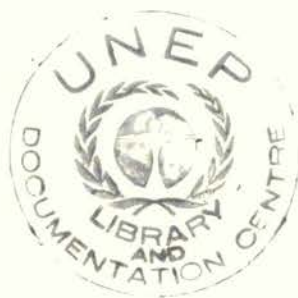
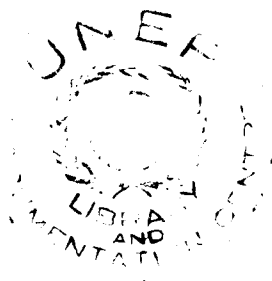


0219

ENVIRONMENTAL GUIDELINES FOR THE MOTOR VEHICLE AND ITS USE



**Environmental Guidelines
for the Motor Vehicle
and its Use**



UNEP - Industry & Environment Guidelines Series

**Volume 1 Guidelines for Assessing Industrial Environmental Impact and Environmental
Criteria for the Siting of Industry**

**Environmental Guidelines
for the Motor Vehicle
and its Use**

Industry & Environment Office
UNITED NATIONS ENVIRONMENT PROGRAMME

Copyright © UNEP

All Rights Reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means : electronic, electrostatic, magnetic tape, mechanical, photocopying, recording or otherwise, without permission in writing from copyright holders.

First edition 1981

ISBN 92-807-1040-0

The designation employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the United Nations Environment Programme concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Moreover, the citing of trade names or commercial processes does not constitute endorsement by the United Nations Environment Programme.

PREFACE

The environmental aspects of the motor vehicle and its use were first brought under review by UNEP at the Seminar on the Motor Vehicle and the Environment, held in 1976. Material gathered in association with the Seminar and subsequently during the on-going correspondence and consultation with experts from Governments, industry and international institutions throughout the world, has been summarized in UNEP's overview and technical booklets. As a follow-up to the seminar, a UNEP Environmental Consultative Committee on the Motor Vehicle was convened and a first meeting held in 1978 as part of the on-going process of communication and consultation on environmental aspects of the motor vehicle and its use.

At the seventh session of the UNEP Governing Council, revised objectives 1/ were agreed in relation to the industry and environment activities, which included inter alia the development, and dissemination of guidelines for the use by Governments and industry in assessing, controlling and minimizing adverse environmental (including health) effects of major sectors of industry. This document responds to these objectives for the motor vehicle sector, and it covers environmental guidelines in relation to motor vehicle air pollution and noise, as well as certain safety aspects. A first draft, prepared with the help of UNEP consultant Mr. Maurice Clavel (issued as IEO/CC/MV.2/2), was examined at the second meeting of the UNEP Environmental Consultative Committee on the Motor Vehicle and its Use, held in Paris, 17-18 September 1980, and these UNEP Environmental Guidelines result from that examination and subsequent exchange of views by correspondence.

The need for environmentally sound use of natural resources has become particularly acute in relation to the motor vehicle as an essential part of transportation, a key factor in economic development throughout each country. In most countries there is a trend to preserve hydrocarbons and encourage fuel economy. At the same time there are pressures to further improve abatement of air pollutant and noise emissions as well as road safety. These pressures have paved the way for the development of new technologies, in some cases combined with vehicle weight reductions. There is, however, acute controversy concerning their performance, durability, cost-effectiveness and adaptability to different conditions in different regions and to the whole range of motor vehicles. Rapidly growing motorization, particularly in developing countries, has moreover led to concern about environmental quality protection in relation to the motor vehicle and road accidents.

With this overall situation in mind, these guidelines have been drafted to help Governments and industry in the development and elaboration of realistic policies in relation to vehicle emission and noise control, fuel economy and road safety. They are not intended to lay down statutory or mandatory rules, but rather, in summarizing current experience and generally accepted good environmental management

1/ UNEP/GC.7/19, Decision 7/3 and UNEP/GC.7/7, para. 119.

practice, to provide a collection of commonly accepted principles to be applied, as appropriate, according to circumstances and conditions. Since specific objectives for environmental quality vary amongst countries, depending on the local circumstances and priorities, likewise the contribution of the motor vehicle to local ambient conditions, these guidelines do not address the question of effects of specific pollutants or noise 1/.

1/ For international review of relevant environmental health criteria see the "Environmental Health Criteria" published under the joint sponsorship of UNEP and WHO, World Health Organization, Geneva: Number 3 Lead; Number 4 Oxides of Nitrogen; Number 7 Photochemical Oxidants; Number 8 Sulphur Oxides and Suspended Particulate Matter; Number 12 Noise; Number 13 Carbon Monoxide.

TABLE OF CONTENTS

	<u>page</u>
Preface	(i)
Table of contents	(iii)
Overall considerations	1
I - Transportation, Urban and Regional Planning	1
II - The Motor Vehicle	5
A - Emission Control and Fuel Economy	6
B - Noise Control	15
C - Vehicle Safety	19
D - Maintenance and Inspection	23
III - Road User Education	26
Summary and Conclusions	28

OVERALL CONSIDERATIONS

Environmental problems related to motor vehicle use are common to almost all countries, but they vary in severity due to different combinations of factors in different places, including: geography, climate, social and economic conditions, infrastructure facilities, and resource availability. Appropriate solutions will therefore vary from place to place, depending on overall priorities set by the countries concerned, and their determination to tackle specific environmental problems. With these considerations in mind, it is desirable in the first place for authorities in countries to identify and define the problems, then evaluate the cost-effectiveness of the various measures being considered, taking into account the full range of related factors such as energy and technological development, impact on public and private expenditure and on cost of living, etc. Finally, balance and trade-offs among possibly conflicting objectives may be required depending on the priorities adopted. Although appropriate solutions would vary according to local need, conditions and resources, a number of basic principles and appropriate environmental measures remain, relating to urban planning and transport, the motor vehicle and road user education. They should be kept in mind as guidelines, when an analysis of the environmental issues and evaluation of possible measures are undertaken.

I - TRANSPORTATION, URBAN AND REGIONAL PLANNING

Whilst nearly all over the world transportation is a key factor in both urban and rural ^{1/} development, the main environmental problems stemming from both stationary and mobile sources arise in urban, industrialized areas. Tackling these problems effectively requires close co-operation among the various authorities responsible for human health and the environmental quality of urban life. This means that tight links should be established, possibly statutory, bringing together at national, regional and local levels, those institutional bodies dealing with environmental protection and human health, urban, regional and land-use planning, industrial development, and transportation. This close co-operation which could, for example, be insured by a co-ordinating body, should be supported by adequate administrative machinery to deal with aspects (i) to (v) discussed below:

(i) Control of urban growth

Control is necessary of the constant urban growth, observed everywhere, and its associated increased need for intercommunication; making the best use of limited resources, including at present available space and facilities, through improved collective management. Consideration should also be given to satisfying the increasing need for intercommunication without increasing the

^{1/} These Guidelines do not deal with environmental aspects specific to rural areas throughout the world, nor with non-mechanized and non-vehicular traffic.

volume of traffic, through, amongst other actions, improved land-use planning. Furthermore, in some regions it may be necessary to reverse the trend of rural-urban migration, particularly through provision of improved conditions in rural areas.

(ii) Establishment of a well-planned and integrated transportation system

A well-planned and integrated transportation system adapted to the local needs and conditions should be established, where specific measures are taken to favour public transport. Depending on local conditions, examples of such measures include: reserved lanes for buses and taxis, use of clean and silent trolleys and trams, which have priority at crossroads, and selective change of traffic patterns. The comfort of public transport, network density, frequencies and speed should adequately compete with the flexibility of operation of the private car. In some countries intermediate personal transport services, such as minibus, shared taxis and jitneys etc., are important modes of transport with their own environmental impact and social role. Their ready access to narrow streets in residential areas and adaptability to supplementing public transport in suburban areas makes them a valuable mode of transport which should be encouraged, as appropriate, within a comprehensive transportation policy. Such a policy will also, as appropriate, encourage rational use of individual transport through for example car pooling and parking policies. A complementary role should be seen for public transport and the private vehicle which reconciles, as far as possible, community interests and personal freedom of choice. It must be further borne in mind that in many countries the private sector is heavily involved in the field of transportation and consequently has a potent role in providing improved transportation orientated towards the needs of the community as a whole.

(iii) Creation of smoother traffic flow

Smoother traffic flow favouring fuel economy and limiting pollutant and noise emission should be created. As examples, use may be made, as appropriate, of separated traffic distribution, fly-overs (e.g., of the temporary, mobile type) and under-passes at certain crossroads, through traffic diversion, computerized traffic signals operation, off-street parking and licensing access to specific inner city areas. Measures may be necessary to reduce obstruction to smooth traffic flow caused by public works and the presence of non-mechanized forms of transport such as cycle, hand- and animal-drawn carts, which are major means of personal and goods transportation in some countries and for which special provisions may be needed (see footnote page 1). It has been reported ^{1/} that, on the basis of simulated urban traffic conditions on a chassis dynamometer, the smooth flow conditions of the early morning (4 a.m.) compared to the same urban route during highly congested

^{1/} R. Herman, R.G. Rule and M.W. Jackson, "Fuel Economy and Exhaust Emissions under Two Conditions of Traffic Smoothness", SAE 780614, Troy, Michigan, United States of America, June 5-9, 1978.

flow (5 p.m. rush hour) resulted in a fuel economy improvement of 31 per cent and a reduction of HC, CO and NO_x 1/ emission levels of 54, 52 and 2 per cent respectively for hot start. Figures 1 and 2 give the results of experiments conducted by the Tokyo Metropolitan authorities on five different ranges of private cars (from cubic capacity of 1,200 to 2,000 cc) and show the influence of various urban speeds on CO and HC emissions. These examples highlight the paramount impact of traffic flow, acceleration, deceleration and idle conditions on motor vehicle emissions and fuel consumption. Furthermore, experience has shown that traffic signals operation at crossroads in urban zones plays a major role in ensuring adequate and constant traffic speed. In this respect, when it is not possible for financial or technical reasons to co-ordinate the operation of signalized intersections through a central computer there is still scope for traffic light synchronization and individual sign control arrangements. Perhaps the most obvious synchronization is the progressive and simple linking of signals along arterial roads which can both minimize the number of acceleration/deceleration operations and limit the cruising speed range of the smoother traffic obtained to keep it closer to levels at which emission rates are lowest. Moreover, combined smooth traffic flow conditions, urban speed limits and smooth road surface are the essential parameters to prevent noise Leq 2/ exceeding an acceptable level (approximately 60 dBA when measured at the building facade along urban roads and highways).

(iv) Providing suitable community infrastructure, especially for new urban areas

Effective land-use planning should be applied to residential, recreational and industrial zones, particularly in new urban areas. Environmental considerations should be incorporated into the planning and design of new major roads in the proximity to residential and recreational areas. As appropriate, footpaths and cycle paths as well as pedestrian zones should be provided with good access facilities to public transport and adequate parking. Buildings should incorporate sound damping constructional materials and, where necessary, sound barriers should be used. These should become fundamental elements of the community infrastructure.

(v) Reduction of night time noise from vehicles in residential areas

Appropriate restrictions, as necessary, should be adopted for movement of heavy vehicles and use of horns except in cases of

1/ CO : carbon monoxide, HC : hydrocarbons, NO_x : nitrogen oxides

2/ Leq : acoustic energy level equivalent,

$$\text{Leq} = 10 \log \int_{t_1}^{t_2} \frac{10^{\frac{LT}{10}}}{t_1(t_2-t_1)} dt ;$$

LT being the instantaneous sound pressure; t = time.

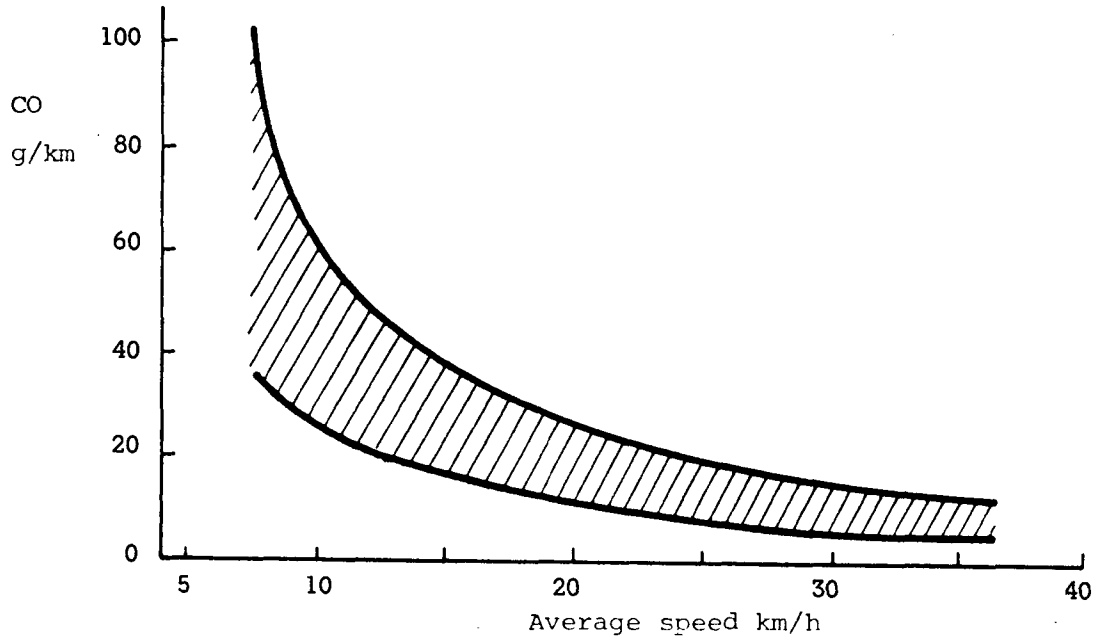


Fig. 1 CARBON MONOXIDE (CO)

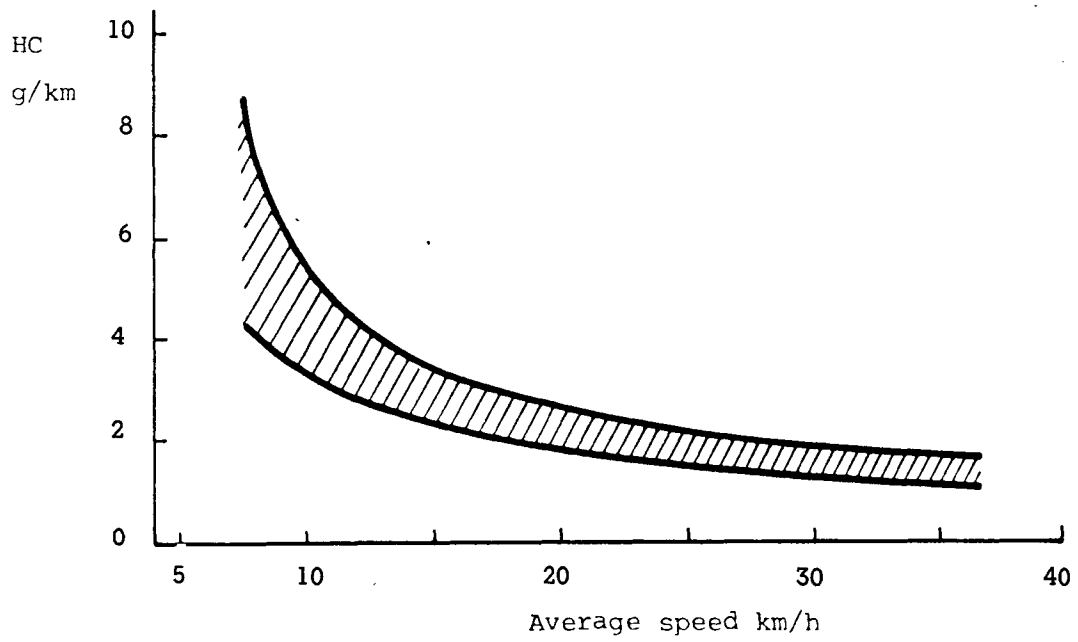


Fig. 2 HYDROCARBONS (HC)

emergency in residential areas during the night time. It has to be noted that a commercial vehicle of more than 3.5 t provokes a similar auditive disturbance to the flow of 3 to 20 private cars, depending on traffic speed, and that the acoustic energy emitted by³ commercial vehicles over 3.5 t increases as the cube of the speed (V^3) for speeds exceeding approximately 60 km/h 1/.

In taking the measures outlined above, authorities should attempt to preserve the city street economic and social function. They should also consider the cost-effectiveness of using existing equipment and infrastructure, and of their better management, which in some cases may prevent or, at least, minimize the adoption of unnecessarily costly expenditure. In this respect, experience acquired by the OECD 2/ through twelve specific city case-studies, could be usefully considered, particularly by those countries facing a fast growing urban population and motorization, since the goals and objectives of this activity are aimed at restoring human scale development of the city, and preserving it as an integrated centre of economic, social and cultural life, by emphasizing efficiency (referring to the cost-effective management of available resources), quality (as far as the reduction of negative external effects of traffic and improvement of transport services are concerned) and equity (referring to a better response to the very differential travel demands of various groups, including the handicapped, the young, the less privileged and the elderly).

Finally, there should be consultation with the public in the analysis and definition of the urban environmental issues. Whilst the approach for involving the public will vary among countries, their views should be sought, periodically, concerning the measures selected to improve the urban environment. In this connection it is essential that the public, and commercial and industrial enterprises, be involved in tackling urban problems, and be provided with relevant information concerning progress being made, as well as what may be achieved within specific short and the long term time frames.

II - THE MOTOR VEHICLE

It has been pointed out that, when attempting to improve the motor vehicle environmental performance, "we are dealing with a sophisticated mass-produced machine, which is fuelled by a complex chemical, operated under diverse road and climatic conditions by motorists with a wide variety of living and driving habits, and serviced by mechanics who range from the expert to the incompetent and unscrupulous" 3/. It is

1/ M. Frybourg "Bruits des véhicules en circulation", Institut de Recherches des Transports (I.R.T.), Arcueil, France, 1978.

2/ Organization for Economic Co-operation and Development (OECD) Group of Experts on Traffic Policies for the Improvement of the Urban Environment. See especially, Proceedings of Seminar on Urban Transport and the Environment, held at OECD, Paris, 10-12 July 1979.

3/ See "Regulating the Automobile", Massachusetts Institute of Technology, Boston, Mass., United States of America, November 1977.

not therefore surprising that the whole range of environmental objectives relating to the motor vehicle, including simultaneous emission and noise level reduction, road safety and fuel economy improvement, remains a complex issue of a multi-disciplinary nature, which may result in conflicting requirements preventing any clear cut solution, and the achievement of which requires international co-operation, and calls for considerable investment by industry in research.

Consequently, implementation of these objectives calls for successive identification and definition of the problems, and examination of the cost-effectiveness of various solutions in the light of priorities selected and in consideration of the full range of relevant factors, such as energy and resource availability, climatic conditions, level of economic and technological development, economic and social impacts, etc. An analysis of this type will identify, in most cases, possible conflicts between the whole range of environmental and fuel economy requirements, and help to find appropriate trade-offs or compromises depending on local conditions and related priorities. The following paragraphs give the principles which should be taken into consideration.

A - Emission Control and Fuel Economy

The following is a number of general considerations concerning emission control and fuel economy:

- (i) When regulating new vehicles, due to the interaction existing in the performance of vehicles between emissions and fuel economy, as well as the current limited availability of fuel resources and their rapidly increasing price, the issues of emission control and fuel economy have to be considered together.
- (ii) For a given technological emission control system, there is a level of emission control that can be obtained with no adverse or even, in some cases, with a positive impact on fuel economy. This is the case when leaner air fuel mixtures above stoichiometric, especially through stratified charge combustion systems or swirl chamber fast burning techniques, are used. If more control is required, a compromise may be made that may result in fuel economy penalties. On the other hand, for a given emission control requirement, there are several technological ways in which the control level can be obtained, some, however, with fuel economy penalties.
- (iii) Some advanced technological approaches (e.g. the combination of oxidation and three-way catalysts associated with a closed loop air-fuel ratio electronic control system, exhaust gas recirculation and air injection) which are more complicated and expensive than simpler approaches and may require generally less but more specialised maintenance, enable stringently low emission levels of HC, CO and NO_x to be attained, while minimizing the fuel economy loss. The benefits of this type of emission control technology will have to be carefully evaluated against the cost to achieve them.

- (iv) Up to 25 per cent of hydrocarbon emissions (depending on conditions and climate) arise through evaporative losses in the vehicle fuel system for spark ignition engines. Inexpensive techniques exist for minimizing evaporation losses in the fuel system from fuel tank to cylinder head inlet. Vapour adsorption on activated charcoal is used for measuring hydrocarbon loss. Further, reduction of these types of hydrocarbon losses helps improve fuel economy.
- (v) In many countries lead alkyls and other substances are added to motor vehicle fuels to improve the octane rating and enable higher engine compression ratios and better efficiency and therefore fuel economy, without significant changes in fuel composition. Lead is recognized as a toxic substance. The contribution of lead from motor vehicle fuel to the total lead exposure of man varies from place to place according to circumstances. Advanced technological approaches to emission control, using catalysts, currently require non-lead fuels to avoid poisoning the catalyst, provision of which calls for a specific additional distribution network and may involve an energy penalty at the refinery.
- (vi) With respect to attaining stringent emission control, including very low NO_x levels, more R and D is needed to fully assess the fuel consumption implications. In general, the basic trade-off that occurs for fuel economy is between NO_x and HC. In this area, efforts to achieve simultaneous HC and NO_x emission rates in an engine optimized for low emissions will result in decreased fuel economy as illustrated by the graph shown in the following Figure 3, which demonstrates that as emission levels are lowered, there is a point below which the fuel economy decreases rapidly as emission levels continue to decrease.
- (vii) When approaching the 80 or 90 per cent control of pollutants, costs involved per mass of pollutant emissions reduced, increase rapidly.
- (viii) There are major uncertainties in ascertaining levels of overall emissions from motor vehicles in use due to degradation with time of control equipment performance and the poor relationship between durability tests conducted on factory prototypes and real vehicle behaviour on the road, given all the variations in maintenance, mechanical adjustment and operating conditions. The United States of America Environmental Protection Agency (EPA) and a number of motor manufacturers have each conducted experiments on current emission control system degradation. Results obtained for vehicles equipped with spark ignition engines have shown that a high degradation rate in the control of CO and HC emissions exists (approximately twice the standard levels at 80,000 km, in some cases), and should be considered as the most serious concern to be faced when attempting to efficient-

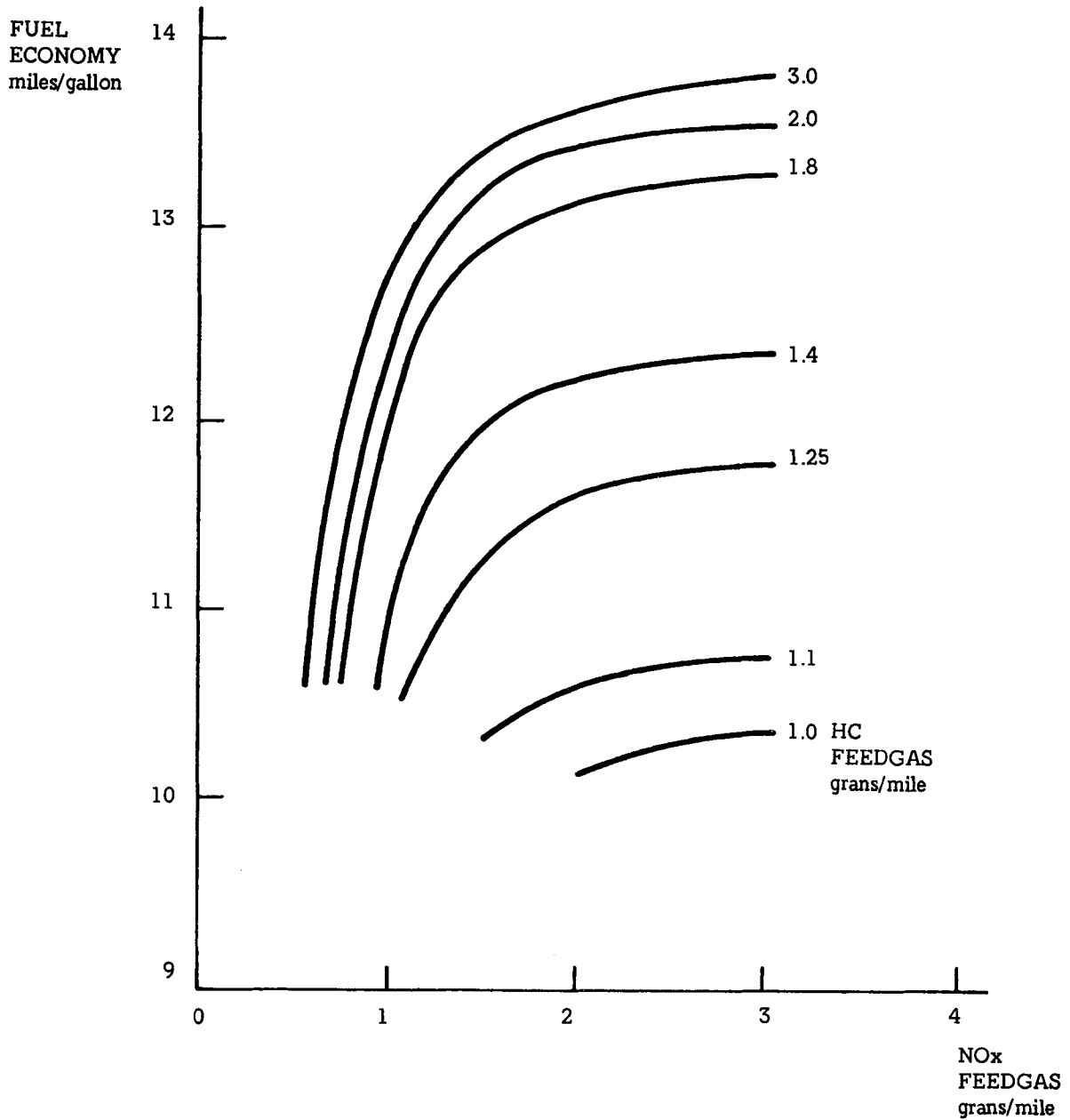


Fig. 3 Maximum Fuel Economy CVS-H Projections

400 2V Ford Automatic Transmission - 2.75 Axle Ratio
5000 lb. Inertial Weight

Note: Testing done with optimized air/fuel ratio, optimized spark, optimized EGR rates, no secondary air.

ly abate vehicles exhaust emissions 1/. Associated with increasing urban traffic and industrial growth, these unfavourable findings, particularly due to poor vehicle maintenance, explain why in some countries, in spite of the continuous introduction of new vehicles complying with more and more stringent emission control levels, there is still a continuing degradation of air quality in main cities, as shown recently in the United States of America 2/. However, CO levels in some European cities have been falling.

- (ix) Special attention should be drawn to the greater use of the diesel engine for private cars, public transport and commercial vehicles, which has a better fuel economy, as well as lower HC and CO emissions and degradation factor than the spark ignition engine. There is concern, however, as to the potential health and technological problems raised by diesel engine particulates and oxides of nitrogen emissions, as well as to the problem of noise from diesel vehicles.
- (x) Whilst it is the responsibility of Governments to set standards for the required pollutant emission levels, a sufficient lead-time should be allowed for the motor manufacturers to undertake research and development, and select the technology needed to attain the standards in the most cost-effective way. For example, in most cases four to five years may be required when there is need to develop new technologies.

These considerations emphasize the need for authorities, prior to taking decisions involving strategies and levels of control to be applied to motor vehicles and related technological solutions, in as far as practicable to collect relevant data and undertake precise analysis of environmental problems. This is particularly true for those rapidly developing countries with limited resources and involved in manufacturing of motor vehicles. Care should be taken not to be led into a course of arbitrary and non cost-effective approaches for emission control which exceed available resources and relative current needs for pollution control. In this respect, the recommendations submitted for consideration by the Mexican authorities during the Meeting of Experts on Air Quality in the Valley of Mexico 3/, is a good example of a realistic and concrete approach to the emission control measures tailored to suit

1/ A recent study conducted in New York by the United States of America Mass Transportation Administration on 132 taxis, of which half were equipped with diesel engines and half with spark ignition engines, has shown that the emission degradation factor is significantly inferior for diesel vehicles.

2/ United States Department of Transport Survey, 1979.

3/ Sponsored by UNEP and held in Mexico City, from 6 to 10 November 1978. For follow-up programme of action see "Programa Coordinado Para Mejora la Calidad del Aire en el Valle de Mexico, 1979-1982", Comisión Intersecretarial de Saneamiento Ambiental, Mexico, August 1979.

local need and situation, including geographical, meteorological, economic and technological conditions, as well as local resources.

Bearing in mind the main principles linking motor vehicle emission control levels and fuel economy performance outlined in the previous paragraphs, attention should be paid to the following actions:

- (i) There is a need for each country to identify, and periodically update, the respective contribution to concentrations of atmospheric pollutants in metropolitan areas, from stationary sources, including industry and domestic heating, and from mobile sources, i.e. motor vehicles. Moreover, where appropriate action is being taken, periodic assessment should also be made of the influence on air quality trends due to reductions in emission from motor vehicles through improved traffic flow and progressive replacement of existing vehicles by new ones meeting improved emission control standards. This is essential in evaluating the need for improved transportation schemes and new types and levels of emission control. Depending on local conditions and resources, this calls for the establishment in the major metropolitan areas of an air pollution surveillance network, covering, for example, carbon monoxide, suspended particulate matter, sulphur and nitrogen oxides and total oxidants.
- (ii) Every effort should be made by national authorities to further reduce vehicle emission performance deterioration, which appears to be due to various causes related to the type and complexity of technology employed for the control systems, to carburation and ignition maladjustment at the service level, poor maintenance and to tampering by consumers. In this respect, as new data are obtained, authorities might evaluate whether, within the field of emission control regulations, both clean air and fuel conservation would be better served by a gradual shift away from greater and more costly tightening of standards applied to prototypes and new vehicles, and toward greater concern for ensuring durability of emission control through appropriate technology and, especially, adequate maintenance and repair of vehicles in use. Further appropriate field tests should contribute to this evaluation. In any case, expenditure devoted to the establishment and implementation of an emission control legislation applied to newly commercialized motor vehicles, would be almost wasted if the necessary measures are not taken at the national level to ensure that these motor vehicles in use are maintained, adjusted and repaired in accordance with sound engineering practice and the manufacturers' specifications.
- (iii) Countries which have not done so, should prescribe smoke emission regulations for diesel equipped vehicles (e.g. UN/ECE 1/ Regulation No. 24 which can be implemented without expensive equipment). These regulations should be accompanied by mandatory periodic inspections of the engine fuel injection system, and strict control by police of overloaded vehicles (i.e. exceeding loading

1/ UN/ECE: United Nations Economic Commission for Europe.

specifications prescribed by manufacturers). Further analysis should be encouraged by those countries wishing to make a much greater use of diesel vehicles, of the potential health and technological problems raised by diesel engine particulates, giving consideration to the levels which may need to be attained and the further technology required for their cost-effective reduction.

- (iv) In the selection of the technologies required for the reduction of pollutant exhaust emissions from spark ignition and diesel engines, various factors, directly related to motor vehicle characteristics, may provide a sound, cost-effective approach to simultaneously improving fuel economy and abating the emitted mass of pollutants. Authorities should encourage further development of practicable solutions and those technologies which are progressively being adopted or still under study in a number of countries, such as:
- a) Use, as appropriate, of leaner and more homogenous air/fuel mixtures, new technologies such as the swirl chamber, fast burning techniques, electronic ignition and, although controversial, stratified charge. The two conventional diagrams (Fig 4. and 5) highlight the well-known relationship for a spark ignition engine between (i) air/fuel ratio and the emission concentrations, (ii) output and fuel consumption. They show that leaner air/fuel ratio above stoichiometric may result in a minimum CO and HC emission associated with optimum fuel economy. This approach, of course, has to be combined with the NO_x emission requirements and acceptable stability of engine operation. It should be understood, furthermore, that an air/fuel ratio above stoichiometric cannot be associated with efficient operation of threeway catalysts. From now on, and amongst other measures, new technologies developed and under development may play a progressively important role in improving fuel economy and emission performance. These include:
- use of electronics for monitoring the air/fuel ratio for carburation through micro-processors computing essential variables for achieving optimum efficiency. Use of electronics also for optimizing ignition and variable transmission ratio. In this respect use of electronic devices may provide the best cost-effective way to optimize carburation and ignition of leaner than stoichiometric air/fuel mixtures, favourable to both reducing CO and HC emissions and optimizing fuel economy;
 - a more precise adaptation of engines to fuels for optimum efficiency, which may call for a refining of the definition of the antiknock characteristics of spark ignition fuels;
 - more efficient lubricants;
 - super-charging for both diesel and spark ignition engines;
 - advanced internal ceramic coating for decreasing thermal losses at the cylinder head and exhaust;

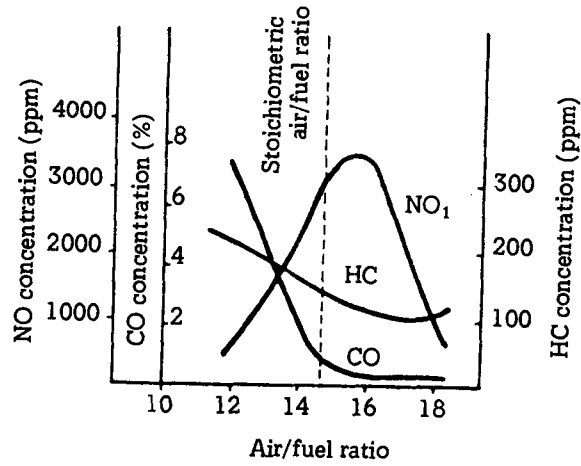


Fig. 4 Typical concentration exhaust emissions caused by air-fuel ratio.

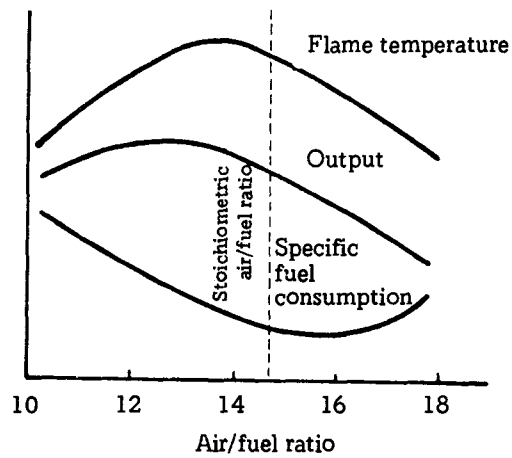


Fig. 5 Variations of flame temperature. Output and specific fuel consumption in relation to air/fuel ratio.

- modular engine using variable valve operation.

It must be borne in mind that the complexity of some of these technologies requires specific vehicle servicing and, therefore, the specialized qualification and training of maintenance personnel, combined with the appropriate equipment of garages and dealer workshops.

- b) Reduction of weight and engine power of vehicles, whilst keeping acceptable space and comfort for the vehicle occupants and adequate power or torque/weight ratio for sufficient acceleration in traffic. It is hoped that the trend of progressive substitution of light alloys and plastics for heavier materials, as has been done for the engine and gear-box, as well as for body fittings, will continue whilst considering both the cost and energy requirements for the manufacturing of light weight materials. The studies for new radical construction techniques, such as lightweight foam filled structural components for energy absorption, now being undertaken in Europe, Japan and the United States, should be encouraged. In this area, the proportion of iron and steel, which today represents about 75 per cent of the total weight of a private car, is expected to be reduced to about 60-65 per cent in the next ten years. It may be assumed in this connection that substituting 1 kg of plastic material for a heavier metal results in about 1 kg reduction in vehicle weight, and that vehicle weight is reduced by about 1.3 kg for every kilogramme of aluminium used to replace mild steel or cast iron. Moreover, new "high strength steels" have yield strengths one and a half to three times the yield strength of conventional low-carbon steel.
- c) Reduction of aerodynamic drag coefficient (C_x), which in the past has been generally well over 0.4 for styling reasons. Being an inverse function of the vehicle length, this coefficient could easily be reduced for the medium and upper categories of the private car range. Reduction should also be encouraged of pumping, lubricating, gear-box and transmission losses as well as of rolling resistance.

According to various sources, an approximately 30 to 40 per cent potential fuel economy gain and some reduction of the emitted mass of pollutants might be progressively expected from the overall introduction by the motor vehicle industry in the United States of America of the measures given in a) to c) above. These potential gains may be significantly lower when considering the European and Japanese automotive production, where the average private car, of lower weight and power, of smaller engine cubic capacity and of lower fuel consumption, cannot presently be compared with those of the United States of America domestic production. In this respect it is essential that vehicle drivers keep in mind the fuel economy obtained when operating various model year, size and weight car categories, especially in city driving.

- (v) There has been a progressive reduction in the lead content of fuels marketed, principally in developed countries. Depending on local refinery patterns and sources of crudes, production of low and non-lead fuels of high octane rating (greater than approx. 95 RON) may be accompanied by an energy penalty of approximately 2 to 3 per cent. Where removal of lead is not required for the use of catalytic emission control equipment, a few countries have currently legislated a trade-off level of 0.4 g lead/litre for premium grade fuel, and are progressively reducing levels 1/.
- (vi) Energy policies vary from country to country depending on their available energy resources, and it is for each country to assess the best use of its fuel resources, especially in relation to the needs of the transportation sector. When alternative fuels for motor vehicles are readily and economically available, authorities should encourage the use, for example, of LPG or LNG 2/, associated with the necessary protection measures in relation to transport and storage of these fuels and, as appropriate, of alcohol blended with petrol including anti-corrosive materials for the fuel system when using methanol.

For instance, in Brazil, a country that is heavily dependent on imported oil, alcohol production in 1979 met 14 per cent of the national automotive fuel needs. Use of petrol alcohol blends would result in hydrocarbon savings and, in most cases, some reduction in exhaust emission levels but a small increase in hydrocarbon evaporation. It must be borne in mind that use of alcohol blended fuels results in higher aldehyde emissions, which are considered to be important precursors of photochemical oxidant air pollution. Where alcohol is produced from agricultural products, attention is drawn to the need for good environmental management of agro-industrial operations. In a longer time frame hydrogen may be developed as a fuel at an acceptable cost and safely employed in motor vehicles. Moreover, in the field of urban transport, use of trams and trolley-buses should be encouraged when local electric energy production, particularly based on hydropower, may contribute towards hydrocarbon fuel saving and environmental protection.

- (vii) Also in the longer term, alternative power systems under development and requiring more R and D to be economically mass produced and used, such as external combustion engines of the Stirling or Brayton cycle, and high energy density batteries for electric vehicles in urban areas, may ultimately provide, in certain applications, a potential for fuel saving and environmental protection.

1/ A reduction of lead in petrol to a maximum concentration of 0.4 g/l (with a minimum concentration of 0.15 g/l) as from 1 January 1981, is recommended by a Directive of the European Economic Commission (J.O.C., 22 July 1978).

2/ LPG: Liquid Petroleum Gas
LNG: Liquid Natural Gas

Finally, and at the international level, authorities should express their interest in and address their efforts toward examining fully, at least, the possibility of achieving a common internationally acceptable "test procedure" for motor vehicle emission control and for measurement of fuel consumption, as has recently been achieved for the emission "measurement method" by the Group of Experts in the Construction of Vehicles of the United Nations Economic Commission for Europe. First discussions have shown that for developing a common emission control test procedure for passenger cars and light duty vehicles a lengthy process would be required, in which goodwill from all parties concerned is essential. Authorities should bear in mind that, if feasible, a harmonization of the three existing test procedures in force in Europe, Japan and the United States of America would eliminate certain impediments to international trade and simplify the various costly laboratory tests carried out by manufacturers for vehicle certification, whilst keeping the emission control levels required under the strict responsibility and decision of each country or region concerned. Since the UN/ECE has recently adopted a United States of America C.V.S. ^{1/} test procedure as a basis for emission control relating to heavy duty diesel powered vehicles, it is anticipated that there will soon be agreement on an internationally acceptable test procedure for certification of these types of vehicles.

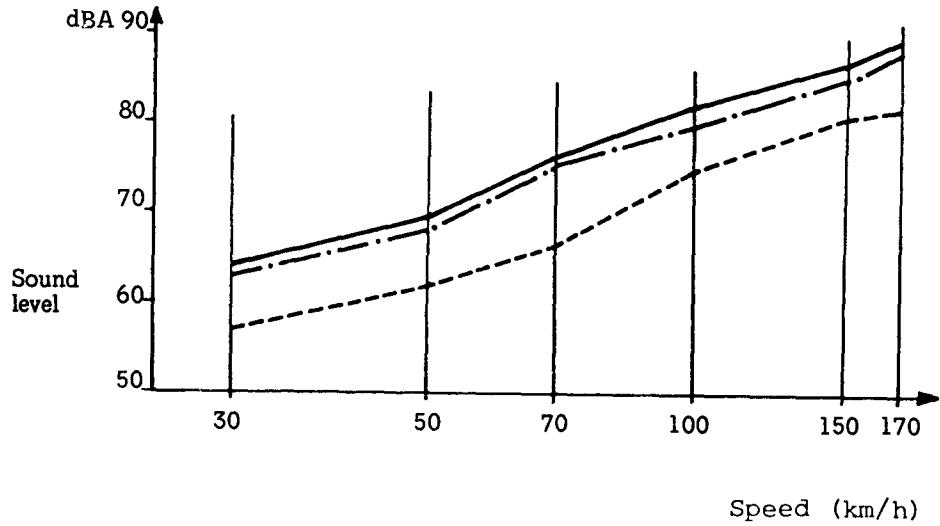
B - Noise Control

Although of a different nature, as for pollutant emission control, trade-offs between conflicting objectives relating to motor vehicle noise control require an analysis of the problems and related factors, prior to defining control levels involving different technological approaches. Determination is required on the part of authorities to define priorities and to tackle environmental problems in relation to noise. In this respect, decision makers should bear in mind the following considerations:

- (i) Particularly in metropolitan areas, noise directly affects senses, and consequently the quality of the urban environment, more than any other nuisance stemming from technical progress. Urban noise is an erratic combination of "peak noise" and background noise of a lower intensity ranging from about 50 to 70 dBA, for which motor vehicles are regarded as one of the major contributors. This is in spite of the significant progress achieved in the last decades in silencing exhausts and reducing mechanical noise. Noise disturbs sleep and may be a cause of stress.
- (ii) Four-wheeled vehicles (passenger cars, public transport and commercial vehicles) and two-wheeled vehicles (motor cycles and mopeds) present different characteristics, as far as their acoustic energy emission and radiation are concerned. Experience has shown that, especially in urban areas, commercial vehicles and motor cycles are responsible for the majority of "peak noise" emissions recorded in traffic.

^{1/} C.V.S.: Constant Volume Sample

CAR
— Pass-by noise
- . - . Rolling noise
- - - - Engine noise



TRUCK
— Pass-by noise
- . - . Rolling noise
- - - - Engine noise

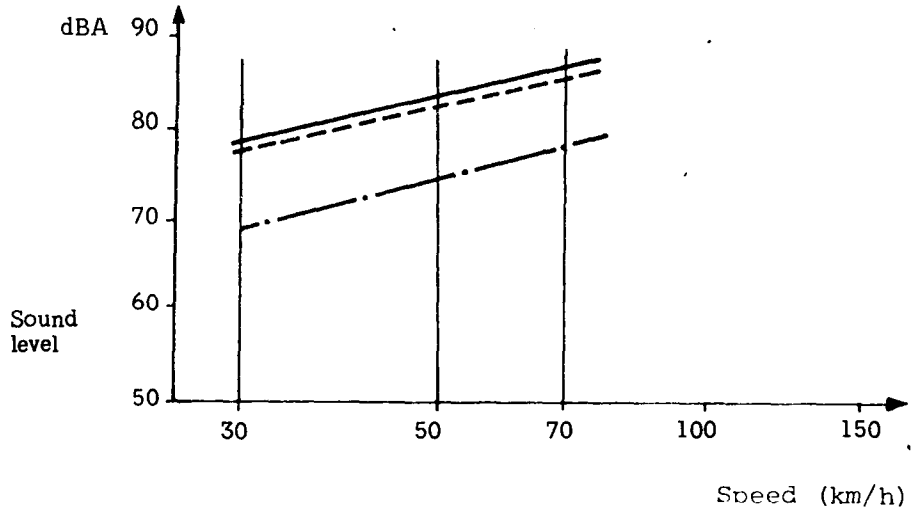


Fig. 6 and 7 Sound level of car and 3.5 t truck pass-by and rolling noise on dry concrete pavement, according to Frietzche ^{1/}, and calculated sound level of engine noise as a function of speed. (Mean of 13 types of car, and 11 types of truck - Unaccelerated runs in direct gear on level road. Pass-by with microphone at 7.5 meters).

^{1/} See footnote 1, page 17.

(iii) Concerning the four-wheeled vehicles, both acoustic energy generation and radiation should be considered. For these vehicles, the noise control levels enforced in Europe, Japan and the United States of America generally result in a minimum exhaust pipe noise, achieved by means of advanced silencers using gas expansion and noise frequency interference techniques. It may be difficult technically to further reduce this source of noise. Conversely, exploration should continue of ways and means to reduce the following acoustic energy emissions and radiations which are unrelated to exhaust :

- fan aerodynamic noise, particularly from air-cooled engines,
- mechanical noise from the engine cylinder block and crank case, gear box transmission and alternators,
- rolling noise from tyres in contact with the road.

Fig. 6 and 7 taken from VDA "Urban Traffic and Noise" 1/ show the respective average sound level attribution from car and truck rolling and engine sources at various constant driving speeds. The substitution of larger engines with lower RPM for engines of smaller cubic capacity and higher RPM coupled with higher transmission ratios, should also be considered in association with related parameters which may be included in vehicle taxation criteria. Many industrialized countries are considering the possibilities of progressive reduction in noise emission levels of motor vehicles of 5 to 10 dBA according to the vehicle type 2/. Attention is drawn to the fact, however, that different noise measurement methods are used in different parts of the world (see page 19).

(iv) Diesel equipped vehicles are noisy by the nature of the engine combustion under very high compression. Public transport and heavy commercial vehicles require special consideration, and authorities should pay particular attention to their proper maintenance and periodic inspection, including their silencing devices. Authorities should also encourage research and development on advanced diesel engine technology, and appropriate engine and transmission encapsulation which, when applied at the vehicle design stage, may reduce their acoustic energy emission and radiation. Incentives should also be given to implement "quiet truck and bus" demonstration programmes where the cost-effectiveness of the solutions demonstrated would be the major aspect to be considered. Such programmes could be complemented by appropriate durability tests to provide data on degradation of noise emission levels as a function of use, age and service. Concerning buses, the interior noise issue should also be considered.

1/ VDA: Verband der Automobilindustrie (Motor Vehicle Manufacturers Association), Frankfurt, Federal Republic of Germany, 1978.

2/ See Conclusions of the OECD Conference on Noise Abatement Policies (Paris, 7-9 May 1980) and UN/ECE Group of Experts on the Construction of Vehicles (WP 29) 60th session, March 1980, Geneva.

- (v) Noise control for motor cycles appears to be one of the most complicated issues amongst those relating to environmental protection and motor vehicle use. Owing to the weight limit, high engine power/cubic capacity ratio, resulting in high engine RPM for maxi torque, have to be used on most motor cycles. Moreover, since, for reasons of cooling and handling in cross-winds, the engine and gear box cannot easily be encapsulated or protected by sound proofing cover, the problem of their acoustic energy radiation remains difficult to solve. However, more than other current road transportation noise problems, the motor cycle noise issue may be seen more as a problem of use rather than one of an originally noisy machine. In this connection, in every country, many new motor cycle owners erroneously believe that they can get extra engine power by tampering with the silencer equipment. As a result, more replacement silencers, which are less effective than the original are manufactured and sold, and consequently, more "peak noise" from motor cycles when overtaking is observed in urban areas. Both public education and Government regulation are needed to progressively correct this situation. Authorities who have not done so are therefore encouraged to adopt both road-user education programmes and noise regulations such as those already enforced or in preparation in Europe, Japan and the United States of America. These regulations should include noise standards and a labelling requirement which, for example, would certify to vehicle owners and the police that a motor vehicle, and especially a motor cycle, equipped with a specific replacement silencer complies with the noise level prescribed.

Amongst the technological approaches which may be considered to decrease motor vehicle noise emission, some may conflict with other environmental objectives, such as safety and fuel economy. For instance, reduction of rolling noise under wet and dry conditions through smoother road surface may give rise to dangerous deterioration of the tyre grip on roads under wet conditions, whilst stone or wood-paved streets give rise to both poor adherence and noisy rolling operation. In the same way, some tyre designs, developed to provide good adherence, lower rolling resistance and improved fuel economy, may be noisier than conventional tyres. It has also to be noted that, for a given vehicle, larger engines with lower maxi RPM, favourable to the reduction of exhaust and mechanical acoustic energy emission, may penalize fuel economy when associated with weight increase or inappropriate transmission ratios. These examples highlight the complexity of the noise reduction issue, and the necessity for the vehicle owner to respect the manufacturers' specifications (i.e. type and pressure of tyres, axle ratio) and for authorities to have an integrated approach towards environmental and fuel economy requirements.

Within an overall strategy aimed at improving the noise situation in urban areas, abatement of acoustic energy emissions from motor vehicles should not be developed in isolation, but be associated with appropriate measures related to improved traffic conditions and road surface, land use planning and siting of residential areas, as well as to the progressive use of sound absorptive materials in buildings and in sound barriers along major highways in urban areas (see also page 2, (iii-iv)). In this respect, for example, the possibility of two people holding a conversation at normal level, between 2 and 3 meters apart in a dwelling,

along any urban road, should be, amongst others, a reasonable and practicable objective. This implies that peak noise should be eliminated and background noise level during the daytime should be less than 60 dBA (as measured at the facade of the building). Fig. 8 illustrates this 1/.

As for pollutant emission control, there is a need for an internationally acceptable test procedure for noise measurement, and efforts should be addressed to reaching agreement on the definition of a common noise testing procedure which, in any case, would better reflect traffic noise than the existing SAE J 986 and ISO R 362 2/ test procedures currently in use. Proposals have been made by the United States of America Environment Protection Agency and the Committee of the Common Market Constructors (CCMC), whilst the Group of Experts on the Construction of Vehicles of the UN/ECE has recently adopted a slightly modified and more appropriate version of the ISO R 362 method. However, these solutions differ significantly, mainly with regard to vehicle approach speed and acceleration and position of microphones in the measurement area. No agreement has yet been concluded as regards the adoption of a common and appropriate noise testing procedure. At the same time new trends are being observed in the evolution of the car market, where there is an increased registration of smaller and lower powered cars in the United States of America. Furthermore, the trend for more diesel equipped cars in Europe is being followed in the United States of America. Both of these trends may change progressively the traffic noise conditions.

C - Vehicle Safety

According to the World Health Organization (WHO), a quarter of a million people are killed every year in road accidents, and amongst the several millions injured, there is an increasing importance of disability. In most industrialized countries, however, the number of road casualties has been appreciably reduced over the last few years. Whereas in developing countries, where the car population is expected to treble by the end of the century, road accident mortality rates approach, and in some cases exceed, mortality rates due to some endemic diseases 3/.

The promising reduction of traffic accidents and road casualties in industrialized countries is the result of technical progress in vehicle design and the introduction of safety regulations governing vehicle characteristics, accident prevention and occupant protection, associated with improvements in road infrastructure, traffic conditions, such as better signalling and speed limits, and in drivers' behaviour, including

1/ Report "Bruit des Véhicules en Circulation" (Motor Vehicle Noise in Traffic), October 1978, prepared by Mr. Frybourg, Institut de Recherche des Transports, Arcueil, France.

2/ SAE: Society of Automobile Engineers
ISO: International Organization for Standardization, Geneva.

3/ World Health Statistics, 6th Report, World Health Organisation, Geneva, 1979.

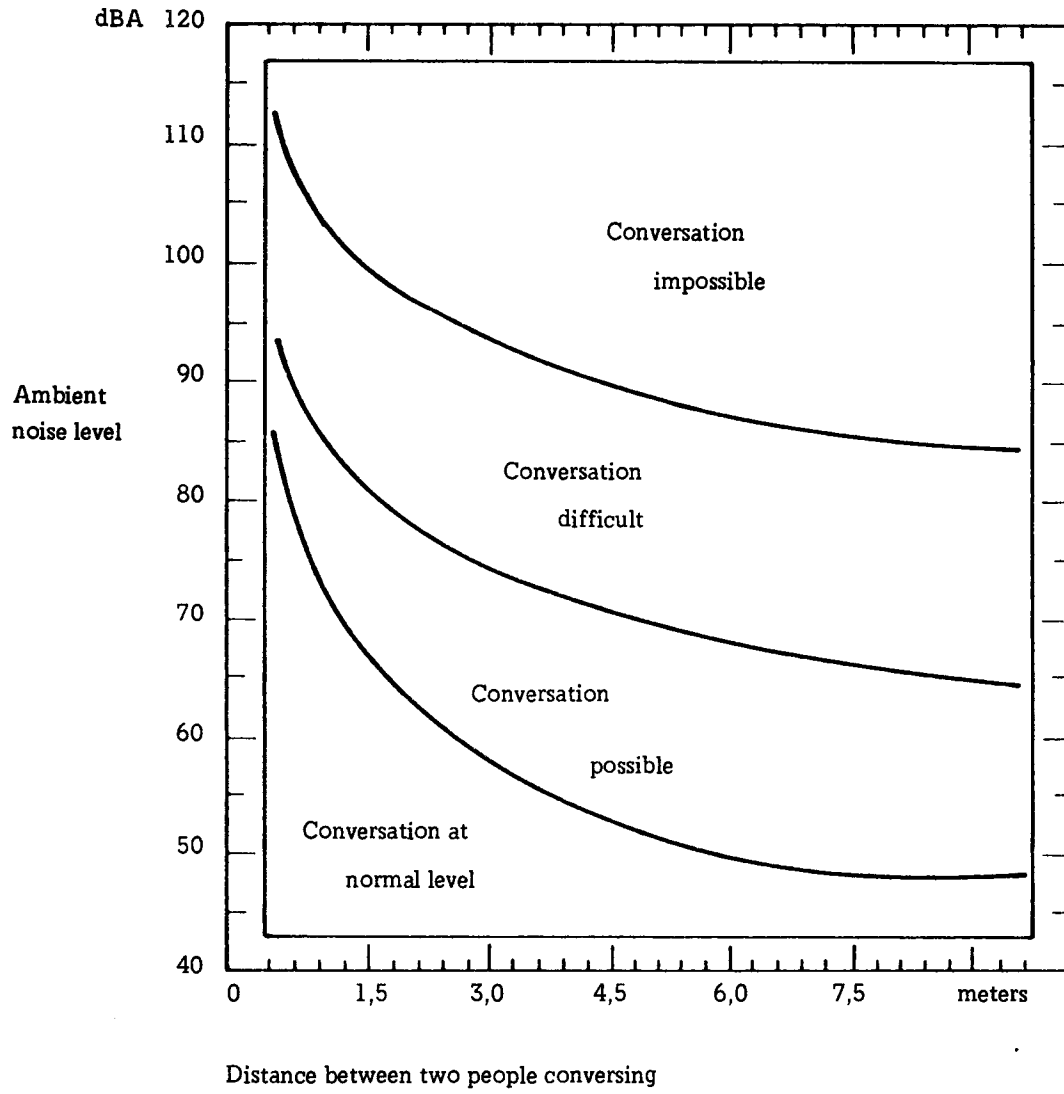


Fig. 8 - Distance between two people conversing

use of alcohol. As far as the vehicle is concerned, authorities should encourage efforts already being undertaken at national and international levels in relation to both vehicle occupant protection and road accident prevention in the following fields:

- Statistical information regarding road accidents, their definition, including agreed criteria for road death, their cause and the way in which injuries and fatalities occur; this information to be associated with improved biomechanical data concerning the relationship between vehicle deceleration, deformation or crushing and the severity of occupants' injuries. This should include a better co-operation between biomedical and biomechanical experts.
- Energy absorption technology with particular attention being paid to the complex problem of side collision, and the case of small vehicles, less aggressive on impact due to their lower mass and normally more manoeuvrable for accident avoidance but handicapped by their low crushing and energy absorption performances, when operating in mixed and heterogeneous traffic.
- Restraint systems for vehicle occupants which should be improved for better acceptance by drivers and passengers, thus increasing the use of restraint systems without sacrificing performance.
- Design characteristics providing improved accessibility of essential safety components for easier and low cost maintenance.
- Braking systems including improved braking devices for optimum performance under all-weather road conditions (heavy rain, ice, etc.).
- Protection of vehicles' safety equipment, including lighting and signalling devices, against damage in urban traffic low speed collisions as is the objective of existing United States of America Department of Transportation (D.O.T.) regulations. A regulation on this subject has also been elaborated by the UN/ECE.

Particular attention should be drawn to the problem in cold climate countries of the adverse effect of salting for ice control of roads, as the sodium or calcium chloride, currently used in winter road maintenance practices, contributes to air and ground water pollution with potentially unfavourable effects on vegetation and providing a possible health hazard to the population through drinking water. Experiments conducted in Canada and Europe of alternative products for ice control on roads and of new technological improvements in road construction should therefore be continued.

In developing countries, the issues of road safety and accidents are more generally associated with factors depending on local conditions, relating to road infrastructure, traffic management, driving regulations, drivers' training and behaviour, and vehicle loading and maintenance. Whilst authorities of developing countries should require that vehicles sold in their countries be fitted with safety equipment tailored to suit local conditions (i.e. air filters, suspension, brakes, etc.), when they have not done so, all countries should also promulgate

appropriate legislative measures relating to the following fields, according to their needs and resources:

- Road construction, road signs and traffic signals complying with the International Conventions on Road Signs and Marking and the Consolidated Resolution (1977).
- Periodical vehicle inspection to check essential safety equipment (see section D below).
- Driving regulations as well as appropriate training and testing, to be nationally applied, for various categories of driving licence applicants, the guiding principles for which have already been developed on an international basis by UN/ECE in liaison with WHO 1/.
- Compulsory wearing of seat belts, at least in front seats, a measure whose cost-effectiveness has been amply proved where applied in industrialized countries.
- Compulsory wearing of efficient crash helmets by all riders and passengers of two-wheeled motor vehicles, a measure already adopted with various modes of application in many developed countries. In this respect, a UN/ECE regulation 2/ defines essential safety characteristics and test procedure for type approval, to be applied to newly manufactured crash helmets.
- Limits on the number of hours that bus and truck drivers, at least, are allowed to work without a break, taking as a basis ILO 1969 Convention No. 67 on hours of work in transportation, and complementary information given at the ILO 64th International Conference held in 1978.
- Strict loading conditions for buses and commercial vehicles according to regulations and manufacturers' specifications, with associated police control to ban overloading conditions.
- Road transport of dangerous goods in accordance with international conventions.

Special attention is drawn to the two following safety areas, where a considerable amount of work has already been done in Europe, Japan and the United States of America, which raise especially complex problems due to the number of physiological and technical parameters involved:

- Protection against head-on collisions between motor vehicles and pedestrians or cyclists, which represent 30 to 40 per cent of road accident fatalities in most countries.

1/ These basic principles are part of the "Recommendations on Minimum Requirements Concerning Professional Instruction for Motor Vehicle Driving" (Revised text Ref. No. 30/SC/1/294 - 14 December 1979, included in the UN/ECE Consolidated Resolution on Road Traffic).

2/ Regulation No. 22.

- Protection of child vehicle occupants through seat and restraint systems scientifically designed to suit the child morphology and physiological reaction to deceleration. A regulation on this subject has been elaborated by the Group of Experts on the Construction of Vehicles of the UN/ECE 1/.

In developing further regulatory requirements, authorities should aim at reconciling improved safety and fuel economy, bearing in mind that vehicle weight is the major factor affecting fuel consumption (see page 13).

Needless to say, for those countries which have not done so, elaboration of the above measures and their enforcement require a considerable amount of legislative preparation combined with an adequate administrative machinery as well as information and co-operation of the public, conditions which cannot be simultaneously obtained without a strong determination to reduce the road accident rate and its adverse human and economic impact. In this connection, attention is drawn to the study "Road Accidents as a Cause of Death in Developing Countries" by the Transport and Road Research Laboratory (United Kingdom).

D - Maintenance and Inspection

It is worth noting that, in the previous paragraphs of this section, vehicle maintenance is emphasized as a major issue in ensuring the original performance in use of a motor vehicle as regards emissions, noise, fuel economy and road safety characteristics. Vehicles have a lifetime up to and sometimes exceeding ten years in most countries after which HC and CO emissions are usually about twice those of the vehicle when new. A recent United States of America Congressional Office of Technological Application Report (19 March 1979) indicated that without any emission control system maintenance, pollutant emissions from ageing vehicles progressively may increase up to from 6 to 8 fold after a vehicle has been on the road a decade. For example, it has been assessed that a very significant proportion of the air pollution problem related to the automobile use in urban areas could be solved by reducing the observed deterioration factors affecting emission performance and fuel economy of the vehicle population (approximately 100 per cent for HC and CO, at 80,000 km, according to United States of America/EPA observations). This could almost be achieved by strictly maintaining and repairing vehicles during their lifetime, in accordance with good engineering practice and the motor vehicle manufacturers' specifications.

Lack of adequate motor vehicle maintenance, resulting in maladjustments and lack of replacement of worn-out equipment, is generally observed in many places throughout the world. In those countries where garages and dealers' workshops are well equipped, and the training of mechanics at repair shop level is adequately conducted in specialized schools applying national or local education programmes, inadequate maintenance and repair are generally due to lack of professional motivation and insufficient recruiting, possibly due to low wage levels and lack of career opportunities. Appropriate incentives, information and counselling would correct this situation and increase recruitment.

1/ Regulation N°44.

In most developing countries, poor vehicle maintenance and repair result from both insufficient garage equipment and spare parts, as well as lack of adequately trained mechanics. The question of equipment and spare parts raises for many governments a problem of foreign currency availability, and especially for spare parts, a cost problem for customers since high transport costs for small quantity dispatching is combined with generally high resale profits by dealers and garages. These problems should be alleviated through adequate management in co-operation of industry with its local import, distribution and retail organizations. Moreover import into a number of developing countries of ageing vehicles which cannot be properly repaired and maintained, contributes to both the road accident situation and environmental deterioration. Import control of these vehicles should therefore be encouraged. However, training of mechanics is by far a more complex issue, and requires from authorities a detailed and realistic evaluation of the situation including evolving needs and resources, complemented by an educational programme committing all parties concerned. This should be undertaken at national level since it is a national responsibility to improve a situation, that may be worsening, where the serious shortage of well trained mechanics is combined with the fact that more and more competent personnel will be required as the number and technical complexity of motor vehicles will increase over the coming years.

A number of documents and programmes have been published by Governments and industry in various countries, giving basic measures to be taken for recruiting and training automotive service mechanics. They generally give practical information and criteria relating to:

- training organization, including co-operation with the automotive service industry;
- establishing training advisory committees at national level or local levels (role and composition of these committees);
- teacher qualification and training;
- students' profile, training programmes and counselling during instruction;
- teaching facilities;
- training tests;
- career development.

This information has been elaborated in general for the need of industrialized countries. However, after careful study and evaluation in co-operation with the local automotive service industry, the motor vehicle manufacturers and international organizations (e.g. ILO and UNIDO ^{1/}), it may be transferable and adaptable to most situations in many developing countries, provided local needs and resources are taken

^{1/} ILO : International Labour Office
UNIDO: United Nations Industrial Development Organization.

into consideration. In this connection, certain documents 1/ could be of significant interest to the authorities concerned in developing countries and, in most cases, may be useful in the setting up of an adequate organization of training personnel involved in motor vehicle servicing at the national level. In the same area, ILO has developed a "Modules of Employable Skill" (M.E.S.) training methodology using basic training elements which can be assembled in a flexible manner to meet a variety of mechanic training needs which may be encountered. A manual is being developed for the education of motor vehicle mechanics.

Although controversial in some industrialized countries, which may only perform spot checks and inspection on a voluntary basis, regulations requiring vehicles to be periodically inspected to ensure that essential servicing is adequately carried out should be considered in developing countries. With the co-operation of the motor vehicle manufacturers who deal in the local market, authorities are encouraged to introduce periodic mandatory vehicle inspections covering certain essential aspects e.g. carburation and ignition setting, smoke emission for diesel engines, steering, braking, lighting and signalling systems, silencers and tyre condition.

As far as the testing of vehicle emission control performance is concerned, whilst there is a simple measurement method for diesel smoke emission using inexpensive equipment (opacimeter to measure the light absorption coefficient) there is no appropriate measurement equipment and single test procedure existing, or to be expected in the short term, for ordinary inspection centres or dealer service workshops, which permit checking of the vehicles' real performance, under driving operation, with respect to CO, HC and NO_x emissions. This can only be done in specialized laboratories using complex, expensive equipment, as well as employing the test procedures and measurement methods for vehicle type approval or for assembly line testing for pollutant emission control. At the inspection centre and garage level, combined with inspection of the silencer, approximate noise performance may also be assessed. On the other hand, CO and HC emission levels at various RPM and engine loads can be measured by using simple, inexpensive, portable infra-red analyzers. Thus, CO concentration at engine idle may be tested and a maximum concentration prescribed, as is done in UN/ECE emission control Regulation No. 15, and has been further adopted in a number of countries for testing vehicles in use. In the United States of America, the Environment Protection Agency is engaged in a substantial programme of emission inspection and maintenance (I/M Programme) for vehicles in use which includes an "idle test". As already experienced in Europe 2/, in the light of results obtained in a

1/ See for example "Action Handbook for Automotive Service Instruction" and the "Career Development Standards for Vocational Automotive Service Instruction" prepared by the Motor Vehicle Manufacturers Association of the United States of America and the American Association Industry Planning Service; and the Syllabus for Training of Motor Vehicle Mechanics, prepared by the Swedish Automobile Servicing and Retailing Employers Association (MAF).

2/ See UN/ECE document TRANS/SC1/WP.29/36.

number of States in North America conducting such I/M programmes, the "idle test" is considered to be of prime importance in identifying high CO and HC emitters in need of remedial maintenance or repair, mainly for carburation and ignition. Whilst the vehicle emission CO concentration under engine idle (or even under specific load) conditions does not entirely reflect the overall vehicle emission performance, it is the only control which can easily and inexpensively be applied in inspection centres and dealer service stations. Moreover, associated with electronic diagnostic equipment which is more and more used in industrialized countries, periodic carburation and ignition setting to obtain the minimum CO concentration at idle prescribed by the manufacturers' specifications, would result in significant improvement in the urban atmospheric conditions with respect to this pollutant. In most countries it is observed that about 30 per cent of driving time in urban areas at peak traffic periods is spent under engine idle conditions (stops at traffic lights and in congested traffic). In this connection, the two documents approved by the French Ministry of Environment 1/ provide valuable information regarding CO concentration measurement at idle, and related carburettor and ignition setting.

Due to the need for provision of testing equipment and well trained personnel, periodic inspection schemes need to be progressively introduced by starting with inspection of older vehicles. With respect to establishing the related legislative provisions, administrative machinery, technical requirements and basic inspection operations, attention of authorities in developing countries is drawn to the assistance which may be provided by the International Motor Vehicle Inspection Committee (C.I.T.A.), the Union of Technical Motor Assistance for Motor Vehicles and Road Traffic (UNATAC), and the UN/ECE, which have formulated general vehicle inspection criteria, as a contribution towards harmonizing minimum vehicle inspection standards at the international level.

III - ROAD USER EDUCATION

Co-operation of the population, as road users, is an essential prerequisite to the efficient implementation of any action or measure taken for environmental improvement, road safety and fuel economy in relation to motor vehicle use. Public information and education are required in two different fields: behaviour in traffic and education of vehicle drivers. It should be noted that the type of public information campaigns which will be most effective for a given country will depend on the socio-economic conditions and level of literacy.

General Approach to Good Behaviour in Traffic

General traffic education should be taught in school at all levels through appropriate courses and practical training to be included in student educational curricula. It should concentrate on road safety, providing for everyone, traffic rules applied to pedestrians, cyclists

1/ See "Valeurs de réglage CO et CO₂" and "Mise en conformité anti-pollution d'un véhicule à essence", Ministère de l'Environnement et du Cadre de Vie, Paris, France (1977).

and motor vehicle users, emphasizing the dangers involved in infringing the road traffic rules, and helping to develop a good road sense, as part of the overall sense of responsibility towards each member of the community as well as the community itself.

This basic education at school level should be periodically associated with publicity campaigns through radio and television, where essential road traffic rules should be recalled and the public should be sensitized to specific causes and results of major road accidents. Traffic police, insurance companies, health services and specific organizations devoted to the road accident prevention, should be called upon to participate in these publicity campaigns and to prepare related educational programmes. In this context, attention is drawn to a number of WHO reports 1/ which could provide guidelines for appropriate action.

Drivers' Education

It is essential to bear in mind that drivers themselves, according to statistics and various surveys, are responsible for most road accidents, and that the vehicle driver or owner can do much to reduce the environmental impact on his vehicle, such as pollutant and noise emission, to keep up its safety performance, and to reduce its fuel consumption. In this context, driving schools should be established, organized and controlled, according to local needs and conditions. Consideration should be given to mandatory attendance by all driving licence applicants.

Existing driving school training programmes have usually only covered road traffic rules and signalling, as well as appropriate vehicle driving operations under normal and emergency conditions on the open road and in urban traffic. Where it has not been done, these programmes should also include the following environmental, fuel economy and road safety aspects:

- Development of a basic attitude of good road behaviour associated with a sense of responsibility to other road users.
- Encouragement of driving behaviour which leads to fuel saving combined with reduced pollutant and noise emissions. In this context, brochures are available from motor vehicle manufacturers concerning vehicle characteristics, including appropriate operating modes related to gear box/transmission ratios and engine RPM for maximum torque for motor vehicle types which they produce. Manufacturers should ensure that these brochures are readily available to driving schools and adapted in presentation to the local conditions, particularly in developing countries.
- Motor vehicle maintenance and its impact on pollutant emissions, noise and fuel economy performance (see section II-D above). In this area, attention of driving licence applicants should be drawn to the necessity of strictly maintaining their vehicles according

1/ See "Education on Traffic Safety" (ICP/ADR 013) and "The Role of Health Services in the Prevention of Road Traffic Accidents" (ICP/ADR 038), WHO/EURO, Copenhagen, Denmark.

to manufacturers' specifications and the inspection schedule, as indicated in the "maintenance booklet" delivered to customers with their vehicle. Motor vehicle manufacturers and distributors should also encourage customers to follow the specifications, applying good engineering practice.

- First aid to be provided to injured people in road accidents pending arrival of an ambulance service and transport to hospital, as appropriate.

To complete this basic driver educational programme, here again specific information campaigns should be periodically conducted through the mass media to remind drivers of their essential responsibilities and duties in relation to the educational aspects mentioned above. This should be done in co-operation with the traffic police, the automotive service industry and the national health authorities. In this context, attention is called to the work and documentation of the International Touring Alliance (A.I.T).

SUMMARY AND CONCLUSIONS

A single solution or an arbitrary set of measures cannot resolve the complex environmental issues related to motor vehicle use. Environmental problems vary in severity from country to country and region to region, according to specific local conditions. Their solution may be costly for the individual and the community when measures are not carefully prepared and tailored to suit local needs and resources or technological availabilities. Moreover, environmental protection, which calls at least for the combined reduction of CO, HC, NO_x and noise emissions, the improvement of vehicle road safety performance and the preservation of scarce, and more and more expensive energy resources, often results in conflicting requirements. This situation, therefore, requires insofar as possible that a precise identification and definition of the environmental, road safety and energy problems related to motor vehicle use, be carefully carried out as well as a cost-effectiveness evaluation of the measures and technical solutions contemplated, taking into consideration local needs, resources and health and social priorities.

Measures directed towards maintaining the original performance of vehicles in use as regards environmental aspects, particularly emissions, should be considered as a priority action for environmental quality preservation. It will require co-ordinated efforts of authorities in educating motor vehicle users to maintain their vehicles in compliance with good engineering practice and motor manufacturers' specifications, and of industry in promoting emission control technology requiring simple and inexpensive service operations and in reducing the emission degradation factor by preventing maladjustment and tampering, as well as in training of maintenance and repair personnel.

Land-use, city and regional planning as well as transportation policies for urban areas are important factors in energy saving and improved environmental quality in relation to the motor vehicle. Close association of authorities responsible at national and local levels for urban planning, environment, energy and transportation is needed to define

the most effective local solutions ensuring the rational use of motor vehicles and smooth traffic flow. Cost-effective results can generally be obtained by improved management of existing resources combined with various inexpensive measures.

Government and industry should co-operate in implementing technological developments covering engine and vehicle design and construction, with priority given to the reduction in weight of vehicles; new structural technologies giving adequate crushing and energy absorption, especially in side collisions, and improved pedestrian protection, together with the preventive technologies, which are generally considered cost-beneficial for emission abatement and fuel economy, through electronic monitoring of lean mixture fast combustion, ignition and variable transmission, super-charging, advanced ceramic coating, etc. It is anticipated that use in vehicle construction of new materials which are less subject to corrosion as well as new treatment processes for construction materials will further improve the durability of vehicles.

Traffic regulations and essential safety measures should be included in every country's legislation. Education of all road users should be included in student educational curriculum, supported by periodic public information campaigns. Driving school training programmes should include environmental, fuel economy and road safety aspects relating to driving modes and vehicle maintenance.

Research and development on alternative advanced power systems (gas turbine, Stirling cycle, hybrid systems, advanced batteries with high energy densities, etc.) and alternative fuels should be pursued. In relation to the increasing production and use of diesel equipped vehicles, an adequate analysis of the particulate emissions and their potential health effects as well as more effort to reduce overall emissions from diesel engines are needed.

For the developing countries with fast growing motorization, the environmental, fuel economy and road safety issues take a different turn from the industrialized countries, since the lack of local resources generally prevents authorities from fully undertaking the necessary measures with a view to simultaneously abating pollutant emissions from both stationary and mobile sources, abating noise emissions from traffic and reducing road accidents, while saving energy. The following principles may help these countries to improve an environmental and road accident situation which, in many cases, is worsening and of serious concern:

- Priority should be given to improving the service and maintenance of the motor vehicle population by conducting periodic educational campaigns sensitizing vehicle owners and users to the importance of properly maintaining their vehicles (private cars, motor cycles, buses, intermediate personal transport and commercial vehicles), and by establishing adequate national programmes for training fleet, garage and dealer workshop personnel. This should be carried out in liaison with the motor vehicle manufacturers and the support as necessary of international bodies concerned (UNIDO, ILO, etc.). Availability of spare parts and equipment should be ensured by the manufacturers and local importers and dealers at a reasonable price in order to prevent excessive foreign currency

expenditure and not discourage customers from properly maintaining and repairing their vehicles. It should be kept in mind that if vehicles in use were maintained and repaired in accordance with the motor manufacturers' specifications and if import of beyond repair ageing vehicles were prohibited the worrying environmental and road accident situation observed in the majority of these countries would be greatly improved.

- Periodic mandatory inspection of the vehicles in use should be established to check essential vehicle safety equipment (braking, steering and lights), tyre condition and noise and pollutant emission (e.g. silencer condition, CO measurement at idle, carburettor and ignition setting and smoke emission from diesel engines). This requires inexpensive and simple test equipment as well as low cost operation.

- Studies should be undertaken to explore the whole range of ways and means which, in relation to local needs and resources, may contribute to improved road safety. Where they do not exist, driving and traffic regulations, as well as related training programmes for driving licence applications (to be applied nationally) should be promulgated, incorporating safety measures protecting vehicle occupants such as wearing of seat belts and respect of maximum loading of all private and public vehicles, protection of cyclists and pedestrians, controlling the use by drivers of alcohol, drugs and medicines. Training should also include relevant aspects of public health and sanitary education: application of these measures necessitates establishing driving schools, besides the appropriate administrative structures as well as surveillance by the traffic police.

- Over and above the measures for improving the environmental and safety performances of vehicles in use, there may be a need for the establishment of motor vehicle emission control regulations to be applied to newly registered vehicles. This may be particularly the case of those developing countries manufacturing motor vehicles. Determination of a country's need for new motor vehicle emission control involves the generation of data on current levels of urban pollution accompanied by a projection of future levels if emissions are not controlled, and the part of the pollutant concentration imputed respectively to stationary and mobile sources. It also requires judgment on the level of air quality goals that the nation desires and can afford, taking into consideration the cost both for the community and the individual of the technical and administrative measures necessary to achieve these goals. A cost-effective programme of emission control has to be established in close relation to the country's needs and resources, taking into account economic and social conditions. When arbitrarily set, motor vehicle emission control may result not only in inadequately protecting the public health, but also in wasting scarce resources that could more usefully be devoted to solving more serious health and social problems.

These technical steps related to the motor vehicle and its owner should not be seen in isolation, but should be associated with measures for improving traffic flow and establishing integrated transportation systems, including public and intermediate personal and private transport vehicles.

The appropriate elaboration and efficient application of a strategy aiming at simultaneously abating the adverse impact of the motor vehicle use on the environment, road safety and fuel consumption, obviously involve a balance and cost-effective selection of multi-disciplinary measures, taking into account local needs and resources. Co-operation between countries to explore and solve conflicting requirements relating to environmental safety and energy issues in the most cost-effective way, and to harmonize existing and future regulations applied to motor vehicles, should continue through concerned international bodies such as the UN/ECE in liaison with ISO and WHO. Other concerned international organizations such as UNIDO, UNCHS 1/, ILO, and the international financing agencies such as UNDP 2/, World Bank and the regional development banks, as well as specialized bodies such as CITA and UNATAC, and experienced representatives of industry, may also have a contribution to make in support of governmental action. Finally, a strong political will is an essential factor in developing and implementing an effective strategy which may sometimes question customs of the community and individual patterns of behaviour.

1/ UNCHS: United Nations Centre for Human Settlements

2/ UNDP: United Nations Development Programme