicles representative of type for which the type approval is requested to Automobile Type Approval Test Division of the Traffic Safety and Nuisance Research Institute (TSNRI) for testing. The RTB grants the type approval if the submitted vehicles comply with all requirements and the manufacturer is capable of producing vehicles conforming to the type to be approved.

The manufacturer has to conduct completion inspection of vehicles covered by the type designation and, if the inspection has been passed, has the right to issue a completion inspection certificate. The buyer of such a vehicle produces the completion inspection certificate at the LLTO and can get an initial inspection certificate without presenting the vehicle for initial inspection.

The type notification system is used when the manufacturer/ /dealer does not meet the aforementioned conditions. Like for the type designation, specified application documents should be submitted to RTB and vehicles for testing to TSNRI. However, in this case only the conformity of the tested vehicles with the requirements are required for receiving the type approval. When the type notification has been granted, RTB informs all LLTO about it and send documents describing the notified vehicle type design. The buyer of the vehicle covered by the type notification should submit it for initial inspection to LLTO. This inspection is mainly limited to the confirmation of the vehicle identity with the notified type.

The vehicle which have obtained the type designation are subject to the production control. 1% of production should be tested. The mean exhaust emission values of tests conducted during each quarter of the year should not exceed the mean exhaust emission standards (Table A4/1 and A4/2). This provision is not applicable if annual sales are below 2000 units.

Apart from the comprehensive type designation and type notification relative to the vehicle as a whole, the type approval of device, including exhaust emission control device, may be conducted. Vehicles which have obtained such a type approval are regarded as complying with the requirements relative to that particular device.

3. Definitions

a) Mini-sized motor vehicle means
- motor vehicles other than two-wheeled motor vehicles with or without sidecar having the following dimensions not exceeding: length - 3.20 m, width - 1.40 m, height - 2.00 m except small-sized special motor vehicles (in the case of motor vehicles with internal combustion engines, it is limited to those with an engine displacement of 0.550 liter or less),
- two-wheeled motor vehicles with or without sidecar having the dimensions not exceeding: length - 2.50 m, width - 1.30 m, height - 2.00 m except small-sized special motor vehicles (in the case of motor vehicles with internal combustion engines, it is limited to those with an engine displacement of 0.250 liter or less),

b) Small-sized motor vehicle means
- motor vehicles with four or more wheels having the dimensions not exceeding: length - 4.70 m, width - 1.70 m, height - 2.00 m except mini-sized motor vehicles, large-sized special motor vehicles and small-sized special motor vehicles (in the case of motor vehicles with internal combustion engines (except diesel engines), it is limited to those with an engine displacement of 2.00 liter or less),
- two-wheeled motor vehicles with or without sidecar, or three-wheeled motor vehicles other than mini-sized motor vehicles, large-sized special motor vehicles and small-sized special motor vehicles,

c) Ordinary-sized motor vehicle means
motor vehicles other than small-sized motor vehicles, mini-sized motor vehicles, large-sized special motor vehicles and small-sized special motor vehicles,

d) Small-sized special motor vehicle means
crawler vehicle, semi-crawler vehicle, road roller, tire roller, road stabilizer, tire dozer, motor grader, motor scraper, shovel loader, dumper, motor sweeper, fork lift truck, wheel crane, stradle carrier, asphalt

finisher, wheel hammer, wheel braker, fork loader, turret type platform truck, agricultural motor vehicle, tractor for construction works, and motor vehicles with special constructions designated by the Minister for Transport having the dimensions not exceeding: length: - 4.70 m, width: - 1.70 m, height: - 2.00 m and the maximum speed of 15 km/h or less (in the case of motor vehicles with internal combustion engines, it is limited to those with an engine displacement of 1.50 liter or less),

e) Large-sized special motor vehicle means crawler vehicle, semi-crawler vehicle, road roller, tire roller, road stabilizer, tire dozer, motor grader, motor scraper, shovel loader, dumper, motor sweeper, fork lift truck, wheel crane, stradle carrier, asphalt finisher, wheel hammer, wheel braker, fork loader, agricultural motor vehicle, rotary snowplow, motor vehicle with such construction that the chassis or vehicle may bend while driving and tractor for construction works except light motor vehicle and small-sized special motor vehicle, pole-trailer, and motor vehicles with special construction designated by the Minister for Transport.

4. Emissions standards

The Japanese regulations specified two emission limits (Tables A4/1 and A4/2):

- mean values,
- maximum (max) values.

The mean values should be met as type approval limits (for both type designation and type notification) and as production control average, if the total sales are 2000 units or more per model and calendar year. The maximum values should be complied with as type approval limits when the total sales are below 2000 units or as individual limits in the production control (completion inspection). The requirements with regard to the durability apply to vehicles for which the type designation is conducted. In this case, the maximum values should not be exceeded by vehicles subjected to durability test over a distance of 30000 km (20000 km for some vehicles). This applies only to limits for 10/10·15 - mode test (point 5. below). For vehicles equipped with catalytic converters, the change of converters is mandatory. However, if the optional 80000 km durability run has been complied with, this change is not necessary.

The limits for CO, HC and NO_x are specified in Tables A4/1 and A4/2.

Table A4/1

Current exhaust emission standards for gasoline-fuelled vehicles in Japan

Item	Vehicle category	Test procedure	Limits					
			CO		HC		NO_x	
			mean	max	mean	max	mean	max
1	Ordinary-sized or small-sized motor vehicles with a gross vehicle weight of 1.7 tons or less, or exclusively for carriage of passengers and with riding capacity of 10 persons or less (except two-wheeled motor vehicles with or without sidecar) or mini-sized motor vehicles exclusively for carriage of passengers (except two-wheeled motor vehicles with or without sidecar)	10-mode 10•15mode (g/km)	2.10	2.70	0.25	0.39	0.25	0.48
		11-mode (g/test)	60.0	85.0	7.0	9.5	4.4	6.0
2	Ordinary-sized or small-sized motor vehicles with a gross vehicle weight exceeding 1.7 and not more than 2.5 tons (except motor vehicles listed in Item 1 above and two-wheeled motor vehicles with or without sidecar)	10-mode 10•15mode (g/km)	13.0	17.0	2.1	2.7	0.7	0.98
		11-mode (g/test)	100.0	130.0	13.0	17.0	6.5	8.5

Table A4/1 cont'd

Current exhaust emission standards for gasoline-fuelled vehicles in Japan

Item	Vehicle category	Test procedure	Limits					
			CO		HC		NO_x	
			mean	max	mean	max	mean	max
3	Mini-sized motor vehicles (except motor vehicles listed in Item 1 above and two-wheeled motor vehicles with or without sidecar)	10-mode (g/km) 10•15mode	13.0	17.0	2.1 12.0(1)	2.7 15.0(1)	0.5 0.3(1)	0.74 0.50(1)
		11-mode (g/test)	100.0	130.0	13.0 50.0(1)	17.0 70.0(1)	5.5 2.5(1)	7.5 4.0(1)
4	Ordinary-sized or small-sized motor vehicles with a gross vehicle exceeding weight of 2.5 tons (except motor vehicles listed in Item 1 above and two-wheeled motor vehicles with or without sidecar)	6-mode(ppm)	1.2%	1.6%	410	520	650	850

1) for vehicles with two-stroke engines

Table A4/2

Current Exhaust emission standards for diesel-powered vehicles in Japan

Item	Vehicle category	Test procedure	Limits					
			CO		HC		NO_x	
			mean	max	mean	max	mean	max
1	Ordinary-sized motor vehicles exclusively for carriage of passengers with a riding capacity of 10 persons or less or small-sized motor vehicles with a vehicle weight of 1265 kg or less	10-mode (g/km)	2.10	2.70	0.40	0.62	0.5	0.72
2	Ordinary-sized motor vehicles exclusively for carriage of passengers witha riding capacity of 10 persons or less or small-sized motor vehicles with a vehicle weight of more than 1265 kg	10-mode (g/km)	2.10	2.70	0.40	0.62	0.6	0.84
3	Ordinary-sized motor vehicles and small-sized motor vehicles with GVW of 1.7 tons or less (except motor vehicles provided for in the preceding 2 Items)	10-mode (g/km)	2.10	2.70	0.40	0.62	0.9	1.26

Table A4/2 cont'd

Current exhaust emission standards for diesel-powered vehicles in Japan

Item	Vehicle category	Test procedure	Limits					
			CO		HC		NO_x	
			mean	max	mean	max	mean	max
4	Ordinary-sized motor vehicles and small--sized motor vehicles with a GVW of more than 1.7 tons, but of 2.5 tons or less	6-mode(ppm)	790	980	510	670	260 380(1)	350 500(1)
5	Ordinary-sized motor vehicles and small--sized motor vehicles with a GVW of more than 2.5 tons	6-mode(ppm)	790	980	510	670	260 400(1)	350 520(1)

1) for vehicles with direct injection engines

Apart from the above standards, the following emission requirements for new motor vehicles are specified in the Japanese regulations:

a) no crankcase emissions are permitted (for gasoline-fuelled vehicles),
b) evaporative emissions - 2g/test (for gasoline-fuelled ordinary-sized, small-sized and mini-sized vehicles with the exception of two-wheeled vehicles),
c) pollutant concentrations at idle (for gasoline-fuelled vehicles):

CO - 4.5% vol.
HC - 1200 ppm (for vehicles with four-stroke engines),
7800 ppm (for vehicles with two-stroke engines),

d) smoke level measured in 3-mode test (for diesel-fuelled vehicles) - 50%,
e) gasoline-fuelled vehicles should be fitted with a warning device which starts functioning in the event that the temperature of the exhaust emission control device rises beyond a point where the damage to this device or other devices/systems may occur.

The partial revision of the emission requirements has been announced and partly introduced. It includes:

a) revisions of the test procedures:
   - 10-mode test is replaced by 10·15-mode test for categories listed in items 1, 2, 3, 4 of Table A4/2,
   - 6-mode test is replaced by 13-mode test for categories listed in item 4 of Table A4/1 and item 5 of Table A4/2,
   - 6-mode test is replaced by 10·15-mode test for category listed in items 4 of Table A4/2,
b) the tightening of NO_x emission standards (Table A4/3),
c) the introduction of particulate emission standards (Table A4/3),
d) the tightening of smoke limits from 50% to 40% for all diesel vehicles (date of entry into force as given in Table A4/3).

Table A4/3

Announced revision of emission standards in Japan

Vehicle category specified in	Test procedure	Limits				Effective date
		CO	HC	NO_x	PM	
Gasoline-fuelled vehicles						
item 4; Table A4/1	13-mode (g/kWh)	136	7.9	7.2	-	New models - October 1, 1992 New vehicles - September 1, 1993 Imported vehicles - April 1, 1994
Diesel vehicles						
item 3; Table A4/2	10•15-mode (g/km)	2.70	0.62	0.84	0.34	New models - October 1, 1993 New vehicles - September 1, 1994 Imported vehicles - April 1, 1995
item 4; Table A4/2	10•15-mode (g/km)	2.70	0.62	1.82	0.43	
item 1, 2; Table A4/2	10•15-mode (g/km)	as in Table A4/2			0.34	New models - October 1, 1994 New vehicles - September 1, 1995 Imported vehicles - April 1, 1996
item 5; Table A4/2	13-mode (g/kWh)	9.20	3.8	6.8 7.8(1)	0.96	

1) for vehicles with direct injection engines

5. Test procedures

5.1. 10-mode test and 10·15-mode test

The 10-mode test was used up to 1 November 1991 for domestic production and 1 April 1993 for imported vehicles. It was replaced by 10·15-mode test, however, the limits remained unchanged. The driving cycles are shown in Fig. A4/1.

Both tests are driven as hot start. The 10-mode cycle is repeated 5 times without interruption. Moreover, one pre-cycle is conducted. The sampling and analytical method is similar to FTP 72 (one bag for diluted exhaust gas).

5.2. 11-mode test

The driving cycle is shown in Fig. A4/2. After vehicle conditioning at a temperature between 20°C - 30°C, the engine is started and run at the idling for 25 s. 4 cycles are than driven without interruption. The sampling and analytical method is identical as described in point 5.1. above.

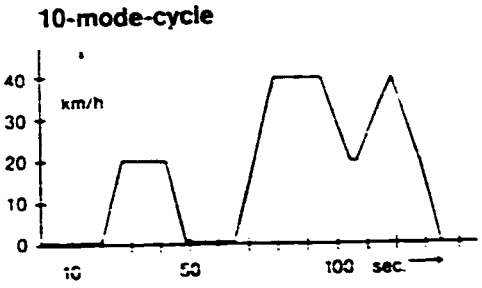
5.3. 6-mode test. 13-mode test

The test is run with the test vehicle placed on a chassis dynamometer or the test engine placed on an engine dynamometer bench. It is composed of 6 modes (Table A4/4). The weighting factors are different for gasoline-fuelled and diesel-fuelled vehicles/engines. The test is conducted on warm engine.

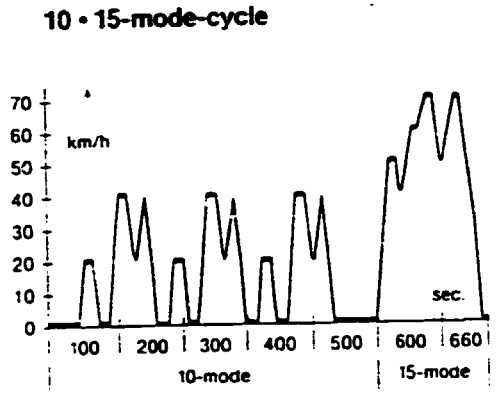
Table A4/4

Japanese 6-mode test

Driving mode	Engine revolution speed (rpm)	Engine load rate (%)	Driving time (min)	Weighting factor	
				diesel engines	SI engines
1	Idling		3	0.355	0.125
2	Revolution speed that is 40% of speed of maximum output	100	3	0.071	0.114
3	Revolution speed that is 40% of speed of maximum output	25	3	0.059	0.277
4	Revolution speed that is 60% of speed of maximum output	100	3	0.107	0.254
5	Revolution speed that is 60% of speed of maximum output	25	3	0.122	0.139
6	Revolution speed that is 80% of speed of maximum output	75	3	0.286	0.091

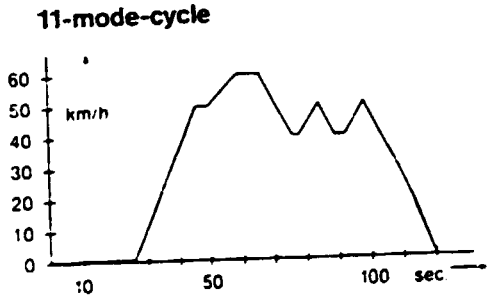


no. of cycles	5
duration of cycle	135 s
total time	675 s
distance per cycle	0.664 km
total distance	3.32 km
average speed	17.7km/h



no. of cycles	1
total time	660 s
total distance	4.16 km
average speed	22.7km/s

Fig. A4/1. Japanese 10-mode cycle (a) and 10·15-mode cycle (b)



no. of cycles	4
duration of cycle	120 s
total time	480 s
	+ 26s first idle
distance per cycle	1.021 km
total distance	4.084km
average speed	30.6km/h

Fig. A4/2. Japanese 11-mode cycle

The analytical system is composed of:

- NDIR analysers for CO and NO,
- Heated FID analyser for HC.

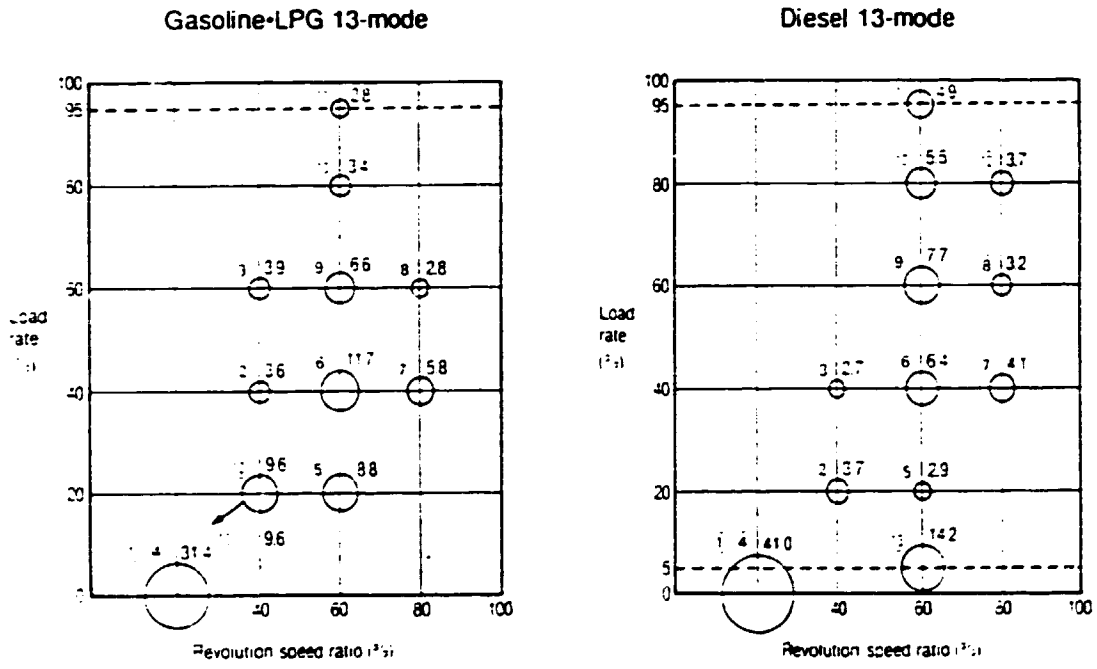
The exhaust gas is sampled directly from the exhaust system (undiluted). The measurement is made for the last one minute of each mode. The mean weighted concentrations are calculated by means of the formula:

$$c_i = \sum_{j=1}^{6} c_{ij} \cdot WF_j \cdot K_H$$

where:

c_i - mean weighted concentration of pollutant i,
c_{ij} - measured concentration of pollutant i over mode j,
WF_j - weighting factor in mode j,
K_H - humidity correction factor (only for NO).

13-mode tests are depicted in Fig.A4/3. Like in 6-mode tests, weighting factors are different for gasoline-fuelled and diesel vehicles/engines.



(Note 1) The figure on the upper right of each circle represents the coefficient percentage.

(Note 2) The encircled numerals denote the driving order.

(Note 3) At the 13th mode in gasoline•LPG 13-mode, the vehicle speed shall be decelerated down to 20% of the revolution speed by closing the throttle valve fully.

Fig. A4/3. Japanese 13-mode test