Commission of the European Communities

Proceedings of the European Motor Vehicles Symposium

and the Seminar on Accident Statistics

Volume I

Brussels, 9 – 12 December 1975

For about 10 years, motor vehicles design has been increasingly influenced by a number of external factors such as safety or environnmental requirements, saturation of the road network, urban congestion, the long-term depletion of resources, etc. Recently, the problems besetting crude oil supplies and rocketing prices have highlighted the need to pursue energy in the most rational way possible. These factors directly influence demand, and the motor industry must, therefore, adapt its products accordingly. This requires long-term research and very heavy investment, but the path can be eased considerably if industry is aware of future requirements sufficiently in advance. The guidelines for regulations applying to motor vehicles from 1980 on must, therefore, be laid down now in order to enable the motor industry to plan its future production.

Community action to date has brought about the EEC type-approval procedure for motor vehicles, together with several special directives forming part of the programme on the removal of technical barriers to trade. Additions, however, will have to be made which take account of technical progress, current restrictions and restrictions which society will demand in future.

The Community must also be in possession of objective scientific data which will form the basis of future regulations and of valid Community-wide statistics. The aims of the symposium were:

— to coordinate the activities of all interested parties with a view to improving vehicle safety and the protection of the environment, while taking account of the need to conserve energy and raw materials;

— to lay the foundations of a programme for the drawing up of new regulations which take account of the economic, financial and social requirements of both users and manufacturers and incorporate a cost-benefit ratio acceptable to society;

— to pin-point the priorities governing the measures to be taken and to avoid any risk of incompatibility between the solutions;

— to stress both the need for avoiding unilateral national measures and the desirability of laying down procedures enabling the geographical scope of Community regulations to be extended.

Manuscript finished in June 1976.

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Printed in Luxembourg

Catalogue number: CD-22-77-047-EN-C

FOREWORD

This work has been produced in two volumes.
The first is devoted to the opening session along with the first five sessions of the European Motor-vehicle symposium.

The second volume covers the sixth session of the symposium and the seminar on traffic accident statistics as well as the final sessions of the Symposium and the seminar; this second volume also covers the list of participants.

The reader's attention is drawn to the fact that oral interventions were recorded in their original version and their spontaneous character has been preserved.

SUMMARY

SYMPOSIUM AND SEMINAR PROGRAMME

TUESDAY 9 DECEMBER 1975

Morning

OPENING SESSION

Opening address by Mr F.O. GUNDELACH, Member of the Commission of the European Communities

SESSION 1

Chairman : Mr F. BRAUN, Director-General responsible for the Internal Market

Vice-Chairman : Mr C. GARRIC, Head of the Division "Inland transport and new means of transport"

Presentation of paper "Structural strength and compatibility of vehicles in the event of impact" (potential hazard to other means of transport and to pedestrians) by Mr H. TAYLOR of the Transport and Road Research Laboratory

Discussion by the panel

General discussion

Summing-up

Afternoon

SESSION 2

Chairman : Mr S. JOHNSON, Head of the Division "Prevention of pollution and nuisances"

Vice-Chairman : Mr D. VERDIANI, Head of the Division "Removal of technical barriers of an industrial nature"

Presentation of the paper "Noise pollution" (requirements, ways of meeting them and methods of measurement) by Mr J.P. THIRY of the UTAC Laboratory

Discussion by the panel

General discussion

Summing-up

WEDNESDAY 10 DECEMBER 1975

Morning

SESSION 3

Chairman : Mr P. SCHLOESSER, Director responsible for the Movement of Goods

Vice-Chairman : Mr D. VERDIANI, Head of the Division "Removal of technical barriers of an industrial nature"

Presentation of the paper "Protection of vehicle occupants" (biomechanical aspects, performance of various restraint systems) by Mr G.M. MACKAY of the University of Birmingham

Discussion by the panel

General discussion

Summing-up

Afternoon

SESSION 4

Chairman : Mr J. DOUSSET, Director responsible for Financial Infrastructure and Technical Aspects

Vice-Chairman : Mr D. VERDIANI, Head of the Division "Removal of technical barriers of an industrial nature"

Presentation of the paper "Accident prevention by suitable vehicle design" (active safety : braking, road holding, tyres, lighting systems, field of vision, etc) by Mr M. MITSCHKE of the Technische Universität Braunschweig

Discussion by the panel

General discussion

Summing-up

THURSDAY 11 DECEMBER 1975

Morning

SESSION 5

Chairman : Mr D. VERDIANI, Head of the Division "Removal of technical barriers of an industrial nature"

Presentation of the paper "Air pollution" (future requirements, potential technical trends in vehicle design) by Mr E. SIBENALER of the Ecole Royale Militaire Laboratory

Discussion by the panel

General discussion

Summing-up

Afternoon

SESSION 6

Chairman : Mr G. BRONDEL, Director responsible for hydrocarbons

Vice-Chairman : Mr D. VERDIANI, Head of the Division "Removal of technical barriers of an industrial nature"

Presentation of the paper "Rational use of energy and raw materials" from Mr F. SEZZI of the Laboratorio Ricerche e Sviluppo - SNAM PROGETTI by Mr ZANONI of the Ufficio Sviluppo Carburanti, Combustibili e Bitumi - AGIP

Discussion by the panel

General discussion

Summing-up

THURSDAY 11 DECEMBER 1975

SEMINAR

"ROAD ACCIDENT STATISTICS"

Opening address from Mr C. SCARASCIA MUGNOZZA, Vice-President of the Commission of the European Communities by Mrs F. DESHORMES, Member of the Cabinet.

General introduction by the Chairman, Mr J. MAYER, Director-General of the Statistical Office.

Introduction of the paper by Mr E. ANDREASEN, who is responsible for road accident statistics in "Danmarks Statistik".

Discussion by the panel on the needs of the main sectors concerned (health services, police, insurance companies, road safety organizations...) regarding internationally coordinated statistics.

General discussion.

Summing-up.

FRIDAY 12 DECEMBER 1975

Morning

FINAL SESSION

Presentation of the conclusions of the Symposium sessions and of the Seminar by the rapporteurs.

Questions.

Summary of conclusions and definitions of priorities by Mr F. BRAUN, Director-General responsible for the Internal Market.

Statement by Mr P. DREYFUS in the name of the European manufacturers.

Statement by Mr ROSSI in the name of Mr MARTINELLI President of the Council of Ministers of the European Communities.

Closing address by Mr F.O. GUNDELACH, Member of the Commission of the European Communities.

OPENING ADDRESS

OPENING ADDRESS

by Mr F.O. GUNDELACH
Member of the Commission
of the European Communities

Ladies and Gentlemen,

I am very pleased to welcome you all to this European Symposium on the Trends in the Regulations of Motor Vehicle Design.

I am also happy to see amongst you observers from countries outside the Community with which we have close relations both in the technical and commercial sense and I would extend to them a special welcome. The organization of the work of this Symposium would not have been possible without the contributions of the rapporteurs who have so diligently prepared the papers which, I am sure will lead to most thorough discussion of all our main themes. From this debate must emerge the principal lines of action fo our future programme. May I thank the rapporteurs not only on behalf of the Commission but of you all for laying such a sound basis for our work.

We have arrived at a point in our programme for the elimination of technical barriers to trade in the motor vehicle sector where most of the directives envisaged in the first phase have either been adopted or proposed by the Council. This Symposium has, therefore, been organised to fix the objectives on which community action must be based for the next decade. However difficult this looking ahead must be, the economic lifetime of the motor vehicle itself demands that we should look more than one or two years ahead.

To set the framework for your activities, it is necessary to retrace a little the progress of our programme in the elimination of technical barriers for the motor vehicle sector and to assess the results. We all know how complex the interrelationships are between the technical, social and economic aspects of the motor vehicle and how difficult it is to assess the effects of legislation on a cost-benefit basis.

This task is made even more difficult by the complete change in economic conditions in the Community which has taken place in the last two years and against which our proposed future programme must be viewed and it is this that I will take as my starting point.

In common with the rest of the world, the Community's Member States have since the middle of last year been suffering from the worst recession in the post war period. The symptoms of this economic illness have been a drop in demand and production, increased unemployment, a fall in capacity utilization and a persistent rise in consumer prices. Though these effects were worse in some countries than in others by mid 1975 industrial production had fallen in most Member States to the level existing in early 1972, on average a fall of 12.5 % in one year!

The reasons for this situation are many and interlinked but the main causes seemed to be contraction and adjustment arising from the severe inflation, energy crisis, and the policies instituted to fight it, the repercussions on world trade giving a reduction in external demand, destocking, and unwillingness on the part of consumers to consume and of investors to invest. With a reduction of 5–6 % in one year in the volume of world trade, the Community experienced a drop of approximately 20 % by volume in external demand from the industrialized countries and an equivalent drop in exports. Nor was this reduction offset by increased imports by the developing countries, in particular the oil-producing and raw-material producing countries. Capital expenditure, especially in the private sector, continued to decline owing to a very low capacity utilization in industry of about 75 %, the continuing rise in costs and the uncertainty of the economic outlook. The situation on the labour market has deteriorated to an alarming degree so much so that by August 1975 the Community had almost 5 million unemployed.

In the period before this general crisis the motor industry had begun to experience a slackening of growth based on a variety of factors. Near saturation of infrastructures and of the market in the more prosperous countries, the long term scarcity of raw materials, problems deriving from the cost and availability of labour resulting in an increasing number of assembly lines being set up outside Europe, all had their effect. The advent of the oil crisis in 1973 turned this slow-down almost overnight into a sharp recession as it hit both industry and the public confidence in the future of motor vehicles. Before the crisis the motor industry itself accounted for between 6 and 7 % of all manufacturing industry employing over a million workers in the major industrialized countries and if the support industries are included these figures could be approximately trebled. In 1973 motor vehicle exports in the Community lay between Italy's 8 % and Germany's 14 %.

The crisis has caused a fall in production of 13.9 % with consequent effects on employment and manufacturers' finances which has continued into 1975.

In recent months there have been signs of an upturn in demand with a revival of purchases of private cars in some countries. However, the return to economic growth is a fragile plant which must be carefully nurtured if it is to grow and bear fruit. The endeavours of government and both sides of industry have been effective in arresting the recession, but dangers and difficulties still exist and for the next few years the motor industry will be operating in a difficult market.

The financial pressure on the consumer to economise in his choice of transport will be accompanied by pressures on the manufacturer for improvements to public health and the environment.

This situation makes it even more important to capitalize on the advantages and savings that accrue from the elimination of technical barriers in the Community Market so that manufacturers will have to cope, basically, with only one set of legislative rules.

In considering how this is to be done, it is essential to note that the directives adopted in the first stage of our programme will be exerting their influence in the next few years, which we could regard as the critical period. One of our first tasks must be to consider in what way they should be modified in the light of the new conditions prevailing. It is for this reason that I consider it useful to make a short review of the present state of progress.

As you will be well aware, work within a Community framework on motor cars began well before 1969, but there was not much progress until the Council had adopted the General Programme of 28 May 1969 for the elimination of technical barriers to trade. At the Paris Summit on 28 October 1972, the Heads of State and Government said in their final communiqué that it was necessary amongst other things to remove technical barriers to trade in order to create a single industrial base throughout the Community. On 21 May 1973, the Council therefore adopted the Supplement to the General Programme, this being necessary on three chief grounds, namely, the growth in intra-Community trade in sectors which had no apparent claim for priority in 1969, the enlargement of the Community which involved the consideration of the laws and regulations of the new Member States and the greater awareness of environment among public opinion which had led to certain governments either taking or planning measures which had to be harmonized at Community level. Further, when it adopted a Programme for Industrial Policy, in which the programme for the removal of technical barriers was a key element, the Council undertook to eliminate all barriers detected until then and to do so by the beginning of 1978.

It is important to note that the Council has several times reiterated the priority it attaches to the motor vehicle sector in the programme of industrial policy of 1973, in the programme for environmental action of 1973 and finally in the programme for the rational use of energy in 1974.

What have been the results of our work in the motor vehicle sector? To date, the Commission has transmitted around forty proposals for directives and the Council has adopted more than half of these. Provided that the Member States show sufficient political will in the Council to overcome the remaining difficulties, within one year the Community type approval procedure could be considered a "fait accompli".

Although each of these outstanding points may appear to be of marginal value their consideration must be carried out in the light of the fact that only when they are all agreed will the procedure become fully effective.

Amongst those directives already adopted, some such as braking devices, air pollution and noise levels have represented important advances in the sense that they have been positive steps towards increased safety and a better protection of health and the way of life of individuals.

A few aspects remain to be covered where the Commission has not yet sufficient technical or economic information to make proposals but with goodwill on all sides these points could soon be resolved.

Perhaps the most important aspect of type approval yet to be established is that of tyres. It is well known that the tyres produced in the Community have a high degree of durability and adhesion, and that accidents caused by tyres can usually be attributed to inferior products or misuse. The decision as to whether they should form part of the type approval procedure should be taken on the basis of a logical evaluation of technico-economic aspects rather than philosophical speculations on the effectiveness of different administrative procedures.

Among the proposal in the directives before the Council there are several which are in the final stages and which could give a considerable improvment in road safety not only by reducing the number of accidents but by diminishing their effects. In particular I would mention the directives dealing with seat belts and those dealing with lighting and signalling devices.

I would here underline two statements I have found in the report of Mr. MACKAY for session 3. Firstly that seat belts are by far the most important piece of safety equipment in a car and secondly that if they were worn universally there would be a 50 % reduction in vehicle occupant fatalities.

The group of proposals dealing with lighting and signalling devices has an obvious effect on road safety and in addition an important economic effect since the positioning of lighting devices has to be allowed for in the design and construction of the vehicle body. The adoption of this proposal moreover governs the adoption of a series of dependant proposals relating to the requirements for the various individual lights.

Under our directives the EEC type-approval procedure means that checks on compliance with the rules regarding construction and testing applicable to vehicles, previously conducted in each Member State before the products were marketed, can be conducted in one State and, provided that the vehicle meets the requirements laid down in the directives, there is no need for those tests to be repeated when the vehicle enters another State or States of the Community. This situation has undeniable advantages for industry. Firstly, all firms in differing states can compete on an equal basis and there is also a considerable reduction in the needs for them to vary their output and duplicate their stocks. Even in their research, design and manufacturing, the fact that only one set of specific requirements has to be met should produce more effective results at lower cost than if a greater number of differing standards had to be taken into account.

As you will all know full well, certain tests involve the total destruction of the vehicle and, if it is possible to carry out those tests once rather than nine times then there is a direct saving in costs. Administratively, too, the system has advantages : for example the number of papers and certificates of all sorts to be filled in and produced or displayed is considerably reduced, the resultant saving in non-productive effort being not the weakest argument for EEC type approval. It is not yet possible to work out exactly how great a saving for industry and consumers has been produced by the introduction of an EEC type-approval procedure, but what can be stated is that the system has shown itself to be advantageous for both groups.

Furthermore, from the users' point of view there will be the advantage of availability of products which are safer, technically more advanced and meet more exacting health and environmental standards not to speak of the reduction in operational problems through easier maintenance and better availability of spares.

The application of cost benefit analysis is at first sight very attractive. However, the difficulty of determining and evaluating quantitative data and the variations in benefits to be obtained between the various Member States makes this approach questionable.

It would seem more logical to apply the concept of cost effectiveness which fixes an objective and analyses the means of achieving it by the cheapest and most rational route. In this way our future work could be given a new dimension provided that the starting point is sound.

The new directives, whether they constitute an adaption to technical progress of the old ones or an introduction of new aspects, must be based on the latest scientific and technical information having the widest possible base in all Community countries.

They must also be evolved at a rate which firstly allows the producer to minimize his costs for modification since these costs must eventually come from the consumer's pocket, and will secondly encourage industry to collaborate by setting the timescale on a realistic basis.

To best clarify this situation we have separated the work of the symposium into a number of major themes. For each of these main themes we think it is necessary to appraise the present situation with a view to determining for which subjects our knowledge is sufficient to establish Community measures and in what areas. Further work is required before a directive can be established.

Hitherto, our work has been based on a "de facto" treatment of existing national legislation or documents of other international organizations established on the basis of recognized commercial barriers or for improvements in safety or the environment. In this second phase, to economise our effort we must identify our priorities and concentrate both public and industrial research on these.

This fixing of priorities is also important for the forming of a common Community policy on the basis of which we can confidently enter into discussions with external states and international organizations. In this way the Community can be seen to be taking the lead in the improvement of not only our quality of life but also those outside the EEC by entering into a constructive dialogue with other major manufacturing countries.

In the economic context I have outlined, we must retain a good relationship with these countries. The realization of an internal market free of technical barriers offers importers the same degree of advantage as those offered to Community producers by unifying both technical requirements and control procedures.

I have no doubt that it is for this reason that observers from other states both European and non European asked to be present and in accordance with our policy of "open house" we welcome them.

We trust that they will adopt a similar attitude by inviting us to take part in the formation and evolution of their ideas and what is more that we are kept fully informed of the timetable for their application, so that Community exports will not have to take a return ticket, because the technical requirements have changed during their outward journey.

In this respect I would underline the importance attached by the Community to the non-tariff part of the multilateral trade negotiations. It is our view that these should be conducted on a basis of complete reciprocity so that the result is an equal facility of access to the markets of the relevant participating countries.

While we have for practical purposes divided this symposium into themes it is important that your considerations have the widest possible basis. As the number of aspects of the motor vehicle covered by legislation have increased the secondary effects and consequent interactions have become more important.

If we talk about preserving life both driver and pedestrian must be considered to be of equal value. Judgements become more difficult when evaluating safety or environmental effects against cost but the problems exist and judgements must be made.

Planning for the future requires the pooling of all resources in terms of initiative, imagination, creativity, as well as technical and financial resources, by all concerned. Only if there can be increased collaboration between governments and agencies, industry, trade unions, consumers and the Commission do I believe that acceptable and satisfactory solutions will be possible. With the hope, then, that our initiative in bringing you all together here may in some way help to build a more integrated Europe that meets the wishes of all Europeans, I wish you success in your endeavours and a very pleasant stay among us.

FIRST SESSION

STRUCTURE OF VEHICLES

STRUCTURAL STRENGTH AND COMPATIBILITY OF VEHICLES IN THE EVENT OF IMPACT, POTENTIAL HAZARD TO OTHER MEANS OF TRANSPORT AND TO PEDESTRIANS

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REPORT OF Mr TAYLOR

STRUCTURAL STRENGTH AND COMPATIBILITY OF VEHICLES IN THE EVENT OF IMPACT

INTRODUCTION

In all the well-developed countries people are grappling with the many problems of motorization which increasingly dominates their lives. In some 70 years the transport scene has been revolutionized and the desire for unrestricted personal mobility expressed by the growing ownership of private transport has brought with it many problems not least of which is road safety. Because road accidents have grown up in a transport context they tend to be regarded as an inevitable penalty for personal freedom and their dispersal into many incidents each with only a few casualties tends to diminish public appreciation of their overall magnitude. Throughout the world some 1 million people die every 4 years in road accidents and for the young adult road accidents are the major cause of death in many countries. Road accidents rank,therefore,as a public health problem of epidemic proportions and need to be treated as such. The vast majority of road accidents stem from human failure but the consequences of these failures can be prevented or mitigated by various means; by education and training, by better highway design, by safer operational techniques and last but by no means least by using safer vehicles.

In this session we are concerned with the influence of vehicle structures on road safety. Though there is scope for improving the structures of other vehicles, especially heavy vehicles, we shall be concerned primarily with passenger cars since they are involved in some three quarters of fatal road accidents. These injuries are caused both to their own occupants, to the users of two-wheeled vehicles and to pedestrians,the majority of whom are injured by cars.

This symposium comes at an appropriate time from several points of view. For more than five years there has been intense international activity on car safety in response to the initiative taken by the

United States. A great deal of research work has been carried out by governments and industry in many countries within an international programme which has perhaps been unique in the collaboration and frankness of disclosure of results between participants; European countries have contributed greatly to this programme and it is appropriate now to take stock. In the last year or two problems of material resources and their conservation have come to the fore and additional commitments to safety have to be considered together with these other interests. This is not solely a matter of energy and materials but involves also the availability of research and development personnel and facilities.

One of the most serious issues arising from the work carried out internationally to date is the extent to which it has led or is likely to lead to greater safety on the roads. This is a complex socio-economic problem aggravated by the difficulty which the public have in assessing the benefits and penalties from prospective changes in the interests of safety. Where improved safety means more expensive vehicles either in terms of first cost or of running costs the less wealthy may be forced to use less safe vehicles unless there are appropriate safeguards. Understandably manufacturers are reluctant to act on their own in this situation and major progress can only come through government action by way of vehicle regulations. The question today, therefore, is the extent to which government action for greater vehicle safety would be justified; this question may be sub-divided into those measures which would improve safety without introducing significant penalties and those which would improve safety but at some penalty to be assessed in relation to the expected benefits.

The assessment of benefits and penalties requires a thorough study of road accidents and of the people and vehicles involved; when prospective vehicle measures are being considered it is important for this assessment to be based on the accident situation to be expected when the measures come into widespread use. Changes expected in the traffic pattern and in the vehicle mix are extremely important in this respect. A great deal of work has been carried out internationally on accident investigation including causation, biomechanical and vehicle factors.

Vehicle safety work is basically concerned with exploiting vehicle design and performance to reduce the frequency of collisions and to reduce the frequency and severity of injuries caused to the people involved, whether they are protected within vehicles or unprotected as in the case of pedestrians. Where compromise is necessary the safety objective should be to obtain the maximum benefit for the majority with the provison that no one class of road user has any more or any less entitlement to survival than another. It would unquestionably be unacceptable to the public to increase the safety of one class of road user at the expense of another. At the present time, pedestrians and riders of two-wheeled vehicles fare much worse in road accidents than the occupants of vehicles with protective structures and increasing attention is being given to their safety.

The European Experimental Vehicles Committee which was set up in 1970 has actively considered many of the issues important to car safety. The governments of France, Italy, Netherlands, Sweden, West Germany and the UK are represented on the Committee and their industries have cooperated actively in the work of specialist sub-groups dealing with :

data sources
human tolerance and occupant protection
order of priority and major requirements for safer vehicles
cost/benefit techniques.

In this paper I have drawn extensively on the work of the Committee[1] and on the proceedings of the various international ESV Conferences[2, 3, 4, 5, 6] piloted by the NHTSA on behalf of the US government.

THE CAR OCCUPANT PROBLEM

It is fortunate and largely fortuitous that cars have evolved so that the greatest occupant protection is available in the most common accidents, namely, frontal collisions. The protection afforded in side collisions is poor by comparison and has received little attention until recently. Roll-over and rear impacts are of lesser importance in Europe.

The facilities afforded to the car occupant should include :

1) Protection against intrusion
2) Arrangements for decelerating the occupants without exceeding limits of human tolerance
3) Prevention of ejection from the car
4) Prevention of fire
5) Easy egress from the vehicle after a collision.

When these matters first received serious attention road accident experience was causing concern in several cases :

1) Collapse of the passenger compartment
2) Injuries and death caused by the "second collision" of the occupants with the interior of the car
3) Failure of doors to remain locked during an impact resulting in ejection of the occupants
4) The death of occupants by fire following fuel leakage
5) Difficulty in extracting occupants after a crash.

These matters have received worldwide attention by way of regulations and legislation under discussion or planned for extending this work.

VEHICLE LEGISLATION

National regulations governing the construction and use of vehicles have existed for many years but differences between them have created non-tariff barriers to international trade. These barriers have been tackled by intergovernmental cooperation aimed at harmonizing standards internationally and the development of standards concerning road safety and environment have been pursued as an integral part of the removal of trade barriers :

UN/ECE : THE E-MARKS

The work of international harmonization began with the conclusion of a treaty in 1958 under the auspices of the UN/ECE. This is usually referred to as the "1958 Geneva Agreement" and it is concerned fundamentally with achieving multi-lateral recognition of national states' procedures in enforcing vehicle construction standards. It provides in effect for the establishment of international standards for the safety and other (e.g. pollution) requirements of vehicle components and parts (e.g. braking systems, lights, etc.). Such internationally agreed standards are embodied in subsidiary instruments, referred to usually as "ECE Regulations", that are annexed to the 1958 Geneva Agreement. Once an ECE Regulation is in force, Governments signatory to the 1958 Geneva Agreement may test and approve vehicle components to the standards embodied in that ECE Regulation. The testing and approval carried out is of the sort known as "type approval" i.e. a production model is tested and approved after which any serially produced component that conforms to the approved production model is regarded as approved for the purposes of the 1958 Geneva Agreement. This status is established by the affixing of an "E-Mark" to all serially produced components.

The principle is that vehicle components showing the E-Mark can be imported without having to be tested and approved by the authorities of the importing country. In practice this means that a member country accepting any or all of the ECE Regulations can issue approvals certifying that the requirements have been met and these approvals are then accepted by all other accepting countries as meeting their own requirements without further examination of the vehicles.

But the E-Mark system does not provide a complete and universal elimination of technical barriers for the following reasons :

a. No country, even if signatory to the 1958 Geneva Agreement, is obliged to accept any particular ECE Regulation if it does not want to. The E-Mark is, therefore, effective only in the countries that accept the particular Regulation to which an E-Mark refers.

b. As yet, there are not enough ECE Regulations to cover all important components of all categories of vehicle.

c. The E-Mark system confers approval for vehicle components only and not for whole vehicles. As a result it does not prevent national authorities imposing unique national requirements in addition to any aggregate of internationally agreed standards justifying E-Marks.

EUROPEAN COMMUNITY

Article 100 of the EEC Treaty of Rome provides for the harmonisation of Member States laws and administrative practices where these affect the establishment or functioning of the common market. This includes the removal of barriers to trade created by disparities in Member States regimes governing production methods and product characteristics. In the last five years, considerable priority has been given to eliminating technical barriers to trade in motor vehicles.

To date about 20 Council of Ministers'Directives have been made establishing Community standards for type approval of vehicle parts. The standards they embody are in most cases the same as those previously agreed in the UN/ECE. Under Article 100, Member States are obliged to amend their domestic law and practice to enable the aims of the Directives to be achieved.

This may be an appropriate time to consider whether it is desirable for the existing European practices to continue; a comprehensive package of international legislation is ripe for completion so that whole vehicle type testing may be implemented at the current state of the art without allowing it to be extended indefinitely because of fundamental discussions of optimum standards.

USA AND JAPAN

Particular problems arise in trade in motor vehicles with the USA and Japan.

a. Neither the USA nor Japan are signatory to the 1958 Geneva Agreement and so cannot approve for E-Mark purposes. Both USA and Japan accept a few standards contained in ECE Regulations but not all. US and Japanese regulations are,therefore, predominantly national in character and procedure.

b. Exporters to USA and Japan have to build in accordance with the national US and Japanese standards and this may involve considerable deviation from normal production runs. US and Japanese exporters to the UK or Western Europe must also have special production runs for their European markets.

Under the 1966 National Traffic and Motor Vehicles Safety Act and Highway Safety Act, the United States government instituted a major national attack on traffic accidents which is now conducted by the Federal Highway Administration and the National Highway Traffic Safety Administration.

NHTSA is responsible for providing leadership and coordination of a national programme to reduce traffic crashes, deaths and injuries. This is accomplished primarily in the following ways :

Developing and issuing motor vehicle and equipment safety Standards of performance.

Developing and issuing uniform Standards for the States and communities to incorporate in their highway safety programmes (FHWA develops and issues uniform Standards relating to identification and surveillance of accident locations, highway design, construction and maintenance, traffic control devices and highway-related aspects of pedestrian safety).

Administrating a programme of Federal assistance to States and to assist them in implementing their highway programmes formulated around the highway safety Standards.

Conducting research, testing and demonstration to develop the new scientific data needed.

In addition to its research, rulemaking and Federal assistance programmes, NHTSA is responsible for evaluating compliance with Standards and providing the technical records in litigation arising out of noncompliance with the motor vehicle Standards.

The resulting programmes are essentially national in character and conducted with considerable energy. At the first NATO/CCMS meeting in 1969, the United States took the initiative of proposing to lead a broad pilot study on road safety covering eight major projects led by individual countries. The experimental safety vehicle (ESV) programme led by the United States was one of the most important and the leading Western European car manufacturing countries agreed to participate in it.

The United States has launched various proposals for vehicle legislation and has carried out major R & D programmes to assist in defining future regulations for safer vehicles. The European contribution to this programme has differed between participating countries; some elected to work against the background of the prospective American legislation whilst others preferred to expand their national programmes along more basic lines which concentrated on the investigation of accidents and injuries and on the improvement of vehicle systems to meet these situations. The occupant protection test requirements of the ESV programme represented a major step beyond current regulations in stipulating human tolerance criteria which were to be determined from anthropomorphic dummies representing car occupants. The first Federal Motor Vehicle Safety Standards (FMVSS) were issued in 1967, and became effective on vehicles manufactured after January 1, 1968. They were applicable primarily to passenger cars (which consistently constitute nearly four-fifths of the US vehicle population) and covered those automobile parts, or systems, known to cause serious injury or death in highway collisions - the steering column, the windscreen, exposed hardware, the dashboard, and the side pillar, among others. In all, more than 50 standards and regulations are in operation today; many of these have been upgraded and extended to trucks, buses, and multi-purpose vehicles. The early standards have been in force long enough so that over 75 % of the cars now on the road incorporate the basic safety requirements.

1970 marked the transition from the initial Federal Motor Vehicle Safety Standards required by the Act into the era of new and advanced safety standards for motor vehicles. The Program Plan was also introduced describing the anticipated schedule of rulemaking actions for several years ahead. It was decided to adopt a systems approach relating to crashworthiness systems and operating systems. In the case of Occupant Crash Protection, Standard FMVSS 208 was introduced which was intended to be an overall performance standard. The purpose of FMVSS 208 was stated to be to reduce the number of deaths of vehicle occupants and the severity of injuries by specifying vehicle crash worthiness requirements in terms of forces and accelerations measured on anthropomorphic dummies in test crashes and by specifying equipment requirements for active and passive restraint systems. Thus the ESV programme was complementary to the development of Standard 208. With the completion of the ESV programme which set severe performance targets it was evident that attempts to make a large single step in car safety quickly, based on existing knowledge had not been successful in practical terms, that is in providing a ready basis for much safer production cars at acceptable cost. Nevertheless, the programme made major contributions through the international research work which it caused to be carried out, in the establishment of open exchange of information between all the participants and through the proceedings of the ESV conferences which are freely available worldwide.

The NHTSA has now embarked on the Research Safety Vehicle (RSV) programme. The project addresses the transportation requirements of the 1980's for safety performance, fuel economy, resource conservation and low pollution as the basis for future rulemaking and relates to smaller vehicles i.e. less than 3000 lbs (1360 kg).

There is no doubt that the international collaborative programme has had a bearing on the development of US Standards and in the case of Standard 208 has influenced consideration of its full implementation. There are also signs that the exchange of information between countries offers prospects of narrowing the differences between the Standards in prospect for the USA and Europe.

CURRENT VEHICLE REGULATIONS RELATING TO STRUCTURES

At the present time, with the exception of developments under FMVSS 208, vehicle regulations in Europe and the United States are basically design standards as opposed to performance standards based on human tolerance criteria determined by the use of instrumented dummies.

Current quantitative legislation on vehicle structures, specifically car structures, can be divided into three main groups. The first comprises those designed to ensure that a suitable occupant space is maintained during a crash, the second governing restraint systems intended to prevent or reduce the "second collision" of the occupant with the interior of the vehicle and the third designed to reduce the risk of injury once a human being comes into conflict with a vehicle either as an occupant or as an exposed road user.

Door latches and hinges

Among the first regulations issued to deal with passenger compartment integrity was the one designed to produce a satisfactory standard for door locks and hinges and thus reduce the risk of the door bursting open on impact and its consequent high level of occupant ejection. The need for this type of regulation was recognised internationally and similar requirements exist in USA, UK, Australia, Sweden and France, and the ECE. The UK, France, Belgium, Netherlands, Federal Republic of Germany, Sweden, Czechoslovakia and Italy have accepted ECE Regulation 11 which is a typical standard.

ECE 11
EEC 70/387

Requirements :

1. Latches must have an intermediate and fully latched position.
2. Transverse and longitudinal static strength requirements for the latch in both positions and for door hinges.
3. A dynamic test or calculation to show that the latch will not release under a 30g deceleration in the unlocked condition.

Steering mechanism impact

The need for a controlled crush at the front end of a vehicle in order to maintain the integrity of the passenger compartment was another early objective. This implication can be seen in regulations limiting the rearward movement of the steering column to 127 mm, for example FMVSS 204 (USA), ARD 10b (Australia), F7-1970 (Sweden), C and U 16 (UK), Directive 74/297/EEC and ECE Regulation 12 accepted by UK, France, Netherlands, Sweden, Belgium, Czechoslovakia, Federal Republic of Germany and Italy.

<u>ECE 12</u> Requirements : 1. 48.3 kph perpendicular barrier test
<u>EEC 74/297</u> without dummies to check horizontal rearward movement of column < 12.7 cm measured dynamically.

2. Energy absorption requirement in Blak Tufy body block impact test.
3. No sharp edges.

Further requirements have been quantified with the introduction of ECE Regulations 32 and 33 catering for the behaviour of a vehicle in rear-end and head-on collisions respectively. The Regulations lay down minimum values for the residual space in the passenger compartment of cars after they have been subjected to stylised front and rear impacts and they have been accepted by UK and Sweden. A further impact test Regulation 34 is concerned primarily with fire risk as is FMVSS 301 and F 13-1968 (Sweden). Regulation 34 has been accepted by UK and Sweden.

<u>ECE 32</u> (rear impact protection)

Requirements : 1. Mobile barrier rear impact to ensure adequate survival space.

<u>ECE 33</u> (front impact protection)

Requirements : 1. Head-on 48 km/h barrier impact to ensure adequate survival space.

<u>ECE 34</u> (fire risk)

Requirements : 1. Design and installation of requirements for fuel and electrical systems to guard against fire.

2. Mobile barrier rear impact to check fuel leakage.
3. Head-on barrier impacts to check fuel leakage.

Note : Regulations 12, 32, 33 and 34 have been aligned to use the same tests.
Regulations 12, 33 and 34 use the same front impact test.
Regulations 32 and 34 use the same rear impact test.

Side strength

Regulations exist or are at least drafted to cover the side strength of cars, namely ADR 29 (Australia) due to come into force in 1977 and the existing FMVSS 214 (USA) both of which have similar crush requirements for the door area of cars. Furthermore, the roof strength of cars in the roll-over accident are covered by FMVSS 216 (USA).

Occupant restraint installation

Many countries already had national regulations in force governing the requirements for safety belt systems when the first international regulations were drawn up. For example FMVSS 209 and 210 (USA) ADR 4C and 5B (Australia) F9 1968 (Sweden) and BS 3254, AU48, AU160a and AU48a (UK). Internationally ECE regulation No. 14 governing safety belt anchorages is accepted by the Federal Republic of Germany, France, Netherlands, Belgium, Czechoslovakia and Spain. Regulation No. 16 for safety belts is accepted by all the above countries and in addition Luxembourg. The EEC proposals for a directive have also been published.

ECE 14 (seat belt anchorages)

Requirements :
1. Specification of number of anchorages to be provided.
2. Tests to ascertain minimum strength.
3. Specification of anchorage location to encourage correct lie of the belt for injury reduction and user acceptability.

ECE 16 (seat belts)

Requirements :
1. Dynamic test to ensure adequate strength and forward movement limitation.
2. Buckle release test to check emergency release capabilities.
3. Tests for durability and reliability.
4. Design and performance requirements for components to ensure easy and safe operation.
5. Tests of locking devices for retractors.

In addition occupant restraint in rear impacts is dealt with by national requirements for head restraints, for example, FMVSS 202 (USA) and ADR 22A (Australia). The ECE regulation 25 is accepted by West Germany, France, Netherlands, Czechoslovakia and UK. The EEC proposal has been published.

ECE 25 (head restraints)

Requirements : 1. Location is specified relative to the seat occupant.
2. A test to assess deflection under load.
3. A headform impact test to assess energy absorption for head impacts.

There is as yet no international agreement on requirements for child restraints although this is being actively considered by the ECE Group of Rapporteurs. National regulations exist in many countries, for example, FMVSS 213 (USA) ADR 4C and 34 (Australia) BS 3254 and AU 157 (UK) and F41-1975 (Sweden).

Interior fittings

There has been international action on interior fittings so that not only has the vehicle structure been designed to absorb the energy of an occupant in a collision, but also attention has been paid to detail design so that knobs, switches and the like are not potentially hazardous. These requirements are illustrated nationally by FMVSS 201 (USA), ADR 21 (Australia) and F8-1968 (Sweden) and internationally by ECE Regulation 21 accepted by Belgium, France, Sweden, Czechoslovakia, UK, Federal Republic of Germany and Italy and Directive 74/60/EEC.

ECE 21
EEC 74/60

Requirements : 1. No sharp edges.
2. Headform impact test to check energy dissipation in head impact zone.
3. Specification of size, radius of curvature, degree of projection and in some cases retractability or detachability of knobs, etc.

This regulation excludes rear-view mirrors.

EEC 71/127 (rear-view mirrors)

Requirements : 1. Impact test with headform to check injury potential of mounting and mirror glass.

External projections

In FMVSS 211 the United States has produced a regulation designed to eliminate the hazard to exposed road users caused by wheel spinners, wheel nuts, etc. However, the European requirements have an extended scope and cover the whole concept of exterior projections. Directive 74/483/EEC and ECE Regulation 26 include not only the road wheels, but also body panels, sheet metal edges, etc. The ECE Regulation has been accepted by Belgium, France, Sweden, UK, Czechoslovakia and Italy. By introducing the above standards it is hoped that there will be a reduction in the risk and seriousness of bodily injury to a person involved in a collision with a car.

ECE 26
EEC 74/483

Requirements : 1. Limits on height of projections above surface, and/or curvature and/or hardness.

Strength of seats and seat anchorages

Seat anchorages are covered by FMVSS 207 (USA), ADR 3 (Australia), F10-1968 (Sweden), ECE Regulation 17 accepted by France, Netherlands, Sweden, UK, Czechoslovakia, Federal Republic of Germany and Italy, and Directive 74/408. The main requirements are for the anchorages to withstand forward and rearward forces of twenty times the weight of the seat. In addition there is a requirement for the anchorages to withstand a rearward moment applied about the seat's "H" point. There is a difference in the size of this moment between specifications.

SUMMARY OF AMERICAN STANDARDS RELEVANT TO STRUCTURES

FMVSS	201	Occupant protection in interior impact - passenger cars
	202	Head restraints - passenger cars
	203	Impact protection for the driver from the steering control system - passenger cars
	204	Steering control rearward displacement - passenger cars
	205	Glazing materials
	206	Door locks and door retention components - passenger cars, multipurpose passenger vehicles, and trucks
	207	Seating systems - passenger cars, multipurpose passenger vehicles, trucks and buses
	208	Occupant crash protection in passenger cars, multipurpose passenger vehicles, trucks and buses
	209	Seat belt assemblies - passenger cars, multipurpose passenger vehicles, trucks and buses
	210	Seat belt assembly anchorages - passenger cars, multipurpose passenger vehicles, trucks and buses
	211	Wheel nuts, wheel discs, and hub caps - passenger cars and multipurpose passenger vehicles
	212	Windshield mounting - passenger cars
	213	Child seating systems
	214	Side door strength - passenger cars
	215	Exterior protection - passenger cars
	216	Roof crush resistance - passenger cars
	301	Fuel system integrity
	302	Flammability of interior materials - passenger cars, multipurpose passenger vehicles, trucks and buses.

It will be appreciated that this digest of current regulations is presented for information only; the subject has become extremely complicated and changes occur frequently so that it is difficult to maintain an up-to-date index.

CURRENT RESEARCH AND EVOLUTION OF TECHNOLOGY

International data illustrate the relative magnitude of casualties to the various classes of road user (Fig. 1).

C o u n t r y	W.G.	F	I	U.K.	EEC	USA	
Pedestrians	31.6%	21.3%	26%	39%	28.1%	19.4%	
Two wheelers	17.6%	24.9%	30.5%	15.2%	22.8%	5.9%	
Cars	46.8%	49.7%	37.7%	38.4%	44.3%	62.8%	
Other Vehicles	4.0%	4.1%	5.8%	7.5%	4.8%	11.9%	1970

Figure 1 : World deaths and injuries in road accidents, 1970 for all accident types.

In view of the high involvement of cars (Fig. 2) it is right that attention should be concentrated on accidents involving them. Basically the problem consists of containing the conditions imposed on persons involved in collisions, within the human tolerance levels that their bodies can stand without permanent injury. For occupants of moving vehicles this means that they must come to rest in the collision without being subjected to intolerable forces or acceleration; They must be protected from direct injury by interior parts of the vehicle that they may contact during the impact; they must not be severely injured by the collapse of the structure nor by intrusion from outside the passenger compartment. In the case of pedestrians struck by a moving vehicle this means first of all that ways must be found of preventing them being thrown to the ground and secondly they must be "acquired" by the vehicle without causing severe injury and retained there until it is safe for them to be freed.

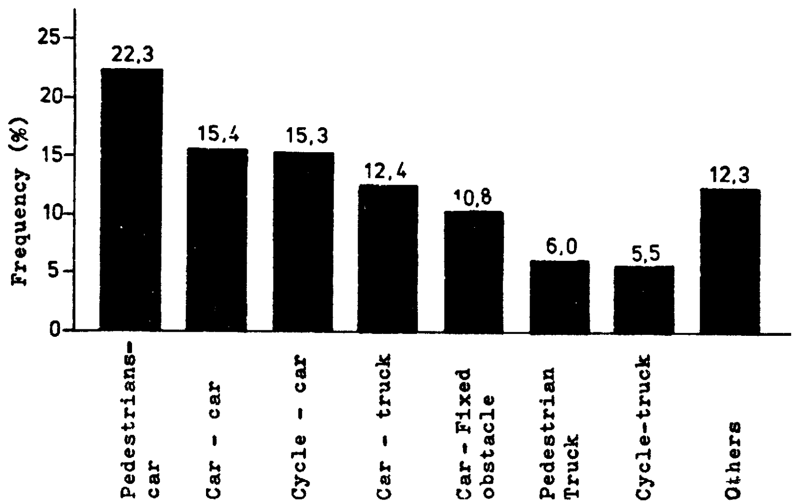

Figure 2 : Distribution of Fatal Accidents in Different Crash - Types (Europe)

It is evident in the pedestrian case that a major incompatibility exists between the vehicle and the unprotected pedestrian. It is also perhaps obvious that complex compatibility problems also exist in the vehicle to vehicle collisions because of the wide range of vehicle masses and their physical arrangements. The problem is especially severe in collisions between cars and heavy goods vehicles but it is also significant in car-to-car collisions.

Four main collision modes can be identified :

Mode 1	Frontal collisions
Mode 2	Front/side collisions
Mode 3	Front/rear collisions
Mode 4	Roll-over.

Accident investigation has shown that Mode 1 is the most important cause of injury followed by Mode 2; the remaining Modes though not negligible are of lower importance in Europe provided that adequate fuel system integrity is ensured (Fig. 3).

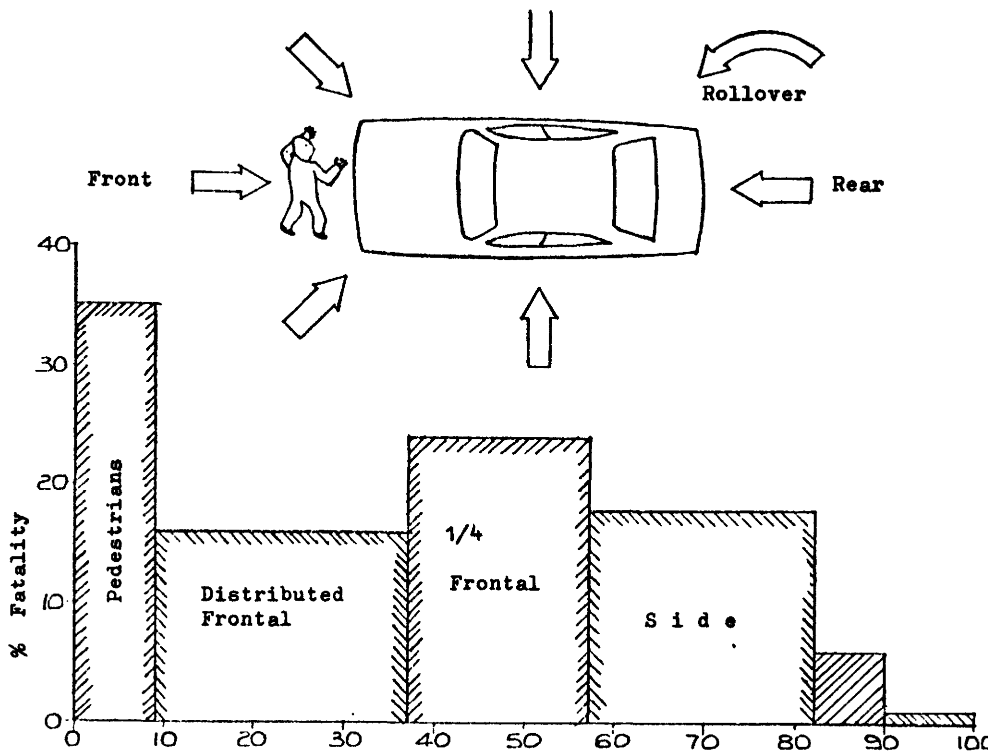

Figure 3 : % Accident Incidence

The following factors have an important bearing on vehicle to vehicle collisions :

1) The masses involved
2) The vehicle speeds at entry to the collision phase
3) Deformation characteristics of the vehicles
4) Vehicle layout or architecture.

These factors have been internationally studied by European research workers notably in France, Germany, Italy and the UK[2,3,4,5]. France has long emphasised aggressivity as an important aspect and Italy has been greatly concerned to see that the future for small cars is not impaired by future regulations.

When two vehicles collide the relative masses of the vehicles have an important bearing on the severity of the accident for the vehicle occupants. The larger the difference between the two masses the greater will be the change of speed of the lighter car for a given impact closing velocity, assuming that other factors remain the same. The mass distribution of the vehicle population is therefore important and changes in the distribution over a period of time, for example, towards a lower proportion of large cars would directly affect the consequences of collisions on the road.

The analysis reported by Seiffert[5] in 1974 (Annex 1) is indicative of views expressed by various European organizations in recent years and the problems outlined form the basis of much current technical debate on the future form of car safety requirements.

In recent years there has been a shift away from assessment of accident severity in terms of an equivalent impact with a fixed massive barrier to the concept of velocity change experienced during the impact or Δv. In some cases, for example accidents involving offset frontal impacts where the cars glance off each other, assessment in terms of equivalent barrier impact speeds can result in misleading estimates of the severity of the impact.

There are, therefore, three inter-related aspects, firstly the assessment of the types and severities of collisions taking place on the road, secondly the design of vehicles to minimize the consequences of these collisions for the people involved and thirdly the development of test methods which will be realistic and encourage the type of vehicle population which it is desired to achieve in the future.

Assuming that the first aspect can be determined in ways which are meaningful for structural design purposes then the other two aspects are very closely related. In a mixed vehicle population the force/deformation characteristics of each vehicle and the structure need to be designed in the light of road accident data to provide the best overall solution for the vehicle population expected in the future.

Occupant protection

The complexities exposed in analysing road accident collisions have a direct bearing on the compatibility between occupants and vehicle structural characteristics if optimum protection is to be achieved. Research has shown that a heavily padded vehicle interior can provide some improvement but the best prospect for the foreseeable future in Europe is the universal use of seat belts, a view that has been amply confirmed from the study of road accidents involving unrestrained and restrained occupants. Current regulations were to some extent conditioned by the relatively low usage of seat belts and accepted that occupants would probably not be restrained. It is now evident that future progress in reducing occupant casualties is vitally dependent upon the use of occupant restraints as a prerequisite of further safety improvements. There is some confusion at present regarding this point, it being contended by some that no worthwhile progress is possible beyond the universal use of seat belts in conventional vehicles. To explore this question Neilson[6] has made an assessment of the further benefit from additional measures that could accrue from implementation of the TRRL "Preliminary specification of safety requirements for a car design for the immediate future" and estimates that it would be a saving of some 40 % of vehicle occupant fatalities. There would seem to be little doubt that substantial benefits are possible from structural changes.

Pedestrian Safety

In one country where a high proportion of road deaths are pedestrians some 60 pedestrians are killed by cars for every 100 car occupants who die. Quite apart from the basic desire to reduce these pedestrian casualties it is evident that failure to face the problems will eventually lead to increased public concern if substantial reductions in car occupant deaths are achieved. Because car/pedestrian accidents are so widely spread there is only limited scope by segregating pedestrians from traffic to reduce such accidents; furthermore the tendency for vehicle speeds to rise over the years offers little prospect that other means will deal adequately with pedestrian safety.

The difficulties of modifying car structures to protect pedestrians are considerable but the placing and profile of the front structure which first contacts pedestrians are of great importance. It is already clear that the initial impact, which is likely to be with the vehicle bumper, must be below the knee and this sets a basic requirement on bumper height which is not satisfied by current legislation or proposed legislation. Fortunately the desired height provides a favourable arrangement from the point of view of front/side vehicle to vehicle collisions.

STRUCTURAL IMPLICATIONS OF IMPROVED STANDARDS

Improvements can be made to many current models by re-locating or redesigning components which prevent the vehicle having crush characteristics that are essential to optimum occupant protection. These modifications can usually be accomplished without economic penalty in subsequent vehicle models. But to improve the crush characteristics of the best of current vehicles it is necessary to add to the vehicle structure with corresponding weight penalties. These penalties have been explored by manufacturers as part of the international programme and judged to be prohibitive if the original ESV specifications employing severe frontal tests with rigid barriers were to be met, especially for small cars. However, the situation changes if the principle can be established that heavier cars must accept some structural penalty in order to compensate for the mass imbalance in collisions with small cars. This leads to the concept of designing for compatibility with a "standard vehicle" which could minimize the penalty of achieving higher occupant protection especially for small cars, whilst leading to an overall improvement.

In view of the vast amount of structural research work carried out in recent years,structural design as such would seem to be much less of a technical problem than defining the requirements which the structure should meet and the associated test methods. Since some additional structure will also certainly be needed for higher occupant protection standards a philosophy needs to be developed for reconciling safety requirements with energy, environmental and economic considerations - the S3E's so-called by Dr Gregory.

At first sight it seems plausible to talk of these aspects as competing with safety for their share of the vehicle 'cake' and to oppose vehicle weight increases for safety on grounds that this leads to economic and resource penalties. But these arguments seem to be fallacious since there is no absolute rule about the range of vehicle sizes and weights that must exist. If it is desired to remain within a specified target for example of total fuel consumed by cars it is possible for this to be met over a period of years by changes to the vehicle mix, for example by moving to lighter vehicles and by centering attention on compatibility so that safety is in fact enhanced. These aspects are being explored within the American RSV programme and merit further study in Europe.

THE DIRECTION OF FUTURE REGULATIONS

It is necessary to distinguish between the objectives behind regulations and the requirements specified for ensuring that they are achieved. Sometimes regulations have failed in practice to achieve their objectives.

In the case of vehicle structures the basic objectives must be to improve road user protection in road accidents and to do so in the most cost-effective manner; ideally the test methods chosen for demonstrating the required levels of occupant protection should employ criteria relating principally to the people and not to the vehicle; an approach using biomechanical criteria has not been implemented in regulations to date except for optional approval against FMVSS 208, but is intended in that case to be made mandatory in the near future. Dr Mackay is dealing with these aspects but it is evident that the introduction of dummies for compliance testing adds greatly to the complexity.

Frontal impacts

There is ample evidence that the current car test impact at right angles into a massive flat barrier represents just under a half of severe injury impacts and that vehicle parameters or design requirements are inadequate criteria for assessing occupant injury. In spite of these limitations the test fulfils several useful functions provided its limitations are recognized. Nevertheless an essential objective is to move to a performance standard based on human tolerance requirements for restrained occupants, using dummies for testing purposes. The question of the test itself is highly complex and in the longer term it is desirable to move to vehicle-to-vehicle tests where the standard vehicles may well be deformable mobile barriers designed to provide the optimum vehicle mix in road accidents.

Eventually the test requirements should extend to pedestrian compatibility requirements but beyond specifying bumper height these cannot be defined without further research.

Side impacts

These would seem to offer a less complex problem than frontal impacts though they are of course inter-linked from the standpoint of structural design. By matching bumper height to sill height substantial gains in front/side impact safety can be obtained as well as in pedestrian safety through the use of a low bumper[*5]. Here again the use of a deformable barrier would be appropriate for test purposes.

In proposing new test methods for regulation purposes it has to be recognized that relatively few destructive tests (in statistical terms) will be possible in the case of major vehicle structures or whole vehicles on cost grounds. If the complexity of the tests or the variety are increased it becomes much more difficult to ensure a satisfactory assessment of compliance; in the case of complete vehicle performance standards a satisfactory assessment will be sought from just one test in each case. It would seem,therefore,that increased effort on the use of simulation techniques is desirable and that these methods could be employed to augment a framework of approval tests. By using vehicle crush characteristics and other parameters it should be possible to predict vehicle collision performance in a variety of situations which would be far too costly to contemplate as actual structural tests.

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*5 - Finch, Tarrière, Jehu and others.

In view of the long lead times required for the implementation of new regulations and the further period before the vehicle population is significantly affected, early action is needed if cars manufactured in the early 1980's are to be affected by new regulations. This point was emphasised by Osselet in 1974[5]. Unfortunately it will never be possible for research to provide guaranteed answers to all of the questions now being asked and judgements will be needed based on current knowledge. To do this in an acceptable manner means moving step-by-step in the directions indicated, trying at each stage to ensure that the next step will yield genuine benefits; in some cases for example standardization of bumper heights, it must be accepted that full benefits will inevitably be delayed. Nevertheless this item and side compatibility between vehicles is probably the clearest for early action.

With these issues in mind the EEVC tabled proposals for future requirements (Annex 2) which might be considered for inclusion in regulations in the near future; they would be backed during their establishment by ongoing programmes of research in the participating countries. These preliminary proposals were developed in WG2 of the Committee by representatives of government and industry under the Chairmanship of Dr Pocci. They do not at present provide a complete picture nor do they represent the requirements eventually desired. Nevertheless they offer a basis for discussion in moving in the near future to higher standards of occupant protection.

CONCLUDING NOTE

The background road safety situation and the present state of accidents involving cars has been reviewed. The framework of current regulations in Europe and the USA has been explored and regulations relating to vehicle structures outlined.

The impact situation is seen to be extremely complex and great care will be needed in selecting test conditions for future vehicle regulations if they are to produce real benefits in road safety and to be cost effective. The importance of compatibility has been emphasized both between vehicles and in vehicle/pedestrian accidents.

Progress in vehicle safety is essentially a step-by-step process but there are certain fundamental aspects. These include :

1) The essential need for occupant restraints to be employed.
2) The achievement of an optimum balance in impacts between large and small vehicles so that the latter are not subjected to unrealistic requirements.
3) The urgent need for standardization of bumper heights at a low level appropriate to vehicle/pedestrian and car front/side impacts.
4) The need for early action on new vehicle safety standards if cars to be produced in the 1980's are to be influenced by them.

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ANNEX 1

COMPATIBILITY ON THE ROAD

Ulrich Seiffert, Research and Development Centre, Volkswagenwerke AG

The following analysis as reported by Seiffert[5] in 1974 is indicative of views expressed by various European organizations in recent years and the problem outlined forms the basis of much current technical debate on the future form of car safety requirements.

Masses involved - Apart from the case where a vehicle crashes into a fixed immovable obstacle and only the mass of the car under observation is involved, the masses of two partners are involved in the accident. The larger their differences the greater will be the change in speed of the lighter one, for any given impact velocity. In extreme cases, the speed change of the small car will be so large that the smaller car reaches (twice) the impact speed, Δv will become 2v. As this physical fact cannot be eliminated, one must extract the masses to be observed from statistics. Figure 4 shows the cumulative frequency of the registered cars within the EEC for the year 1972 and for the United States. The mass difference of the registered cars can be seen clearly. In the United States, a merging of today's two peak

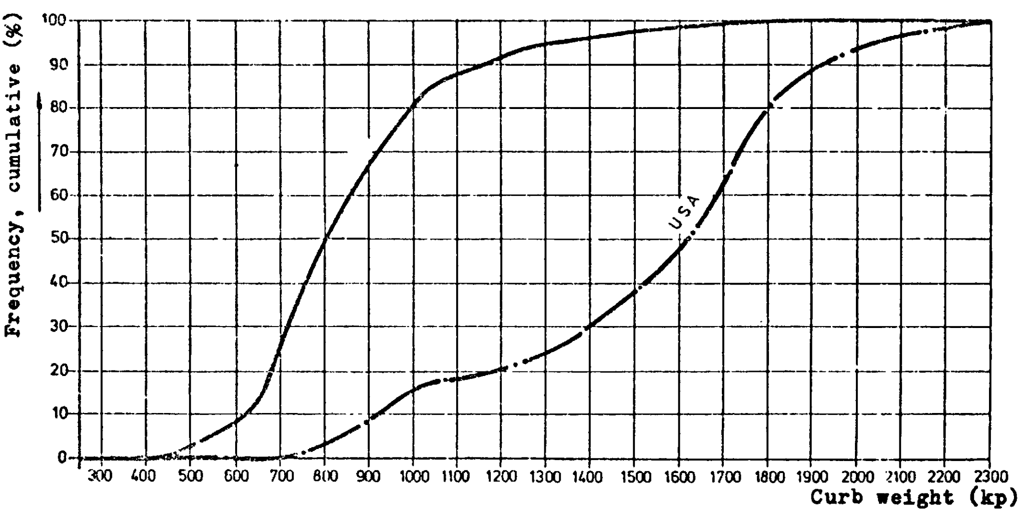

Figure 4 : Cumulative Distribution of Vehicle Masses in Europe (1972) and USA (1971)

values can certainly be expected, because here a tendency of the larger cars in the direction of the medium US cars can be forecast. As there is today still very little statistical material on collision probability, the cumulative collision frequency shown in Figure 5 was calculated in conjunction with the involved mass conditions. As can be seen, in 95 % of car to car collisions the mass relationship is approximately up to 1 to 1.8. If one takes this mass relationship as a

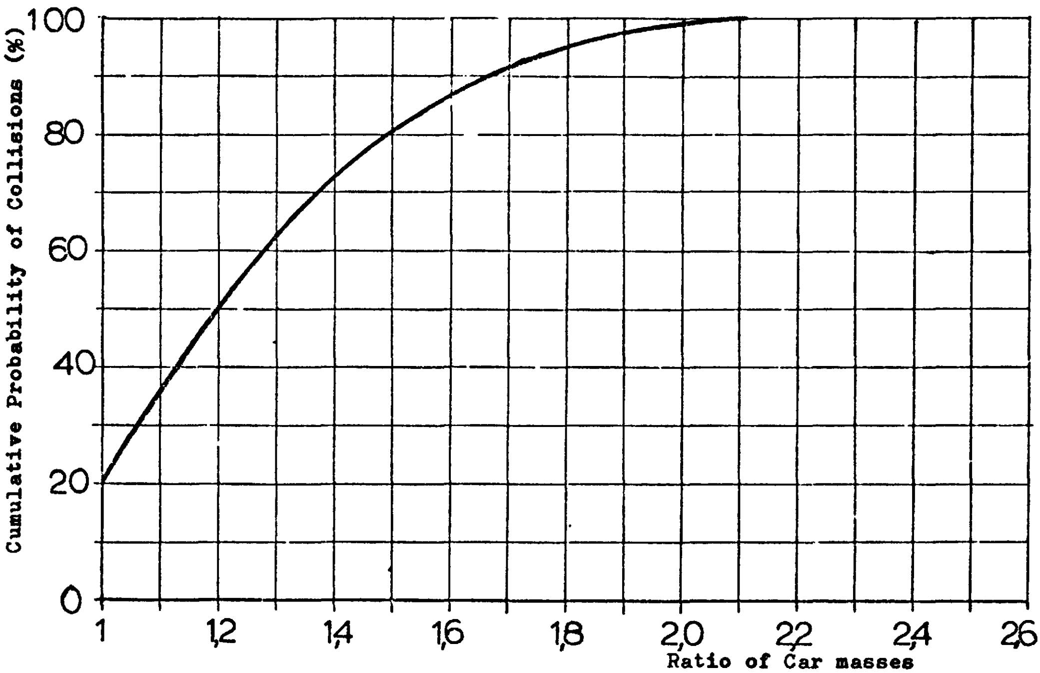

Figure 5 : Probability of Collisions

basis the speed change for the small vehicle with the same impact velocity will be :

$$\Delta v_{1.0m} = v_i - \frac{(mv_i - 1.8mv_i)}{2.8m} = v_i + 0.286v_i = 1.286v_i$$

$$\Delta v_{1.8m} = v_i - 0.286v_i = 0.714v_i$$

With a collision speed of v_i = 30 mph per vehicle, the Δv for the small car would be 38.6 mph and for the large car it would be 21.4 mph. A shift of the overall accident probability due to mass changes of future cars can be expected. Even if this is taken for granted, there will be no significant change in accident probability between two cars, as long as the trend of mass change of newly registered cars does not vary.

Impact Velocity - It is clear that the impact velocity between the traffic participants is a significant factor in relation to the force on the car and the car occupants. Usually, the frequency of deaths, severe and minor injuries from the accident analysis is related to equivalent barrier impact speeds and equivalent test speeds. The earlier ESV conferences have discussed this subject in detail and have shown the problems involved in those derived speeds.

We know from the accident analysis, that more than 75 % of frontal passenger car collisions are not equivalent to frontal barrier impacts.

If there is no central impact exactly on the vehicle's longitudinal axis, the deceleration-time history and thus $\Delta v = f(t)$ is such, that the speed in the car's longitudinal direction - and consequently the deceleration - is lower.

Extrapolation from this accident analysis in the direction of higher barrier impact speeds of 45 or 50 mph is critical, as will be shown in the following example.

A 1500 kg car develops in a 30 mph barrier impact a mean deformation force of 30,000 kp or 29,400 daN, at a mean deceleration of 20 g and with a deformation distance of 460 mm.

If the speed is increased, for example, to 50 mph, it is necessary for energy absorption purposes to either extend the deformation distance or increase the deformation force. In order to avoid lengthening the vehicle excessively one will frequently go up to the limit of the deceleration level at which the injury criteria are still fulfilled. Assuming that the deformation distance increases to 600 mm, the mean vehicle deceleration would then increase to 41 g, and the mean deformation force to 61,500 kp or to 60,000 daN, that is to say, more than double. In a car-car collision this would mean, that the smaller car is not only subjected to the larger mass, but also exposed to the larger deformation force, so that the g-level on the small car would exceed the survivable limit.

In addition, the measures used to increase the deformation force would have a very negative effect in a side impact through the reinforcement on the bigger vehicle. Therefore, before one demands considerably higher impact speeds for the barrier impact, v (closing) of 60 mph for the given mass relationship of 1/1.8 should first be considered as the problem to be solved.

Collision Direction and Impact Area - The accident analysis shows that of all accidents, 60 % are frontal collisions, 28 % side collisions, 7 % vehicle rollovers and the rest rear end collisions. The concentration of the deformation in the frontal collisions shows furthermore that it is not symmetrical with the vehicle longitudinal axis. More than 75 % deviate from the 90 degree frontal barrier impact and represents an asymmetrical impact. In the side collisions it is found that the impacts are concentrated at the level of the so-called strong passenger cell mainly on the side doors. The impact direction is approximately 75° from the front, based on the longitudinal axis of the vehicle struck. This knowledge must also be taken into consideration with regard to the compatibility.

The rear end collisions are relatively slight from a statistical point of view, so that they do not need to be considered at the moment in connection with the question of compatibility.

Deformation Characteristics - The deformation characteristics of vehicles on the market at present vary considerably. Investigations of more than 30 vehicles between 690 and 1,324 kg produced minimal forces of 23,500 daN and maximal forces of 95,500 daN with deformation distances of from 430 to 885 mm.

By collecting these deformation force-distances one could, with the aid of a computer programme, record these values statistically. The large differences existing at the moment could be levelled off in the development of vehicles when the normal deformation characteristics are known.

Architecture of Vehicle Structures - The architecture of vehicle structures has a significant influence on the performance of the traffic collision partners. This applies particularly to the car-truck collision where by optimizing the underride protection a further degree of optimization can be obtained. One can determine the energy absorbing structures of many models in genuine accident simulation tests. However, within the individual companies one can assume that knowledge of these energy absorbing components is available and one could attempt to classify this information and evaluate it with computers.

ANNEX 2

REPORT OF WG2 - THE ORDER OF PRIORITY AND MAJOR REQUIREMENTS FOR SAFER CARS FOR THE NEAR FUTURE

I. MAIN GUIDING PRINCIPLES

After considering the information discussed by Working Groups 1 and 3, this group was to proceed with an analysis of the various problems leading to the definition of the corresponding safety requirements and their order of priority. Finally proposals for possible future action were to be made to the main committee.

The actual speeds and other detailed suggestions made by Working Group 2 in this report for possible impact tests and other procedures are preliminary indications rather than final statements of an EEVC point of view. Time was not available for WG2 to estimate costs and benefits to be expected from a range of measures, such as speeds of impact for a test procedure, so that optimum conditions could not necessarily be selected.

The WG2 programme has developed along three main guiding principles and with the following priorities :

A - Car internal and external design features for occupant protection.

B - Car external design features for protection of other exposed road users.

C - Primary or preventive safety design features.

II. CAR OCCUPANT PROTECTION

The car occupant safety characteristics must be established as a function of the following two requirements :

A - Reduction of direct impact and consequential severity of injury in the various accident modes.

B - Elimination of indirect risks ensuing from such accident events (fire, impossibility of timely aid, etc.).

The above two basic requirements should be met by specifying suitable performances for standard impact tests conducted on cars with restrained or suitably protected dummies.

The performances to be required could be as follows :

1 - Compliance with biomechanical tolerance limits.
2 - No bursting open of doors during impact.
3 - Possibility, after collision, of opening at least one door without tools.
4 - Possibility, after collision, of removing the complete dummies.
5 - No fuel spillage or fire.

2.1. Restraint Systems

Among the presently known restraint systems, the seat belts (3-point type, in particular) are certainly the most effective and simple in providing a reasonable direct protection of car occupants in the majority of road accidents.

It is desirable to have future regulations which make it mandatory to install and wear seat belts in all European countries. In view of this, utmost R & D efforts should be devoted to seat belts in order to improve their present features and performance. Ameliorations should be concentrated on the following aspects :

- Installation in the car
- Dimensional and strength specifications of the different components
- Location relative to occupants
- Occupant comfort
- Manual fastening
- Automatic adjustment and locking
- Dissipation of occupant kinetic energy through absorbing devices
- Starter inhibition or some other interlock when belts are unfastened (possibly)
- Warning systems when belts are unfastened.

The rational solution of the different problems associated with the use of seat belts will require the close coordination of all the effort spent in this field.

Further development of passive restraint systems should be investigated.

2.2. Test Methods for Impact Simulation

The discussion of the answers given by the various National Delegations to the questionnaire prepared by WG2 has led to a common attitude on the four main impact modes intended to verify the occupant protection performance.

For each of said impact modes, at this time, the alternative of different test methods was indicated : the final choice will be made when the comparative test results and accident analysis data will both be available.

The comparative tests on current production cars should highlight the severity level of each impact mode being investigated from the standpoint of damages to the car and possible consequences on the occupants.

In this connection, cooperation by European Car Manufacturers will be requested.

2.2.1. Frontal Impact Test

Test procedure

To be selected between the following two tests A and B, both are considered to be practical modifications of the existing head-on test. They are likely to lead to further reductions in injury according to predictions based on existing accident studies.

A. Impact against barrier angled at 60° to vehicle main axis.
B. Offset impact against barrier with radiused edge (15 cm radius). The impact must involve half of the vehicle front (provisional agreement). As a rule, the impact half must be the steering wheel side but the test can be repeated on the opposite side, when found advisable.

Test Velocity

50 km/h.

Test Conditions

Vehicle in running order. Two (2) dummies (50th percentile, male) in the front outboard sea+ing positions. Restraint systems in the normal position and conditions specified to enable them to act on the dummies.

Requirements to be met

As specified in Para 2, items 1 to 5 inclusive.

2.2.2. Side Impact Test

Test Procedure

Apart from improving the protection available for occupants of cars struck the side, these tests should encourage compatibility between the fronts of vehicles and the sides of cars which they strike. At present the tests may be selected from A and B, but these may be further developed by substituting for the striking vehicle an impactor with a standardized front, representative of future European car frontal structures.

A. Stationary vehicle struck on its side by the front end of an identical vehicle. The velocity vector of the striking vehicle must make an angle of 75° to the main axis of the struck vehicle.

   The main vertical plane of the striking vehicle must pass through the driver's seating position H point.

B. Moving vehicle struck on its side by the front end of an identical vehicle. The main axes of the two vehicles must be set at 90°. The relative velocity vector of the striking vehicle must make an angle of 75° to the main axis of the struck vehicle.

   The main vertical plane of the striking vehicle must pass, at the instant the impact begins, through the driver's seating position H point.

Test Velocity

40 km/h (relative velocity of striking vehicle to struck vehicle).

Test Conditions

Two (2) dummies (50th percentile, male) in the seating positions adjacent to the struck side.

Restraint systems in the normal position and conditions specified to enable them to act on the dummies.

Requirements to be met

As specified in Para 2, items 1 to 4 inclusive.

2.2.3. Rollover Test

Test Procedure

To be selected between the following two :

A. Rollover test with two full rotations

Test Velocity

50 km/h (initial speed).

Test Conditions

Vehicle in running order.

Windows closed.

Two (2) dummies, (50th percentile, male) in the front outboard seating positions.

Restraint systems in the normal position and conditions specified to enable them to act on the dummies.

Requirements to be met

As specified in Para 3, items 2 to 5 included. Additionally, no ejection (even partial) of dummies and absence of excessive deformations (collapse) of roof.

B. Dynamic impact test on roof's front corner by pendulum or moving barrier having a mass corresponding to 60 % of the weight of the test vehicle.

Test Velocity

10 km/h

Test Conditions

Vehicle body fast on ground. No dummy on board.

Requirements to be met

Absence of excessive roof deformations (collapse).

NOTE : The test could be run statically by applying to the roof's front corner a pre-established load by means of a rigid flat plate. Complementary static tests could be carried out to verify the capacity of the door locks to prevent accidental door opening under loading from inside and outside the passenger compartment.

2.2.4. Rear Impact Test

Test procedure

A. Stationary test vehicle struck from rear along the longitudinal axis by a moving barrier or pendulum of 1100 kg.

Test velocity

35 km/h

Test Conditions

Empty vehicle, in running order, unbraked and in neutral.

Requirements to be met

As specified in Para 2, items 2 to 5 inclusive.

2.3. Compatibility

It is clear that the problem of compatibility must be viewed within reasonable limits and that the possibility of compatibility should,therefore,be ruled out in the event of collisions between vehicles quite dissimilar as regards mass, size, shape and structural characteristics (e.g. cars and trucks).

The objective of compatibility should,therefore,be confined to cars and, presumably, to a limited range of these.

For an exact definition of the limits of the said range, the following data should first of all be analyzed :

- Characteristics of cars on the road in Europe (weights, size, mechanical layout, etc.).
- Mass ratios in the various car accident modes.

The final compatibility performance will almost certainly amount to meeting requirements 1, 2, 3, 4 and 5 listed under para 2 in front, side and rear impact tests.

The main problem will indeed be to define a representative impactor. Taken to the extreme, this could be reduced to a single structure simulating the front end of a car whose shape, size, mass and stiffness (local and overall) are representative of those of all cars pertaining to the range considered.

Another criterion could be that of testing using a standard obstacle (deformable barrier, large framed sheet-metal restrained at either side, etc.) on which to measure intrusion depth, space, piercing , etc.

III. PROTECTION OF PEDESTRIANS AND EXPOSED RIDERS

The problem of the protection of exposed road users is second only to car occupant protection.

However, potential solutions are not very encouraging and even the more optimistic proposals are somewhat lacking in terms of effectiveness. According to present knowledge, there are only few possibilities of improving the safety features of cars for the protection of pedestrians at collision speeds above 10 km/h.

The accidents covered by this area of safety can be classified according to the topic of investigation as follows :

a - Pedestrian
b - Pedal cyclist and motor cyclist

3.1. Pedestrian Protection

The most important of the various types of accidents involving a pedestrian consists of three phases as follows :

1 - Pedestrian is hit at leg level by the outermost part of car front end
2 - Pedestrian hits bonnet and can be hurled onto windscreen
3 - Pedestrian falls on road

At low speed, impact severity and risk of fatality grow rapidly in phases 1 to 3, whereas at medium and high speeds phases 1 and 2 may already cause death.

Safety requirement investigation will be carried out in the above phase sequence in order to :

- Assess the effect of shape, size, stiffness and location of car front end protrusions on risk of fatality at initial impact.
- Evaluate the effect of shape, size and stiffness of bonnet and windscreen on risk of fatality at second impact.
- Examine the potential of pedestrian restraint systems designed to prevent third impact.

3.2. Pedal Cyclist and Motor Cyclist Protection

Though no laboratory test information is available on simulated accidents with pedal and motor cyclists, it can be assumed that the sequence of events differs from that of accidents with pedestrians mainly at initial impact, when, in most cases, only the car and cycle come into contact with one another, involving the front side or rear of the car. As a consequence, second impact can involve areas other than the bonnet or windscreen.

Some of the safety requirements for pedestrian protection may well apply also to pedal and motor cyclist protection, at least for straight-ahead impact against car front or rear end.

A definition of specific requirements is unlikely.

IV. ORDER OF PRIORITY OF SECONDARY (OR PROTECTIVE) SAFETY MEASURES

The following numerical code is used for priority and practicability ratings :

PRIORITY	1 = Maximum	2 = Medium	3 = Minimum
PRACTICABILITY	1 = Available	2 = Foreseeable	3 = Doubtful

Priority is an overall assessment indicating the need for work to be carried out, whether this be further investigation or final development of test procedures. Practicability is the engineering practicability for producing cars with the safety measure of the performance suggested.

	Priority	Practicability
Improvement of seat belt systems to increase performance, convenience and comfort related to their use and the standardization of buckles	1	1
Investigations to improve protection for pedestrians when struck by cars	1	3
Frontal impact measures for restrained occupants	1	1
Side impact measures	2	2
Rollover measures (prevent door opening and roof collapse)	3	2
Rear impact measures	3	1

	Priority	Practicability
Fire prevention	3	1
Release of occupants whether injured or uninjured	3	1

V. PRIMARY SAFETY

The need for new or improved primary or preventative safety requirements seems to be much less urgent than that for secondary or protective safety for car occupants and other road users.

In fact, many primary safety improvements have been introduced in the past, and at present detailed accident investigations are showing to what extent various safety measures may actually contribute to safety. The following notes summarise tentative conclusions of this work.

	Priority	Practicability
BRAKES		
Antilocking systems (good potential but need assessment and further development for reliability)	2	2
TYRES		
Low pressure and deflation warning	2	2
Safety tyres	3	1
DRIVING AIDS		
Warning or driver control devices for unexpected hazards, driver fitness and car speed are all potentially useful, but need development and trials	2	2
Ergonomics of driving (comfort and optimisation of controls and layout)	3	1

	Priority	Practicability
HANDLING		
Research needed to study car behaviour, drivers and their inter-relationships	2	3
LIGHTING AND VISIBILITY		
Visibility of cars by warning and signalling lights and by other means, needs re-assessment. Driver's view at night and in adverse conditions also needs re-assessment	2	1

DISCUSSION BY THE PANEL

INTERVENTION

by Mr. Fiala

1. Structural strength.

1.1. The structural strength of a vehicle body has a direct connection with the injury risk in the event of an accident. It would not be the most effective way to solve all matters of injury prevention through measures of vehicle structure. More reasonable is the combination of several means such as restraint systems, together with the vehicle structure for the occupants and splitting of the traffic streams between pedestrians, cyclists and vehicles.

1.2. All measures to optimize the vehicle strength are meaningless if the occupant does not use his restraint system. For this reason, the usage of the restraint system available must be enforced with all possible power.

2. Results of the Accident Investigation

The results of the accident investigation show, that in almost 75% of all vehicle accidents at least two vehicles are involved in the collision. This is the reason why for the second generation of safety standards a reconsideration of the previous requirements on the basis of new research results of accident analyses is necessary.

3. Future Performance Requirements for the Structure

The report "Comparative Crash Test Results" which is contributed by CCMC, shows clearly that the load on the occupant varies depending on the accident and on the accident simulation. For the future we need, therefore, a legislation which takes the real accident into consideration.

For restrained occupants the performance criteria, which are mentioned in the session "Occupant Protection", should be considered. For the structure it is necessary to realize the problems of compatibility.

For the European situation it is sufficient to consider a mass ratio of 1 : 18 for car to car accidents.

The design of the structure in respect to mass and deformation force as a function of deformation distance should be defined for a long term, that means 10 years after final approval of the requirements.

The criteria for compatibility defined by tests against the representative deformable moving barrier or by a precise force deflection measurement, should be developed as soon as possible.

It is a wrong direction to increase the impact speed against the rigid barrier. This would increase only the rigidity of the vehicles and would tend to decrease the compatibility of the overall collision behaviour.

I would like to show you a short film on this subject.

(Projection of the film)

Instead of the design criteria today performance criteria have to be established.
The most important are :

a. Development of a representative test for evaluation of the restraint system.

b. Development of a representative test for the frontal crash. It seems that the 30° frontal barrier test might be the answer.

c. Defining requirements for compatibility between light and heavy vehicles. A sufficient lead time in this respect could be 10 years.

d. In respect to side collision a 90° movable barrier as specified ECE should be sufficient as a first step.

e. Also the fulfilling of the rear end collision test as specified in ECE is an appropriate requirement to prevent fuel leakage.

f. In respect of the occupant protection in rollover we feel, that the door latches have a primary function. A 720° dynamic rollover or a representative static test would be appropriate. The only criterian should be that the door latch does not open during the test.

g. Interior fittings and exterior projection in the EEC - directives are not meaningful. For example the tolerable radius depends on the location of the car and the material used.

Conclusion

The European automobile industry is studying, on the basis of consistent benefit/cost measures, the requirement to approve structural safety including the protection of cyclists and pedestrians. For this it is essential that the European legislation will grant standards with the following tasks :

1. Uniform standards in accordance with worldwide legislation.

2. Identical effective dates.

3. Careful judgement of the standards on basis of cost/benefit figures with forecast and control of their effectiveness.

4. Sufficient lead time related to development and amortization.

The continuous pursuing of these four points is my urgent request to the authorities here in Brussels.

INTERVENTION

of Mr. Danese

In this panel, if one wants to remain strictly within the theme, one must only discuss the problems tied to the crashworthiness subject and what is more, this being the first session, it would not be logical,at least in theory, to refer to what speakers will say during the subsequent sessions.

But, considering that the texts of the other communications have been known for some time and that Messrs. Taylor and Mackays' texts deal with intimately interdependent subjects, I shall consider Mr. Mackay's report as having been read, and base my contribution on both communications.

I must first of all as a research man,but also as a man from the Administration charged with rulemaking, compliment the two Authors for the clarity and professional honesty with which they have pointed out the problems and difficulties which we will have to face for the creation of new standards. Clarity and honesty which perhaps the laymen or semi-specialized section of the public may regard as superficiality and an attack on the religion of safety.

But every now and again in the international context, it is good that someone has the courage to state the truth clearly, not to stop the progress of rulemaking, but to point the way offering the best savings potential in terms of mistakes and money. That must be done especially here in Brussels where we are together to try and define the work programmes and where we want to verify what can and must be attempted for 1980 and beyond.

My contribution will consist of the following :

- Considerations on usage of design standards published by EEC and ECE whose cycle should be officially declared closed today.
- Considerations of a practical nature deriving from declarations by the two "Rapporteurs" on performance standards, i.e. second generation standards.
- Reflections on what can be done at the intermediate stage.

Mr. Taylor has outlined the position as regards safety standards throughout the world and in particular in Europe, and has mentioned that implementation of standards in European and EEC countries is governed by two treaties : The Geneva Convention and the Rome Treaty, signed in 1958 and in 1957 respectively.

The very dates of the signatures make one think that, if then the belief was to create something perfect, these treaties today - some 20 years hence - may show up some defects.

The Geneva Convention is a substantially valid agreement for Europe because virtually all European countries have signed it. Broadly, it states that signatories may or may not adopt the regulations that at least two members have accepted to use and submitted to the UNO for ratification.

I should also like to remind you that the adoption of a regulation on the part of two or more countries does not imply recognition of approval by the other parties as regards vehicle registration in their country. As this procedure is still in force today, it seems strange that there still are countries sending their representatives and experts to Geneva to define standards which they do not intend to implement.

Through the Rome Treaty, the EEC has attempted to remedy this anomaly and reduce the problems imposed on European manufactures, at least in the Common Market area, by introducing the principle of acceptability of vehicles conforming with the EEC directives in all member countries. Normally, in order to avoid repeating a job already done in Geneva, the EEC has adopted a good many of the ECE regulations. However, it must be said that implementation of directive is adversely affected by an anomaly to be traced back to the origin.

In fact, the EEC does not compel Member States to observe the directives issued in Brussels, but leaves the Member States free to maintain local regulations in force, and issue new directives as well. Thus, it has solved the problem of accepting a vehicle conforming to the new standards but, allowing the coexistence of national standards that may be more or less strict than the directive, it has permitted a certain measure of ambiguity which does no good for the clarity and final removal of barriers to trade.

Where there was an ECE regulation, the EEC, after verifying its applicability, has ratified it as it stood where no such regulation existed or was obsolete, it has created new standards, and this for the purpose of arriving at a complete vehicle approval standard.

To this end it is right to recognize that with the directives actually issued and proposed that have almost gone through the approval procedure, the majority of requirements listed in directive 70/156, which can be regarded as the legislative framework for motor vehicle approval, have been met. This could be considered as the achievement of a remarkable target if it was free from the above mentioned problems concerning the attitude of the various governments in view of the compulsory nature and coexistence of national laws constituting an alternative to the directives or integration of them. Table 1 illustrates the situation as regards compulsory EEC standards in Member States.

And here is a second table containing a list of standards belonging to the first generation which continue to be discussed here in Brussels. Some are fundamental for barriers to trade and it is a real pity that they cannot be launched. I shall draw attention to one standard only, that on the installation of lighting and signalling devices on motor vehicles.

This is a brief picture, certainly not complete: must we be proud of this situation now, in December 1975? Frankly, turning to manufacturers and my colleagues, I should say that we cannot be completely satisfied and, before starting the study of anything new, I think it would be desirable to make some decisions asking EEC governments to assume total responsibility, especially in view of the time these necessitate.

In my opinion the EEC should decide that :

- Current directives and those to be issued in future, must be accepted within a maximum of two years as national law by all EEC Member States. And then, finally, European type approval will be a reality. The obstacles of a legal nature which surely exist may be overcome if there is a determination to do so.

- The criteria governing the adoption of the directives should be standardized (for new approvals only ? On different dates for new approvals and approved vehicles respectively ?).

- Regulations in local use by some member countries should be adopted at Community level through standardization if judged valid (e.g. engine performance specified by Germany and Italy only).

- No new local regulation should be permitted.

Both Authors state that future rulemaking (concerning the so-called second generation standards) must be **based completely** on the requirement of performance of a biomechanical nature.

It is in fact logical to let manufacturers select constructional solutions, simply requiring them to ensure that the human body, once the test characteristics are defined, is capable of getting out alive or better still, of getting out with a higher probability of survival. Mr. Taylor also indicates **the types of tests to be developed using this philosophy**, affirming in practice that the EEVC programme presented in London last year, is the programme to be adopted and developed.

These declarations and proposals find me in perfect agreement both because the Italian government has been one of the founders of the so called London Club, subsequently officially called EEVC, and because my country, being in charge of WG2, whose task it is to work out the test standards, has maintained right from the start that this was the right way.

I am indeed very pleased to hear today that both Mr. Taylor and Mr. Mackay have come to agree with the opinion I have had right from the beginning, namely that it is useless asking WG2 to come up with standards if the biomechanical information is not available. Also, it is a proof of realism that both authors **have come to the conclusion that the reply to my request for** data is not for tomorrow. The whole world talks of performance indices but to the question : "What can you propose as a basis for medium range solution towards final indices ?" nobody can presently provide an answer. For years we have been discussing the first indices to be defined for the points of the human body that seem the most likely to cause serious injury and death, and we can say nothing about the head, chest and abdomen. The femur is an exception, although the proposed index varies by a mere 1 to 2 ratio.

Even the Americans, who have fewer difficulties than we Europeans and study the performance index/human body/dummy correlation problem practically, following the fireworks of Standard 208, have recently declared in Rome, during the EEVC meeting of May 15:
"The research programme recently outlined by the NHTSA clearly reveals the actual poor status of human tolerance levels knowledge and the urgent need for acquiring, through a coordinated and strict investigation, a corpus of ad hoc biomechanics elements which might serve as a basis for the individualization of realistic safety conditions for vehicle occupants and suitable measuring systems".

Even more recently, i.e. during the last Stapp Conference held three weeks ago in San Diego, it was emphasized that :

- There are reservations on the validity of results of tests performed using **dummies** ; in fact, at the some level of impact severity, injuries are more frequent and serious than **is** the case with real life car accidents.

- The value of 1000 for HIC (head injury criteria) is not valid.

- It is important to maintain a sufficient space for belted occupant head movement.

- Chest deflection is a more significant parameter than deceleration, whose effectiveness as a tolerability criterion is regarded as doubtful.

- As from January 1, 1976, Ontario State will make the use of seat belts compulsory and will reduce the speed limit from 70 to 60 m.p.h.

Therefore, I welcome the recommendation to seriously reflect before starting the o peration, even if limited in scope, if there is a doubt that what is regarded as good today will not be so tomorrow or the day after, with the consequence that the technology policy adopted to solve the problem has to be abandoned.

The picture is sad, but it is this very sadness **which must spur us to react** and produce intelligent work plans, to be well coordinated and followed enthusiastically by everyone so as to try and reduce EEVC programme time as much as possible. And this, in my opinion, can be achieved if :

- We can lay down priorities and target dates for the various objectives, but dates chosen to ensure that the end results are convincing and certain.

- We stop saying that in Europe we know all about accidents, their mechanisms, their statistical distributions.

- The documents everybody claims he has are unveiled and we, as WG2, are supplied with the information needed to start working; and if those documents are incomplete, a programme should be agreed to collect the necessary statistical data.

- **A biochemical programme based on partial and progressive targets is seriously established. In other words, priorities should be allocated to certain indices rather than proceeding with a general programme for human body overall protection involving simultaneous detail definition of all specifications. As a practical example of priority, say : chest first, head next, then the rest of the body.**

- On behalf of EEVC (and here I think the Community should find a way to finance this research) form is given to a tentative programme covering impact tests on the entire European vehicle population, or at least the most representative part thereof, to establish a test procedure, pending the provision of indices.

- European industry is asked to disclose any experimèntation it has conducted in this area. My feeling is that if this **is** done we shall have a programme needing only some completion rather than having to work it out altogether.

- Industry is asked to complete such a programme - and financial contribution is offered to this end - because the setting-up of its own laboratories by EEVC is useless; also, confidence can be had in the results furnished by industry.

- Common Market industry is asked to provide itself with an organized structure, that will put an end to dealings with individual Companies or, even worse, between individual Companies and their respective national Governments; and if industry is offered the possibility of attending our meetings not as accused (or, at best, as expert) but as contributor on equal terms with EEVD representatives.

CCMC has practically provided evidence of such willingness only yesterday by publishing the results of a remarkable research effort.

If all this is done, then many standards could certainly be finalized within the first past of the 80's, possibly having on the road really safer vehicles starting from '83-'84.
But, can we, the governments, ask users to wait so long ? The two Rapporteurs have posed this question and their answer is "No"; in fact, they suggest we should begin to study an intermediate phase during which the standards would be a performance/design mix, where by performance something bound to biomechanics is certainly intended. I do not agree entirely with this point and would, therefore, like to submit some of my own views.

On considering the WG2 proposal - appended to Taylor's report and entitled "The order of priority and major requirements for safer cars for the near future" - it may be noted that under "Main guiding principles", after stating that all the tests must be based on principles of performance with the use of dummies, proposals are set forth which are actually design standards.

In fact, quoting from chapter 2 :

"The car occupant safety characteristics must be established as a function of the following two requirements :

A - (Omission)

B - Elimination of indirect dangers ensuing from accident events such as fire, impossibility of timely aid, etc.

and then, immediately after :

"The performances to be required could be as follows :

1.- Compliance with biomechanical tolerance limits.

2.- No bursting open of doors during impact.

3.- Possibility, after collision, of opening at least one door without tools.

4.- Possibility, after collision, of removing the complete dummies.

5.- No fuel spillage or fire".

Next, under Restraint Systems - item 2.1 :

"Among the presently known restraint systems, the seat belts (3-point type, in particular) are certainly the most effective and simple in providing a reasonable direct protection of car occupants in the majority of road accidents.
It is desirable to have future regulations which make it mandatory to install and wear seat belts in all European Countries. In view of this, utmost R & D efforts should be devoted to seat belts in order to improve their present features and performance.

Amelioration should be concentrated on the following aspects :

- Installation in car
- Dimensional and strength specifications of the different components
- Location relative to occupants
- Occupant comfort
- manual fastening
- Automatic adjustment and locking
- Dissipation of occupant kinetic energy through absorbing devices
- Starter inhibition or some other interlock when belts are unfastened (possibly)
- Warning systems when belts are unfastened.

The rational solution of the different problems associated with the use of seat belts will require the close coordination of all effort spent in this field.
Further development of passive restraint systems should be investigated .

Finally, in defining two basic tests such as the frontal and side impact tests :

"2.2.1. Frontal Impact Test

A. Impact against barrier angled at 60° to vehicle main axis.
B.(Omission)
Test conditions : 2 dummies on board.
Requirements to be met :
All the items - 1 to 5 inclusive - listed above under Performances.

"2.2.2. Side Impact Test

(Omission)
Test conditions : 2 dummies on board
Requirements to be met : items 1 to 4 inclusive listed above under Performance"

In other words, the proposal specifies tests which still require design actions needing verification with dummies and more importantly also the immediate, mandatory use of seat belts in conjunction with active and ample efforts for the improvement of same.

Why not then take the decision of commencing, along with the total programme that involves knowledge of all bio-engineering data, a second, more limited and readily applicable programme which could proceed either on the name of parallel lines and require dummies only for mass and size ?

We could begin with a basic concept statement around which the whole programme would hinge and develop, namely, that the use of seat belts shall become mandatory throughout the Community in the shortest possible time, as the best occupant protection system known to-day. Immediately after this, however, a statement should be made to introduce the concept that if effective tests and optimization (mechanical, at least) of this accessory are desired, then the use of dummies only as inertia force contributors will have to be accepted. Once this point is reached, the next step is quite easy : the dummy can be used initially as a dimensional checking instrument in all the other tests, utilizing immediately to the fullest possible extent a near-sure biomechanical concept : the load on the femur.

Such fundamental approach solutions would enable us to issue the new standards on frontal and side impact tests, on the proviso of later up-dating and completion as more will be learnt about biomechanics. Some of you might object that this proposal is too poor and fruitless.

Yet, my feeling is that if we succeed in imposing compulsory use of seat belts throughout the Community and improving belt design and safe use in cars, the leap forward would be remarkable indeed, particularly if combined with a more realistic impact test, though incomplete and imperfect.

My views find supporting evidence in a WG2 Report-Outline (Table 3) providing the order of priority and practicability where a numerical code is used as follows :

- Priority : 1 means Maximum and 3 Minimum.
- Practicability : 1 means Available and 3 Doubtful.

Now, if we consider this table in detail, starting with Practicability, the following rating is obtained :

1. Seat belt improvement.
2. Frontal impact measures for restrained occupants
3. Side impact measures
4. Rear impact measures
5. Release of occupants
6. Fire prevention

This classification is in line with the Priority ratings on two fundamental points :

- Seat belts
- Frontal impact

Next in line as to priority is the side impact to which both ratings assign 2 ("Foreseeable" under practicability).
It may then be said that both the Manufacturers and ourselves could agree on a short-term programme with these targets :

a. Seat belt use and improvement
b. Barrier test
c. Side impact test

But, basically, what I call the "intermediate programme" should end here with these standards only and should be conducted jointly by all, namely, Community, EEVC, and Common Market Manufacturers.

Should this materialize, I figure that the standards mentioned could be issued sometime between early 1977 and late 1978 so that they would become effective practically in the 1977-1980 period.

In conclusion, my recommendations are :

1. Issue the last group of Directives now waiting in Brussels,
2. Obtain within two years the true and total application of EEC Standards throughout the Community.
3. Prepare a single package of standards, either by accepting or discarding some which are essentially local.
4. Stop issuing national standards.
5. Give full effect to the EEVC programme and establish performance standards for issue within the 1980/85 period.
   To obtain this result, industry must be asked to cooperate fully and accept deep involvement.
   This can only be accomplished if the EEVC and the EEC will have a sole respondent in industry, at Community level.
6. Start an interim plan which within three years will establish comprehensive standards on the following topics only, using dummies :

   - Compulsory use of seat belts and their improvement study
   - Frontal impact test
   - Side impact test

E.E.C. DIRECTIVES - NATIONAL ADOPTION STATUS

Tabel 1

December 1975

DIRECTIVE		RATIFICA-	NATIONAL ALIGNMENT	EFFECTIVENESS DATES								
REF.	SUBJECT	TION DATE	DEADLINE	B	D	F	I	NL	GB	IR	DK	L
70/156	EEC Motor Vehicule Certification 1)	06/02/70	10/08/71	19/07/71	26/10/71	10/03/72	08/05/74		01/07/73	01/07/73	01/07/74	
70/157	Noise Levels (Part I)	06/02/70	10/08/71	10/08/71*	26/10/71	06/02/73*	01/01/76	25/07/71	01/07/73	01/07/73	01/07/74	01/07/72
73/350	Exhaust Silencers (Amendement of 70/157 Part I)	07/11/73	01/10/74 01/10/75 (For earlier type Approvals)		08/02/74	01/10/74* 01/10/75*			01/03/74 For new type Appr.			
70/220 −	Air pollution	20/03/70	30/06/70 01/10/70 Idle CO and crankcase emissions 01/10/71 CO and HC at variable speed rates	01/10/73+	01/10/70+ 01/10/71+	01/01/71+ 01/10/71+	01/08/71+ 01/10/71+	01/01/74+	10/10/73+	01/07/73	01/07/74	
74/290 −	Air pollution (Amendement of 70/220 Annexes I to V)	28/05/74	01/10/75 - Annexes: I (3.2.1.2.2. except) II, IV (1.5 except) V 01/10/76 - paras: 3.2.1.2.2. (Ann.I) and 1.5 (Ann. IV)	01/10/75+ 01/10/76+	01/10/75+ 01/10/76+	01/10/75+ 01/10/76+	01/10/75+ 01/10/76+	01/10/75+ 01/10/76+	01/04/77+			
70/221	Fuel tanks	20/03/70	23/09/71		26/10/71	16/06/72	01/01/76*		01/07/73	01/07/73	01/07/74	
	Rear protective devices			01/10/72*	01/01/75*	16/06072*		13/01/71*				
70/222	Rear registration plates- Mounting and fixing	20/03/70	23/09/71		26/10/71	18/10/74*	01/01/75*		01/07/73	01/07/73	01/07/74	
70/311	Steering - Max effort on steering wheel	08/06/70	12/12/71		26/10/71	13/03/72	01/01/76*		01/07/73	01/07/73	01/07/74	
70/387 −	Doors (Locks, hinges, footboards)	27/07/70	28/01/72		03/03/72	13/03/72+	01/01/75*		01/07/73+	01/07/73	01/07/74	
70/388 −	Audible warning devices	27/07/70	28/01/72	28/01/72*	22/12/72	13/03/72	01/01/76+	28/08/72*	01/07/73	01/07/73	01/07/74	
71/127	Rear view mirrors	01/03/71	05/09/72	01/09/72*	03/03/72	13/03/72	01/01/75*	01/09/72*	01/07/73	01/01/73	01/07/74	
71/320 −	Braking devices	26/07/71	29/01/73 01/10/74 (for split systems and warning light		22/12/72	01/10/74* Trucks/ Buses 01/10/75* Cars/ Deriv.	01/01/76+	01/10/74+	01/07/73	01/07/73	01/07/74	
75/524	Braking devices	25/07/75	01/10/76		01/10/76*			01/10/76*				
72/306 −	Diesel engine emissions	02/08/72	10/02/74		01/01/77+	01/10/74+	01/01/76+	01/01/75+	15/02/74*		01/07/74	
72/245 −	Radio interference suppression	02/08/72	23/12/73	01/01/75	22/12/72		01/01/76*	01/10/74+	01/04/74+		01/07/74	
72/60 −	Passenger compartement safety	17/12/73	20/06/75		12/03/74	06/07/74	01/01/77*		15/05/75			
74/61 −	Anti-theft devices	17/12/73	20/06/75		12/03/74	24/07/74+	01/01/76*		15/05/75			
74/297 −	Steering gear- Back-up and collapsibility	04/06/74	20/12/75		20/08/74	24/06/74+	01/01/78*		15/05/75		01/10/75+	
74/408 −	Seats and anchoring	22/07/74	01/03/75 - Effective-ness: 01/10/75		20/08/74	12/06/75	01/01/77*		15/05/75			
74/483 −	Exterior protrusions	17/09/74	01/06/75 - Effective-ness: 01/10/75		26/05/75	12/06/75	01/01/77*		15/05/75			
75/443	Reverse	26/06/75	01/01/77		20/08/75							
	Speedometers				20/08/75							
1463/70	Tachographs	20/07/70	Regulations automati-cally law for all the Countries			01/01/75*				01/01/76*		01/01/75*

1) Effectiveness is subordinate to the issuance of all Directives

− Corresponding to an E.C.E. - Geneva Regulation

+ Mandatory observance as alternative of E.C.E. - Geneva Regulation

* Mandatory observance. Dates whithout asterisk are intended as non-mandatory

TABLE 2

PROPOSED DIRECTIVES UNDER DISCUSSION WITHIN EEC

Subject	Project Progress Status
- Field of Vision - Windscreen wipers and washers (under review)	Council 1968
- Weights and dimensions	Council 1971
- Safety glazing	Council 9/72
- Lighting and signalling devices - Installation.	Council 12/73
- For lights	Council 12/73
- Reflectors	Council 1/74
- Seat belt anchorings	Council 8/74
- Noise level abatement	Council 8/74
- Vehicle identification number	Council 9/74
- Number plate lights	Council 12/74
- Side, rear and stop lights	Council 12/74
- Asymmetric beam headlamps	Council 12/74
- Towing devices	Council 12/74
- Seat belts	Council 12/74
- Head restraints	Council 12/74
- Tyres	Commission - In course
- Defrosting systems	Commission - In course
- Tractor-trailer connections	Commission - Discontinued
- Special provisions for buses	Commission - In course

TABLE 3

ORDER OF PRIORITY AND PRACTICABILITY OF SECONDARY (OR PROTECTIVE) MEASURES

	Priority	Practicability
Seat belts, improvements to belt and cars to increase performance, convenience and comfort related to their use and standardization of buckles.	1	1
Investigation to improve protection for pedestrians when struck by cars.	1	3
Frontal impact measures for restrained occupants.	1	1
Side impact measures	2	2
Rollover measures (prevent door opening and roof collapse)	3	2
Rear impact measures	3	1
Fire prevention	3	1
Release of occupants whether injured or uninjured.	3	1

INTERVENTION

of Mr. Grosseau

Mr. Taylor's paper is very detailed. He sets out all the safety problems of all types of road users. However, it is up to the designers to sift out the main angles to enable them to form a concept of future car structure.

Before broaching this particular subject, I would like to emphasize the fact that it is difficult to dissociate the problems of structure from those of passenger retention which are dealt with in session 3.

I regret that the two sessions are not taking place consecutively.

I. INTRODUCTION

The regulation of car structure design goes back almost 8 years. Today, in the U.S.A., Japan, Australia and Europe 118 norms, 30 of which relate to structure are in force, although not common to all these countries. Without entering into details, the considerable technical and economic difficulties for designers in trying to satisfy all these regulations simultaneously become immediately obvious.

In addition it should be remembered that some of these regulations were published piecemeal over 8 years, necessitating continual modification of cars. The important question today is knowing what needs to be done to continue improving safety.

Can we continue to bring out norms the same way as at present ?

New limiting factors have arisen :

- the energy shortage
- the economic crisis which in particular has affected the car sector.

Regulations have until now been created without taking cost effectiveness into account. In particular they have penalized the small car which is in danger of disappearing. If only for this one point then the spirit of the regulations must be reviewed.

II. <u>How do we reconciliate improved safety with methods of economy car design at maximum cost effectiveness.</u>

The answer to this question lies in giving priority consideration to the occupants rather than , as has happened until now, to regulating the structure. Design initiative for maximum economy of materials must rest with the designer. Testing of parts should no longer be imposed but should be confined exclusively to what is called synthesis testing, that is the simultaneous testing of the total structure, seat and the restraint device only to obtain valid protection for occupants. Whatever the vehicle's characteristics on impact, occupants cannot sustain deceleration and other forces above certain values. These values are grouped by experts in biomechanics under the heading "protection criteria".

Here one very important point should be emphasized :

It is absolutely necessary to concern ourselves first and foremost with occupants who are using restraints. Sparing people's feelings by allowing them to believe that they can save themselves in a road accident without some form of restraint would make it impossible to design safe cars.

The stresses acting on the occupants depend so closely on the reactions of the restraint system, the seat and the behaviour of the structure that these must always be considered as a unit : Person/Seat/ Restraint System/Structure must be taken as an indivisible unit. One immediately sees the usefulness of approaching the problem in this way in bringing about optimum cost effectiveness and permitting small car construction.

The basic characteristic of the small car is that it has only a limited amount of material available for absorbing energy on impact. For this reason the material should be judiciously used.

We appreciate the methodology advocated by the French Government which, departing from single elements, consists of seeking the optimum design for absorbing energy on impact as an integrated unit and adding each element step by step to form a complete structure which ensures the safety of the occupants,

In this way we were able to show that about 8 to 9 kg of sheet steel are sufficient to dissipate the kinetic energy of an 800 kg vehicle striking a fixed barrier at 48 km/h, this quantity having the dual function of safety and the mechanical retention of the structure. In this way we hope to arrive at an economic car design which meets future protection criteria. Clearly we will not reach this objective if the design itself of the structure is subject to regulation.

III. The concrete factors at our disposal for improving car safety

These have been taken mainly from inquires made into actual accidents which permit us to determine :

1. The types of impact to be absorbed by selected characteristic impact zones
2. The mechanical behaviour of the main types of current structures
3. The behaviour of the occupants
4. The behaviour of the means of restraint

The reconstruction of these accidents in the laboratory has enabled limits to be set for human tolerance levels and the influence of future car design by the methodical analysis of each element of a structure in absorbing impact energy.

We are thus able to extract the following pointers :

1. The frontal impact test against a rigid barrier at 90° is not representative for the majority of accidents or victims. It results in car deceleration distances which are too short.

2. We can fix performance figures for car occupants which could allow us to say that in most cases they are adequately protected.

3. The displacement of the steering wheel gives an estimate of the reduction in free space after an accident. To stay within specified limits the front of the structure has to be strengthened which entails an increase in weight and most often increased deceleration for the occupants. We have therefore worked out a structure which protects the driver in spite of an above displacement of the steering wheel. To bring this up to the normal legal requirement the weight of the structure has had to be increased and the average deceleration value has also increased. We are far from obtaining optimum protection with optimum cost effectiveness.

4. In a test in which a car reinforced in this way was used in lateral impact on another car , there was excessive penetration into the passenger cabin of the latter.

5. Thus we can observe a chain-reaction of repercussions resulting from an outdated norm.

IV. Desired development of regulations

In order to avoid the above inconveniences, design criteria must no longer be imposed for structures. Current attempts at standardization are open to criticism since each element which contributes to the safety of the occupants is tested separately against mainly mechanical and partly geometrical criteria.

In contrast, the synthesis tests take into consideration the Person/Structure/ Seat/ Restraint System combination.

They take account of the interaction of various components and the possibility of ensuring the protection of the vehicle's occupants using biochemical criteria and represent important progress in the field of safety.

We insist that the old regulations which are based on structural design are incompatible with the future ones based on protection criteria.

Out-of-date norms such as that governing steering wheel displacement should be dropped.

Certain regulations should be firmly rejected such as the specification of survival room under the pretext of taking immediate action.

Although there is still some uncertainty as to the exact human tolerance values, we can move towards evolutionary protection criteria which would enable us to achieve a first stage which would take into account current possibilities of measurement on existing anthropomorphic dummies.

We support the recommendations of the ESVC both on the principles for further testing and on the dates of enactment, that is, in the early 1980's.

In conlusion :

Faced with the problem of safety which consists in saving the maximum number of human lives without favouring one category against another, we are not as ill-equipped as the enumeration of difficulties in Mr. Taylor's report might lead us to suppose.

We can propose solutions, but we definitely must all use the same methods. The basis must be accident inquiries.

The designer must continue to be the initiator of structural design if at all times cost effectiveness is to be achieved. Only the "respect of protection criteria" objective should be respected. And these should be defined on the basis of reality on the roads.

INTERVENTION

of Mr. Kuyperbak

In view of the rapporteur's sound arguments and although I am not one of the research experts who are here in such large numbers, but rather a civil servant responsible for administration, I shall restrict myself to a few brief comments.

Traffic accidents have indeed increased in step with the growing number of vehicles and are, therefore, considered to be an inevitable product of the transport system.

As the illustrious speaker pointed out, the majority of traffic accidents are due to human failing. He also stated that the consequences of such human failing can be prevented or diminished by various means such as education and "traffic training", better roads, safer traffic techniques and the use of safer vehicles.

In the case of safe vehicles two different safety aspects emerge i.e.,

(a) safety aimed at improving vehicle road holding, braking capacity, steerability, handling on bends etc. This does not concern the subjects dealt with here but is aimed more at preventing accidents;

(b) traffic safety aimed at improving design in order to diminish the consequences of an accident. Hitherto most attention has been devoted to diminishing the consequences for vehicle occupants. As pointed out by the rapporteur more attention must be paid in future to the more vulnerable forms of traffic such as cyclists, motorcyclists and pedestrians.

A question which arises during the search for partial solutions carried out to date is :

Will, by improving both active and passive vehicle safety without devoting the necessary attention to the "education" of road users at the same time and also improving the quality of driving lessons and consequently improving the quality of motor vehicle drivers, the average drivers reaction not be that because he is sitting in a safer vehicle and driving on a safer road he can take still more risks and drive still faster ? Will this reaction not make the problem which we are facing i.e, doing what is necessary for vulnerable forms of traffic, still more difficult to solve ?

I would think that research in this area is also urgently needed.

A subsequent point dealt with by the speaker concerns the compatibility in the event of a collision between the vehicles of different weights. Research publications in this field indicate that the solution to this problem should be sought in influencing the final weight categories of the vehicles on the road.

The question arises as to whether as a result of this new barriers to trade will not arise if such a solution as this were not applied on a world-wide scale.

Finally I would like to comment on the differences between standards laid down in the European Community countries and for example the United States. It must now be considered fortunate that conversations with the United States and as far as I know Japan, are to take place within ECE Expert Group GE 29, which deals with motor vehicle design, in order to explore the possibility of harmonizing test methods.
It is to be hoped that in the short-term these discussions will yield such results that the much more difficult problem of the harmonization of standards can be discussed. Only in this way can the removal of technical barriers to trade by means of technical specifications be achieved on a world basis.

INTERVENTION

of Mr. Finch

The establishment of an acceptable standard resolves from a compromise between the ideal and the practical. It should include a careful consideration of alternative test procedures, possible production problems, and an appraisal of the cost effectiveness of the proposed solutions. A standard should neither inhibit further improvements in the safety it sets out to provide, nor jeopardize the development of other safety areas. Its intentions should never be ill defined or ambiguous but should be so worded as to be capable of only one interpretation by manufacturers and goverments alike. In certain cases extra clarification of course may be necessary, under these circumstances an internationally agreed answer is required rather than individual government interpretations which may differ.

In a world of rising prices, falling markets and energy conservation the need to restrict the use of materials, hence weight and fuel consumption , to a minimum is apparent every day. We must,therefore, accept that safety measures are not all equally important, the most infrequent accident may demand the maximum redesign; in considering the present situation, if statistics show the comparative ineffectiveness of a standard, or test procedure, it should either be improved or deleted. For future legislation an agreed list of priorities based on accident analysis, benefits and costs has first to be established.

The fact that road deaths and injuries have been significantly reduced in those countries where the wearing of seat belts has been declared mandatory, even though its observance does not reach 100%, raises the question, that in considering further legislation involving structural requirements, should we take into account the 'current' value of seat belts, or the 'potential' value. Should we continue to expend efforts and resources , at this stage, on duplicating this level of safety already attainable by existing restraint systems, or give preference to those areas, or class of people provided with either insufficient protection or none at all.

Consider the mandatory use of seat belts as applying,for example, to the United Kingdom, and assume that an 80% compliance could be achieved. Pedestrian fatalities would probably rise from about 38% to 45% of the whole, with car occupant deaths falling from 41% to 30%. Occupant injuries would probably fall from 48% to about 35%. Since these reductions would result mainly from the protection given by the belts in frontal impacts, it follows that in other impact modes the relative percentage of occupant injuries would rise.

The mandatory enforcement of seat belt wearing would,therefore,not only immediately reduce the numbers killed and injured in cars, but also change the relative importance of other safety standards and thereby produce a different set of priorities. A factor of no small account in planning future legislation.

We can consider a vehicle's structure from two aspects, one from the protection it affords the occupants and the other from the protection it offers other road users. In the past the emphasis has been very much on the former, with little consideration for the latter.

In the majority of accidents involving two road users, one invariably has advantage over the other; impact compatibility being largely fortuitous. In cases involving cars and pedestrians or cars and trucks the ideal answer is 'segregation'. This not being feasible on a universal scale other methods will have to be found, if only to reduce the problem.

The basic difference between occupant and pedestrian protection is one of complexity. For instance, we know that at any given speed, a pedestrian will suffer less injury from contact with the centre of a long smooth bonnet than from the windscreen surround, but the mechanics which determine which of these two impacts a victim will suffer may involve his own pre-impact behaviour, his physical characteristics, the car speed and direction, bumper height, bonnet profile or any combination of these.

To complicated matters,it is possible that different combinations of these variables would require different designs for survival. For example, it would seem that adults impacted at speeds up to say 20 kph are best served by a long low bonnet, whereas at higher speeds a higher bonnet profile may be desirable in order to cope with the victims increased trajectory. The inevitable compromise may also be influenced by the height and location of the bumpers. Low bumpers centred about 360 mm from the ground tend to rotate the impacted victim more rapidly, but have the advantage in reducing the possibility of inflicting serious knee fractures.

The effective reduction of vehicle aggressiveness and the improvement of impact compatibility will require considerable research before firm recommendations are available.

That the possibility exists may be seen from the following series of slides depicting stages in the development of Leyland Cars ESVs.

Slide 1 This shows the effect of a 90° standard car-to-car impact at 50 kph. Maximum penetration into the target car is 350 mm and although the rear seat dummy survived, the one in the front seat registered fatal loads and decelarations.

Slide 2 A second target car was prepared incorporating structural modifications and extensive interior padding. It was impacted by another standard car at the same speed and direction as before.

Slide 3 Penetration was reduced to 133 mm, but again the front seat dummy suffered severe injury, although survival space was 1200 mm.

Slide 4 A second modified car identical to the last was then impacted as before, by a car having a low energy absorbing bumper and a front end designed to improve compatibility.

Slide 5 Vehicle accelerations increased, but maximum intrusion was reduced to 23 mm and the loads on the dummies to acceptable levels.

This is not to suggest that all pedestrian and side impact problems can be solved simply by stipulating a lower bumper height : other factors will also require consideration. But it certainly suggests that any plans to promulgate a high bumper should at least be held in abeyance, until research is completed.

In all side impacts the strength of the door locks and hinges are an essential part of occupant compartment integrity, but without an in-situ door intrusion test existing legislation is incomplete. Theoretically anti-burst locks and hinges can be attached to diaphanous doors and flexible side panels incapable in themselves of resisting structural failure or distortion from either direction.

The replacement of design rules by performance standards is at present restricted by our limited knowledge of the appropriate biomechanical criteria and the capabilities of available dummies. If realistic legislation is to be introduced, work in these areas must continue together with the establishment of repeatable test procedures based on real accidents.

The possible dangers of specifying procedures, based on a limited examination of the problem, can be illustrated by the following three slides again depicting car-to-car side impacts.

Slide 6 This shows the interior of the target car in the standard 90° car-to car tests already discussed.

Slide 7 This the interior of another standard car again impacted at 90° and 50 kph but this time by a mobile barrier having the same overall weight (1154 kg), wheelbase and frontal width as the standard car but fitted with an impact face similar to J.927. You can see that the overall damage is more extensive, particularly in the areas of the fascia and rear seat.

Slide 8 The next slide shows that the injury levels from the barrier were higher than from the bullet car. Only when the barrier speed had been reduced to 40 kph did the dummy's injury levels approach those of the original 50 kph car-to-car combination.

This simplified example does not vary the weight, profile or area of contact of the barrier, it does not examine possible differences resulting from a deformable barrier or an angled impact, and the question of the mobility of the test vehicle is not considered.

Yet questions similar to these must all be examined carefully if sensible legislation suitable for future generations of cars is to be evolved.

INTERVENTION

of Mr. De Coster

Mr. Taylor's presentation truly reflects the work carried out in the past on regulations aimed at improving road safety by dealing with vehicles.

Broadly speaking it can be said that half of the fatalities due to road accidents occur inside vehicles and the other half occur outside. If the research, standardization and regulation carried out to date are examined a different picture emerges. The majority of the work by far has been directed towards improving the fate of vehicle occupants. This choice was legitimate since better, quicker results could be achieved in this area.

It is, however, conceivable that if the same efforts had been applied to pedestrians, cyclists and motorcyclists the results obtained would perhaps have been less spectacular but certainly better than those obtained at present.

The regulations adopted in order to improve vehicle occupant safety are bearing fruit. Recent statistics compiled in Belgium show that during a 5-month period since the wearing of safety-belts became obligatory the number of accident victims inside vehicles decreased by more than 25%. This means that in future the percentage of victims made up of pedestrians, cyclists and motorcyclists will increase sharply and more and more attention will be drawn to accidents involving these. In addition it now emerges that judges are treating motorists who injure pedestrians more severely.

This symposium,which is dealing with current progress on the things remaining to be done, should lay stress on the research to be carried out in order to make vehicles less aggressive towards other road users.

Study is needed on shapes, a certain type of shock absorbing and the avoidance as far as possible of subjecting pedestrians injured on the road to a second impact. The height of the bumpers is particularly important, the main consideration being the difficulty in mending certain knee injuries.

It would be regrettable if the example of the United States were followed in that occupant protection was immediately followed by steps to reduce damage to vehicles rather than to other road users.

In conclusion, I hope that it will be possible in the near future to develop research on structures enabling the aggressiveness of vehicles towards pedestrians, cyclists and motorcyclists to be reduced. Such research is absolutely necessary as a preparation for future regulations.

INTERVENTION

of Mr. Campilli.

The programme does not tell you very much about who is addressing you; so perhaps I ought to introduce myself a little more fully. I am not a technical man in the strict sense of the word but a motor dealer now in commercial vehicles but formerly in motor cars. The European Committee of the IOMTR is the international organization of motor vehicle dealers and repairers and 112.000 businesses in Europe Members.

This will perhaps put what I have to say into a better perspective with relation to the theme of the symposium as a whole and to that of this session in particular. I should like first of all to say that I have read with very great interest not only the reports of the different sessions but also that of the CCMAM, to which I would like to give my reactions now. On page 5 (item 3/4 of section A) of this report the CCMAM says that it is desirable between now and 1980 to limit new regulations to those already planned. I am in complete agreement with this approach. I would like to take a second cue from the tests which are several times referred to in the report. It is quite clear in my opinion that the problem of vehicle safety has to be approached not only from the purely technical point of view but equally from the point of view of vehicle use. The construction of a safer vehicle is no guarantee that the vehicle will always remain safe or that it will always be used in accordance with the safety regulations. We must not allow ourselves to forget that at the present day in the Community there are 70 million motor-vehicles and 30 million motor-cycles on the road. That is a plain fact. At this point I should like to mention (and may I repeat that I am aware that I am a man in the street by comparison with the technical experts gathered here) the impression made on me by the report of Mr. Dammasio, now of ENI, on a checking and tuning test carried out in Milan in 1970 on around 50 000 road vehicles for the purpose of collecting pollution data. More than 50% of the vehicles checked had emissions reading above 5.5 on the index, which was considered the maximum tolerable amount. After a simple tune-up of these vehicles only 295 were still above 4.5 on the index and 53,5% of them were actually below 3. This shows that it is possible to obtain remarkable results with correct periodical maintenance alone.

Before reaching a conclusion I should like to make another observation. In some European countries, around 21% of the vehicles in circulation are 13 or 14 years old or even older. (In the Federal Republic of Germany this proportion rises to 33% and in my own country, Italy, it jumps to more than 55%) What I wonder is what share of the responsibility for road accidents is borne by these vehicles, often antiquated, often poorly maintained, and in some countries seldom subject to any kind of check. I am afraid that the technical experts are working on the development of something which though laudable is probably not adequate, from the statistics on the accidents and characteristics of vehicles in circulation, and secondly from the repairs necessary to keep vehicles in a safe condition through their working lives.

A French survey carried out in 1970 showed, for example, that accidents linked to technical defects in vehicles, either as the major or aggravating factor, increased (from 8.8% for vehicles under three years old to 40.8% for vehicles over 10 years old). These are facts which should make us stop and think. A survey carried out last year by a major tyre manufacturer revealed that only 20% of cars in the survey were using tyres with the proper amount of tread and the right level of inflation.

I should like to put this thought to the technical experts present here today, to civil servants and, above all, to the senior personnel in the Community. I imagine that Mr. Cornelis will be talking about periodic checks; let me, therefore, merely underline the importance of these checks which are not always considered in quite the right light. In general, the manufacturers technical departments follow the vehicles technical efficiency during guarantee period (usually 6-12 months). However, after this period data becomes increasingly scanty and inconsistent. Personally, and here I also speak on behalf of the European Committee of the IOMTR, I feel that the only sure way to cooperate not only in producing a safer vehicle but also in maintaining its safety over time, is to organize an efficient system of compulsory technical and medical checks throughout Europe. There is a draft Community directive on technical control. It is one of a number of directives omitted from the list of draft directives suggested in the Danese's talk, but I believe these to be be essential, as complementary texts, in the discussions which must ensure on vehicle safety. Similarly I feel it is extremely important to organize comprehensive systems for recoding the causes and effects of street accidents, with the cooperation of the insurance companies and the hospital and police networks, so that a data bank can be built up, for instance at Community level, which would receive information both in advance of and as a follow-up to the design, development and construction phases.

Some steps have already been taken in the German Federal Republic and in Belgium to organize technical inspections and aptitude checks on driver behaviour (which I believe to be equally important). I feel that other countries have done less in this respect. My own country has done very little in this field, in spite of the fact that manufacturers, distributors, garages and, more recently, consumers, that is to say the Automobile Club of Italy, have all stated their readiness to contribute to this kind of work in terms of both organization and financial support.

In closing, I should like to remind you that organizing, first of uniform technical checks in Europe, secondly of a proper aptitude test for drivers and thirdly of collecting data upstream and downstream of the design stage is a matter of importance to the work of the technical experts and civil servants gathered here to discuss the problems of vehicle safety.

INTERVENTION

of Mr. Hofferberth

On behalf of myself and the other representatives I would like to compliment Dr. Taylor on his paper and his clear and concise statement of the issues. I shall confine my comments to several points contained in this paper.

In the early part of Dr. Taylor's paper, he states that, 'it would unquestionably be unacceptable to the public to increase the safety of one class of road user at the expense of another'. This statement is easily misunderstood. I interpret it to mean, for example, that one should not give up two fatalities to one class of road user to prevent one fatality to another class.

However, it is important to note that the reverse is also true, that one must be prepared to concede one fatality to one class of road user to prevent two fatalities to another.

This is central to the pursuit of the maximum safety benefit to the majority, or as it is sometimes called "compatibility', and it would appear that nothing is truly free. An advancement in one dimension of motor vehicle safety invariably implies a decrease, or at least a reduction in the potential safety level in some other dimension, although not always in the same measure.

The question is further illustrated when one considers the tradeoffs necessary to achieve a proper balance between the factors of safety, protection of the environment, efficient use of energy and economy; the principal elements of S3E. In this area, the safety of motor vehicle users is directly traded off against other factors, some of which are almost purely economic, and all of which must ultimately be reduced to economic terms, or to some other common unit, such that rational tradeoffs can be achieved.

This presents difficult questions, but until one comes to grips with such questions as :

- How much is society willing to pay to prevent a motor vehicle fatality ?
- How much is it worth to consume one barrel of oil ?
- What is the social cost of some measure of increased environmental pollution?

one has not dealt with the central issue.

This leads to another comment in the paper to the effect that "ideally the test methods chosen for demonstrating the required levels of occupant protection should employ criteria relating principally to the people, not to the vehicle". Dr. Taylor then makes reference to the biochemical criteria contained in the United States Standard 208, and notes that the introduction of dummies for compliance testing adds greatly to the complexity.

Let me agree that using test dummies does indeed greatly complicate compliance testing, although not to the extent indicated by Mr. Danese, in my judgment It is much easier to define objectively and perform component tests, static loading tests and the like; but it is very difficult to relate the results of such tests to the benefit that will accrue in the real world.

Tests that closely simulate real crash events, and forms of possible injury to simulated crash victims are more complex, but the linkage to safety benefits is much closer. With today's need to balance carefully all of the social costs and benefits of motor vehicles, this linkage is essential. In my view it is clearly feasible in the area of crash survival testing; and the precision with which it can be accomplished in advancing rapidly.

In the other areas it appears to be more difficult ! Mr. Grosseau made this point. He also indicated, and I agree, that there is a second reason for the testing of the entire vehicle system against criteria that relate primarily to people. Initially it may be possible to achieve a desired level of safety performance by either component requirements or system performance requirements. However, component requirements tend to be closely related to the current state of art and are frequently much more design restrictive than system performance requirements. For example, it is clearly possible to achieve a high level of safety by requiring the installation of lap and shoulder belts, and using any available means to encourage the motoring public to use them. However, such a requirement usually eliminates any likelihood of finding a better way. System performance requirements, properly drafted, encourage development of better, more reliable, less costly ways of achieving the desired result.

I would like to close with one final comment. Dr. Taylor indicates that "with the completion of the E.S.V. programme, it was evident that attempts to make a large single step in car safety quickly, based on existing knowledge, had not been successful in practical terms". It is agreed that the E.S.V.s produced in the United States left something to be desired in terms of practical demonstrations of high levels of safety performance. However, the proposition that such attempts, in general, have not produced such demonstrations is not at all evident to me.

Other programmes in the States have provided very encourageing demonstrations, and the R.S.V. programme and several other Research and Development projects are currently pursuing demonstrations of safety performance levels comparable to those contained in the E.S.V. specifications for vehicles that weigh as little as 900 to 1000 kilograms.

As part of this overall programme, several current production vehicles are being evaluated. It appears that some of those which weigh less than 1400 kilograms, may provide such performance levels in frontal impacts if advanced restraint systems are installed, with little or no structural modification.

Mr. Chairman, I would like to express my sincere appreciation for this opportunity to express my views.

GENERAL DISCUSSION

Intervention by Mr. CHABROL

I should like to know what progress has been made in the studies on a dummy that is truly representative of a human being in the event of an accident.

Answer by Mr. MACKAY

As I understand the question, it was to find out what a dummy is. It is a very complicated question, and the state of the development of dummies is changing rapidly. Almost all the dummies that are used, in my opinion, for legislative purposes are known to specialists to be unsatisfactory in terms of their detailed response. The question is, really, to have a dummy which is complicated enough to be a reasonable simulation of a person and yet simple enough to be of value in any legislative testing-procedure, and this problem, I think, really has not been fully solved, if you want to measure on a dummy all of the injury parameters that are of interest. These, for example, will be to the head, to the chest, to the abdomen, to the legs, in a frontal impact situation, and perhaps also the same parts of the body in impacts from other directions, from the side as well and as things stand at the moment, in my view, we do not at this stage have a dummy which can faithfully represent the human being for all these loading conditions.

Intervention of Mr. GOODE

Vehicles may have to provide features which are almost entirely not for their own benefit but for the benefit of others. Such a case is the rear underrun guard which if made deformable could provide protection to passenger car occupants involved in rear end collisions with trucks.

Answer by Mr. GROSSEAU

In short, the question asked by Mr. Goode concerns an accident between a lorry and a passenger car. There is little that we can do today to solve such a problem completely. I should nonetheless like to recall that Mr. Finch, in his report which we heard earlier on, suggested that, as regards the potential hazard that one vehicle type constitutes for others heavy vehicles' be equipped with special devices which, if properly designed, would enable the energy of the impact to be absorbed and would also prevent the passenger car from running under the lorry.

At present, there is no standard that stipulates a special rear structure; the only regulation which nowadays requires the constructor to do something is an American standard relating to the integrity of the fuel tank. Once the petrol fuel tank is protected, there is obviously better protection for the occupants. In conclusion, I should like to refer to Mr. Taylor's report, particularly to his comments on rear-end collisions, and to the study carried out by the ESVC which may be a first step towards facilitating the design of vehicles with the aim of reducing the severity of rear-end collisions. In Mr. Taylor's report, the rear-end collisions mentioned are obviously those of cars against cars and not lorries against cars.

Intervention by Mr. LEFRANC

When the gravity (mortality rate) of side-impact accidents is considered , these accidents rank easily second after frontal impact as regards the number of occupants killed or seriously injured.

According to the report by Mr. Taylor and Mr. Finch, these side collisions seem to present fewer technical problems than do frontal impact as regards reducing their severity (height of side members, etc.). Can regulations concerning side impacts be expected in the near future ?

Answer from Mr. FINCH

As a manufacturer I have no idea whether any legislation has been planned. Of course, it will depend greatly upon the severity of the impact and the availability of a suitable dummy as indicated by accident analyses, as to the type of test or the severity of the test that we have to undertake. The one that I illustrated on the screen was a fairly extensive modification to the impacted vehicle.

Therefore, I would think that this sort of test, if I was aiming at a 50 km/hour, 90° impact, would certainly be possible in the near future. And in any case very long lead times and a lot of development work will be necessary but I think the important thing is really to determine first of all what percentage of side impacts and what severity of side impacts one is going to aim at.

Answer from Mr. HOFFERBERTH

I might comment that side impact is an area that is interesting for more than its own sake. There are some indications coming from our work in the United States now that indicate a very strong relationship between the side characteristics of cars and the characteristics that must be built into the front end to avoid excessive penetration in side impacts. It appears that at least some current cars are extremely vulnerable and extremely soft to penetration in the side. In terms of early rule-making action or early considerations, the side impact might very well be an area that could yield substantial future benefits. When one truly comes to terms with compatibility and trying to define what the front crash response characteristics of vehicles should be, it seems to be one which is right for action.

Intervention by Mr. TEESDALE

Mr. Gundelach mentioned a more scientific basis for the next generation of EEC requirements. Mr. Taylor and Panel members mentioned the significance of EEVC work. Will Mr. Taylor please comment on the role he sees for EEVC and how it will fit into ISO/TC22, EEC and other research programmes already in existance ?
We can use all the help we can get but all together please !

Answer from Mr. TAYLOR

Mr. Chairman, I am grateful to Mr. Teesdale for mentioning this point because I think it is important to understand where the European Experimental Vehicles Committee fits into this very complicated grouping of international committees.

Perhaps I can start by saying that the EEVC was set up by the European Governments concerned with their full backing to respond to the American initiative under the ESV programme, and the original objective was that by pooling our knowledge and by having a better understanding of the work being carried out in research on vehicles in Europe that we would be better able as governments to contribute to the international scene.

The work has since then developed along lines which we think are not competitive with the other organizations but are complementary to them. The advantage of the EEVC is that it can look at the technical problems quite separately from the question of regulations and so forth, and can above all look at the options and the possibilities for making improvements to vehicles. Some of those may be economically possible - some may not - but this is also part of the committee's work, and I think the main feature of the committee's work is to look at and provide options rather than to make formal Government decisions. It is in the looking at the problems and in the demonstration of the various options that may be possible, and in the economic assessment of those possibilities, that the EEVC provides support to the work of the committees dealing with regulations themselves.

I think perhaps that it is also important to emphasize that membership of the EEVC now includes government representatives who are also themselves members of the regulation committees and we also have had for a long time observers from the EEC Commission, so we do have direct crosslinks to these other organizations I think one thing which we have particulary welcomed in the working group activities of the EEVC is the participation of the manufacturers and other organizations who have given valuable technical support in this open discussion of possibilities and priorities.

Intervention by Mr. POCCI

A number of remarks have been made on the work carried out at Geneva by the Group of experts on automobile construction which is known as WP 29.

WP 29 was formed in June 1952 when the Sub Committee on Road Transport of the Economic Commission for Europe adopted its Resolution 45 concerning certain technical conditions.

Let me say that, at the official level, an attempt is being made to achieve safety through automobile design. Fifty regulations have been drawn up, thirty-six of which are in force, together with sixty technical recommendations. The most noteworthy success achieved by all this work is, in my opinion, the fact that the most important European inter-governmental organisation, the Common Market, has adopted most of these regulations and has based directives on them.

In addition, we must not forget the World Conference on Road Traffic at Vienna and the 1968 Convention signed by sixty countries, for which our Working party had prepared Annex 5 on the minimum conditions for automobile equipment in international traffic. Owing to the spread of foreign vehicles in a country, it is essential for national traffic to become international. WP 29 thus thought it useful to integrate national standards with international standards as rapidly as possible with the intention of having the national standards become identical to the international ones in the future.

I am dwelling on the subject of structural behaviour to remind you that we have regulations concerning passive safety (locks and hinges, impacts against the steering wheel , seat belt anchorages , seat belts, strength of seats, internal and external fittings, head restraints, strength of the passenger compartment,frontal impacts, rear-end impacts, etc..)

These regulations are not intended to be highly technical or scientific works, but have the aim of establishing specifications suitable for eliminating dangerous cars in which passengers are injured in the slightest accident, which impale the pedestrian or the cyclist, which catch fire at the slightest collision, which open up like a water melon and collapse like a sardine tin.

All these regulations are applicable to automobile production as a whole and thus do not prevent the existence of small vehicles. Even the smallest vehicles comply with these regulations. The constructors have made sacrifices and have embarked on a course of what might be called collective and active defence. In short, these regulations can be applied and, in my opinion - and I believe, in that of my colleagues - this constitutes a not inconsiderable result.

There is also the question of the behaviour of the human body, and collaboration exists with the World Health Organization for the purpose of introducing new ideas. Unfortunately, in this field, instead of a lack of information we have far too much, some of which is at variance with the rest. I believe that the first thing to do would be to sort the data in an intelligent and objective manner.

As regards the question that was raised a short time ago concerning the relationship with the law-making and with the study groups such as the European Experimental Vehicle Committee (the EEVC, in whose work I had the honour to participate), I should like to stress that the results of these studies should not be ignored, but on the contrary, adapted to mass production.

The present situation with regard to international technical regulations, which seem to be rather simplistic, can be improved precisely on the basis of the results that can be obtained from the EEVC.

Overall type approval of the vehicle has also been mentioned. I should like to inform you of the latest decision of the Sub-committee on Road Transport at Geneva, taken yesterday evening, which is to support the idea of WP 29 and achieve overall type approval of the vehicle. This is a long term objective, but all possible means will be used to attain it.

The difficulties between the USA and Europe have also been brought up; fortunately, the USA has gone a long way towards accommodating us by proposing that we should get together to harmonize the procedures and the principles for removing these misunderstandings which prevent common standards from being set up. This is something to be pleased about.

The fact that not everybody is participating in the work of WP 29 has been criticized. In reality, twenty-six countries and nineteen inter-governmental organizations are involved. Of these twenty-six countries, four are non-European (Japan, USA, Australia and Canada). Furthermore, in accordance with sections 8 and 11 of the terms of reference of the Economic Commission for Europe, the work of this organization is open to all countries. Hence this Working Party can accept any partner. And to conclude, I quote a phrase from the Gospel : "Knock and it shall be opened unto you".

Answer from Mr. BRAUN

Thank you Mr. Pocci; we all know of the contribution made by the work in Geneva, and, in truth, the Commission has relied for a long time on the initial work done down there and we are indebted to you for much in this field.

Intervention by Mr. KLAMMER

Are you also of my opinion that it is difficult, if not impossible, to effect harmonization and to provide for the technical future simultaneously, that is in one step ?

If this is the case, should not the General Programme be first implemented, or is it intended to break off this work ?

Do you believe that the salient points brought up today are already in a sufficiently concrete form to enable appropriate regulations to be drawn up in the near future ?

If not, does the Commission see its way to financing research work which will then enable such regulations to be drawn up ?

Answer from Mr. BRAUN

Since these questions are directed more especially to the Commission, I shall attempt to answer them myself. I believe that we should continue to implement the programme, as drawn up by the Commission and widely accepted by the Member States, in the field of motor vehicle harmonization, which means that I see no reason for and no advantage in interrupting the work we have began.

The question that arises from this is whether, once this programme has been defined, it is necessary to wait until clear concepts have emerged concerning the safety features of the car of the future. I tend to think and this is in itself, so to speak, a comment by me on what was said this morning - that there is concomitance between two things : first of all the public authorities must respond to what appear to them at a given moment to be very specific needs which are inescapable. In this case, the means to be used do not always seem to derive from the technology of the future. On the other hand, there are the long-term objectives which, in the light of today's discussions, seem to be the attainment of performance standards. There are doubtless some points on which we can proceed more easily than on others, and I am thinking, for example, of tyres, for which it can well be imagined that, from the outset, the standards must be standards of performance rather than of design.

In other words, I believe that there is no interruption, that there is continuity and that, at a given moment, there will be an increasingly pronounced shift away from the design standard towards the performance standard.

I believe, moreover, that a number of the observations that we are in the process of making are more relevant to Mr. Mackay's report than to Mr. Taylor's, which is concerned more with "continuity" than with, say, 1985.

I do not believe that we shall have the answers to all our questions by the time this symposium is over, but what is going to emerge is that, on the basis of the contacts that this syposium enabled us to establish,attempts will be made at various levels and in various quarters to specify what the objectives of the future (1985-1990)are likely to be.

In this connection, the question can obviously be asked : do we gain more by diversifying research or is the concentration of research more advantageous at a given moment ?

I believe that the truth probably lies somewhere in between. Excessive fragmentation would not be desirable and total concentration probably wouldn't be either.

You also ask whether the Commission considers that it would be important, in the field of regulations, to find its own scientific resources. My reply is yes, without the slightest doubt. But I should like to add : do not draw from this the conclusion that, at the present time and at this stage, I am asking for financial contributions from the governments to create something new. I know that this would be particularly counter-productive. My reply is thus one of principle, and it is not a request for funds from the next budget. Moreover, the implementation of such a programme calls for a considerable concentration of financial efforts, which in the long run,however, would be to the benefit of the Member States, since it would enable them to achieve savings elsewhere .

But this is not a question to be debated here, it is a problem to be dealt with by the State Secretaries for the Budget or by the Ministers concerned.

COMMENTS

by Mr. Braun

I believe that we have profited this morning to a considerable degree from the results of the work of the ESVC ever which you, Mr. Taylor, have presided. I would like to see how we can put into practice what you have told us at the level of the Community and the regulations it can adopt. First, you consider that there is a basic principle, that safety for one class of road user must not be achieved at the expense of another. According to what has been said this morning , this plainly poses the problem that increasing the strength of a vehicle's structure can result in an unreasonable increase in its weight; this in turn results in increased "aggressiveness" with harmful effects in any collision between vehicles of different sizes or between vehicles and other road users, quite apart from the fact that an increase in weight automatically leads to an increase in fuel consumption. Here clearly we are only partly involved in the field of safety regulations: we are also partly involved in a field in which one can discourage by other means - such as the price of petrol - the use on our roads of cars of excessive weight.

So, starting from that point, let us try to identify the priorities so as to establish the direction in which we can concentrate joint efforts to arrive at a concept for a safer and less "aggressive" car which will not only be a basic prototype but can also be mass-produced in the not too distant future.

In such a case, it will of course be necessary to resolve the very complex problem of reproducing collisions as they actually occur under test conditions: this observation has moreover been repeated two or three times in one form or another after Mr. Taylor delivered his report. Mr. Taylor put the emphasis on having a global concept of the vehicle and its occupants. I think we can all subscribe to that. However, that takes us on to the problem of knowing how to collate our information on human tolerance levels on impact, so as to encompass the safety standards to be guaranteed by a vehicle. Unfortunately, no dummy is yet available - and Mr. MacKay confirmed this in reply to a question from M. Chabrol - which allows us to reproduce human reactions on impact in a fully representative way. But these problems are to be examined in greater detail in Session 3. What we can conclude from our discussion this morning is that we cannot let ourselves slow down our work of making regulations and I repeat almost exactly what I said just now in answer to Mr. Klammer's question : until the day we have a full understanding of the biomechanics of the behaviour of the human body at the moment of impact.

We are engaged in a continuous task and are not in a situation where we can halt projects while awaiting completely ideal conditions.

As for the different types of impact, I think I can conclude from the discussion that we must concentrate our particular efforts on laying down test procedures for frontal impact, which is the most common type of collision . Of course, certain problems still have to be solved : (adequate angle of impact, a barrier more representative of frontal collisions between cars) but from the preparatory studies in the matter we can hope that specifications can be drawn up in the not too distant future. Again, we have learned a great deal more this morning about what we know, and what we thought we knew. Lateral collisions - which are moreover more frequent than frontal collisions - seem less complex. This observation was made during question time. Thus it will be easier to find more satisfactory solutions to these more quickly : these will involve modifications in vehicle design, and it is on this point that I think we heard one of the clearest remarks or proposals which Mr. Taylor made to us - that is, promoting the research on bumper height, which is the most likely to avoid dangerous penetration of other vehicles or serious injury to pedestrians. As rear impact and overturning are relatively rare accidents, they can be considered as being of lower priority, but this does n ot mean that the problem is not recognized. It is only in relation to frontal and lateral collisions that I would assign priority 3 to 4 to rear impact or overturning accidents.

The most tricky question, and one to which it will be extremely difficult to find a satisfactory solution immediately, is that of collision between a vehicle and another road user (a pedestrian or rider of a two-wheeled vehicle). The percentage of serious injuries or fatalities is very high, as you have heard this morning, and moreover, the situation is different from that in the USA. In this context it is understandable that we give a different priority to this problem in Europe than they do in the United States. The percentage in relation to the overall figure for road casualties tends to rise as the beneficial effects of protective measures for passengers and those which result from compulsory use of safety belts are enjoyed by the occupants of a vehicle. Our present state of knowledge does not allow us to set a precise course towards making the car less aggressive to other road users : no doubt we can in the not too distant future, as Mr. Taylor wishes, fix the height of bumpers to reduce the consequences of collisions involving pedestrians, but very thorough research will be necessary to have an overall view of every aspect which this denotes, which are of more concern that the mere design of a vehicle. I think that at present all that we have discovered is that we must go further than the requirements at this stage of the directive on external projections of vehicles, which in itself is only a first step.

In what I have just said, I have touched on what seems to me to be one of the most striking elements of today's proceedings and of Mr. MacKay's report, namely the importance assumed by the introduction of compulsory wearing of a system of restraint. This I think, is one of the problems which on our side we must either resolve or submit to some other authority as those which deal with the abolition of obstacles to trade are not the same as those which deal with human behaviour on the road.

I would like to close this session by stating that we can, within a reasonable period, establish requirements for structural strength and compatibility between cars by fixing suitable tests for frontal and lateral impact. On the other hand, it would seem difficult to arrive in the very near future at an overall solution for collisions between vehicles and other road users. Since, however, we are all strongly aware of the importance of this problem, no doubt we shall have to go into this problem very urgently and thoroughly with all concerned, in order to reduce the consequences of this type of accident.

That, briefly, is what I would like to conclude from what we have done this morning.

CLOSING STATEMENT

by Mr. H. Taylor

On this occasion I have been asked as Rapporteur to summarize Session 1 and to relate it to discussions in other sessions. In doing this, I hope I may be forgiven for not referring individually to each contribution made by panel members or session participants.

Every session has related to important matters affecting the health and well-being of the people of Europe and to road safety and, indeed, in all Sessions we will be talking about matters which affect virtually every person in the Community.

In the case of road safety there is general recognition that the present toll of road accident casualties is unacceptably high and this has focused attention in this vehicle Symposium on the passenger car which is involved in very many of the accidents.

There was a recognition in Session 1 of the considerable amount of safety and standardization work already carried out on vehicles both by industry on its own initiatives and by Governments in association with industry. There was clearly a strong feeling that a major stage in car safety regulations has been reached both in terms of dealing with the most obvious and urgent problems and in coming to terms with the new problems that now face us. It would seem that a stage in this work has now been reached when a complete package of measures can be consolidated in the form of whole vehicle type testing. But a warning was sounded regarding the barriers that can remain due to differences in national practices regarding vehicle regulations.

A timely reminder was also given that the in-service condition of vehicles, especially of the other vehicles, may not match the intention of regulations framed for new vehicles.

What of the future ? It is tempting to assert either that it is no longer possible to pursue safety improvements because of the overriding need to conserve fuel, or that the present economic climate precludes consideration of greater safety in cars.

As to the first point, I suggested in Session 1 that this view was fallacious: in the longer term the vehicle population could develop or be encouraged to develop according to the priorities given to safety, noise, pollution and energy conservation, always of course within some limits; the totally safe, silent, pollution-free vehicle that consumes no fuel is truly unattainable.

In the case of car safety, the massive international programme of work carried out to date over the last five years has shown that much greater safety can be achieved; by this I mean that a much safer car can be produced which will be attractive to the users at an acceptable cost and will be more compatible with other road users from the safety standpoint. I suggest that these results are still valid in spite of current economic problems; though it may take longer to achieve the desired improvements, the basic goals need not change.

In considering the safety of cars, other vehicles must be disregarded - for example two wheeled machines and commercial vehicles. But undoubtedly the most important vehicle category overall from the safety standpoint is the passenger car.

During the Symposium, recognition has been given to two important major steps in our thinking for the future :

1) the need to improve the safety not only of car occupants but also of those unprotected road users, principally pedestrians, who are frequently struck by cars;

2) the need to develop impact test methods for cars which truly represent the reality of road accident situations and lead to greater safety in relation to the desired future vehicle population.

These two points have important implications : they require a global view of the accident situation to achieve the maximum benefit for the majority and they imply that car safety must relate to the total vehicle population and not merely to tests of individual vehicles considered in isolation. In road safety, we are concerned to move forward from the current situation in which we live, rather than to deal in absolute values. In doing so, we attempt to honour the concept that no one class of road user is any more or any less entitled to survive than any other and,therefore,that the safety of one class should not be advanced by reducing the safety of another. For example, we should not enhance safety for the users of large cars at the expense, in terms of safety, of the occupants of small cars which are widely used in Europe. One of the clearest messages to emerge from this week is the absolute need for vehicle occupants to use seat belts if further major advances in occupant safety are to be made. Perhaps less well emphasized were the considerable further advances in safety that can be made, over and above the gain from using belts, by exploiting the integrated system of seat belt and structure. It is this essential integration of vehicle design that leads to the desire for performance standards rather than design standards and to standards that relate to human tolerance criteria rather than to vehicle parameters. This proposal was challenged several times and it might well help if I suggest that there are three stages of progress to be considered : firstly, consolidation of current standards and refinement of them,when this is found to be necessary; secondly, an interim stage of development moving towards a third stage when full performance standards are adopted where these are appropriate. The unresolved aspect rather of this proposition seems to have been the timing of this process rather than the validity of it.

For the car structure, the two main areas for action are frontal impacts and side impacts with rear impact and roll-over at a lower level of priority. Frontal impacts are the most important from a casualty standpoint, especially when pedestrian safety is accorded appropriate priority. But the development of suitable test methods is a complex affair. Side impacts, on the other hand, are technically less complex and suitable test methods may be capable of definition more quickly.

The safety of pedestrians demands specific car safety measures whatever developments may be possible in the future : this is the requirement for a low front placing of bumpers on cars. This requirement for pedestrian safety is comparable in its basis technical implications to the need for car occupants to use seat belts. Unless it is adopted, the already difficult job of making advances in safety for pedestrians becomes virtually impossible.

Fortunately, in all these areas, there is a substantial basis from which to make further progress in developing requirements and test methods and the European Experimental Vehicles Committee which has been referred to many times during the Symposium. It must be recognized that, as the subject progresses, there will be a tendency to move to a greater variety of tests or to even more complex tests and great care will be needed to ensure that they produce the safety results intended. In the case of structural tests, some work can be carried out on test rigs,but, eventually, unless other means can be exploited, complete vehicle tests are needed and these can be extremely costly. Considerable progress has already been made with simulation techniques and it seems highly desirable to exploit these techniques before accepting that more comprehensive structural validation cannot be achieved because of the cost.

In conclusion, may I say that, though a great deal of work on vehicle safety remains to be done in framing new regulations, a great deal of progress has been made. The major issues on car safety have already been identified and put into perspective and the uncertainties which remain are not so great as to prevent us making steady progress if we have the will to do so.

SECOND SESSION

NOISE POLLUTION

NOISE POLLUTION
REQUIREMENTS, WAYS OF MEETING THEM AND METHODS OF MEASUREMENT

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REPORT OF Mr THIRY

MOTOR VEHICLE NOISE

This paper concerns only noise produced by road vehicles other than motor cycles.

Noise is one of the major nuisances which go hand in hand with urban development and it is generally accepted that motor vehicle traffic is the chief offender. This was demonstrated by some very thorough surveys carried out in cities such as Chicago, London, Paris, Nice and New York to assess the amount of discomfort that people experience when confronted with different noises. The results published in a report by Professor Wilson, the Chairman of the Research Cooperation Committee of the Organisation for Economic Cooperation and Development (OECD), show that traffic noise comes top of the list with 36% of the people concerned, followed by aircraft noise with 9% and noise from railway trains with 5%.

Thus, something had to be done to prevent a decline in the living conditions of town-dwellers. Accordingly, not long after the War, most of Europe introduced measures to restrict motor vehicle noise. Of course, these measures were not standardized and specialists at ISO (International Organization for Standardization) felt that a standard ought to be worked out to lay down measuring methods and vehicle operating conditions which would enable precise and reproducible results to be obtained.

Work began in July 1958 and a draft standard was drawn up in 1960. After amendments had been made it was put to the vote of the Member Bodies in May 1962. It was approved by 27 countries with only one country against, and was formally published in February 1964 as ISO Recommendation R 362 - Measurement of Vehicle Noise.

At that time several European countries adopted it as their official method of measurement and fixed maximum sound levels for the various vehicle categories.

When the Commission of the European Communities came to examine the problem of vehicle noise it also drew on ISO Recommendation R 362 to draw up the draft directive adopted by the Council of the European Communities on 6 February 1970.

This Directive (70/157/EEC) on the approximation of the laws of the Member States relating to the permissible sound level and the exhaust system of motor vehicles is now in force in all the countries of the European Communities.

The method of measurement described in the Directive can be divided into two parts:

- Conditions of sound measurement
- Vehicle operating conditions.

The first part indicates the requirements regarding the place where the measurements are taken. This must be an open space, free of obstacles over a radius of 50 metres, with a central part surfaced with asphalt, concrete or similar material over a radius of at least 20 metres. Microphones are placed on either side of the vehicle's path, 7.50 metres from the path of the vehicle's centre line and 1.20 metres above ground level. The measurements are taken using the weighting curve A of the sound-level meter and the rapid response characteristic.

The second part, concerning vehicle operation, was designed to indicate the noise produced by vehicles when accelerating after starting up at traffic lights.

To this end, when approaching the line on which the microphones are placed, the vehicles must travel at a steady speed in second gear if they have three or four gears or in third gear if they have more than four, so that the engine turns at three-quarters of the rpm at which it develops its maximum power. When this rule was laid down this engine speed was generally equivalent to the maximum torque rpm of most engines, i.e. the engine rpm at which the vehicle was capable of the greatest acceleration and at which it was likely to make a lot of noise. However, to take into account the rules of sound practice for town driving and the official speed limits, a clause was added restricting this steady speed to 50 km per hour if the preceding conditions led to a higher speed than this.

It was felt that driving at higher speeds than those authorized in town could be dealt with by other regulations and that motor vehicle manufacturers should not be penalized for the abnormal or unrepresentative driving of a tiny minority of users.

Once a steady speed has been reached, as indicated above, and ten metres before the front of the vehicle is level with the line between the microphones the throttle is fully opened as rapidly as possible.

From this moment on the vehicle's engine turns at its maximum power and the particularly stable and reproducible running conditions that result produce a noise level close to the maximum and ensure a high degree of accuracy in the sound measurements.

These are the essential features of the method. Of course, additional provisions have been laid down for the various types of transmission that can be used in vehicles.

It should be noted that the only purpose of these measurements is to classify vehicles of the same category tested under the same conditions, and that they are not capable of providing a subjective estimate of the nuisance caused by the various categories of vehicles in operation.

This basic Directive was supplemented by Directive 73/350/EEC, which requires endurance tests to be carried out on exhaust systems incorporating fibrous material. Vehicle type approval pursuant to Directive 70/157/EEC is carried out either after removing the fibrous matter from the exhaust system or after the vehicle has travelled at least 10 000 km (5 000 km in town traffic and 5 000 km elsewhere) or after an engine test using a dynamometer brake under specified conditions.

Lastly, Directive 70/157/EEC provides for measurements to be taken 7 metres from stationary vehicles, with the engine running at three-quarters of the rpm at which it develops its maximum power or the maximum speed permitted by the governor, if the engine is fitted with one.

SITUATION IN COUNTRIES OUTSIDE THE EUROPEAN COMMUNITIES

Spain, Czechoslovakia and Yugoslavia have implemented a Regulation of the UN Economic Commission for Europe which embodies the same method of measurement as that of the Directive but with slightly different limits.

Australia also uses that ISO R 362 method.

In the USA there are no federal laws on the matter at present but measurements are carried out according to Standard SAE J 986 a, which is very similar to ISO R 362 and is also based on an acceleration test. However, as the measurements are carried out at twice the distance used in Europe the values measured are 6 dB lower. Consequently, American requirements in this area are much less stringent than in the other countries.

In Japan three sets of measurements are taken:

- with the vehicle stationary
- with the vehicle travelling at a steady speed
- with the vehicle accelerating (Very similar to the ISO method).

In Switzerland vehicle type approval includes sound level measurement, with a microphone placed 7 metres from the stationary vehicle, with the engine running at three-quarters of the rpm at which it develops its maximum power or the maximum rpm permitted by the speed governor if the engine is fitted with one.

This method highlights only part of the noise caused and, apart from certain categories of vehicle, cannot be regarded as representative.

It can be seen therefore that, with the exception of Switzerland, the methods employed in the other countries are very similar to those laid down by Directive 70/157/EEC and fix permissible limits which are very close to those of the European Communities.

The worth of ISO Recommendation R 362 is emphasized by the fact that most of the countries have implemented it. In addition, Directive 70/157/EEC is the most stringent of all the regulations in force at present, and is likely to become even more stringent since the Commission has just proposed to the Council that the present limits be reduced.

COMMUNITY ACTION

Effects on the environment

As Directive 70/157/EEC has been in operation in the countries of the European Communities for only three years it is obviously difficult to gauge the effect it has had on the environment.

On the other hand, the national laws in some countries, France for example, were identical to the specifications of the Directive, the only exception being the permissible sound levels. As the permissible levels laid down in the Directive are slightly lower than those of the national laws it can be concluded that the Directive has made the measures in force more stringent.

Judging by the situation in France, these national laws have made a considerable contribution towards noise abatement since they came into effect in the early 1960s. Since then noise levels in France have dropped by 7-10 dB(A) in the case of commercial vehicles and 6-8dB(A) in the case of passenger vehicles.

This would not have been possible without the huge efforts made by manufacturers and, as a result, despite the constant increase in motor vehicle performance, noise has been kept within reasonable limits.

Effects on motor vehicle design

These stringent rules have provoked a number of reactions in the motor industry.

The initial reaction was a sudden awareness of the problem of noise as a source of nuisance for "roadside" residents.

The second reaction, following on from the first one, from the major manufacturers was to set up planning offices and laboratories to conduct research into the sources and causes of noise and ways of reducing it. On this point in particular, Directive 70/157/EEC, which reduced the permissible noise level, gave these efforts a fresh boost and launched a series of detailed studies on the causes of noise.

Getting down to more practical matters, the most obvious headway has been made in connection with the most important sources of noise, i.e.:

- the intake;
- the exhaust.

It is now common for vehicles to have three or four devices which contribute to exhaust silencing.

However, manufacturers have also examined other aspects and reductions in noise have been made by altering the power-unit suspension and the cooling system.

It is becoming increasingly common for cooling systems to incorporate fans which can be either disengaged or are electrically-driven.

Special attention has been paid to diesel-powered passenger vehicles.

These aspects have all been explored in the case of commercial vehicles as well, but in addition more intensive use has been made of sound-proofing materials in the engine compartment.

Some idea of the headway made regarding heavy goods vehicles in the last twelve or thirteen years can be glimpsed from the fact that their noise levels have been kept more or less constant even though their average engine power has increased from 150 to about 250 metric hp.

NEW DEMANDS THAT MUST BE FACED

Despite the current difficulties, continued traffic growth in the most densely populated zones can reasonably be expected.

As a growth of the urban areas is forecast at the same time, it may be concluded that a growing number of inhabitants will be exposed to traffic noise in future years.

Some estimates forecast a 50% increase in the total number of cars by 1985. All things being equal, this increase would correspond to a rise in the average noise level of the order of 2 dB(A) (for fairly dense traffic, at N vehicles per hour, the discomfort is linked to the average noise level which varies as 10 log N. However, this is only an approximation as an increase in traffic often entails a reduction in the average speed of vehicles and subsequently a tendency towards a reduction in the average noise level).

It is therefore imperative to take all the requisite measures necessary to limit and if possible reduce the discomfort arising from this noise.

In these measures, priority should naturally be given to reducing the noise level of every vehicle considered as a source of noise.

But if this measure is to have maximum effectiveness it must fit in with the general fight against noise, and effective measures must be taken at the same time as regards the architecture of dwellings, town planning and traffic organization.

It must be remembered that, whatever progress is made, traffic will always generate noise, perhaps at a lower level than at present, though there will still be a need to protect wayside dwellers from it so that they can at least rest in relative silence. The quality of the sound-proofing of buildings, the layout of the various rooms in flats, for example, and traffic organization can, like reducing vehicle noise, also lead to attractive solutions.

What criteria should be used as a basis for a programme to reduce the noise emitted by the various types of vehicle?

The figures which will be chosen must evidently be sufficiently low for the effects of noise on people to become negligible.

Unfortunately, despite the large number of very extensive investigations of the physiological effects of noise which are currently being conducted in various major countries, information on this question is still very limited.

It can only be said that traffic noise causes discomfort which appears to vary appreciably according to whether it is basic noise of a continuous nature and at a moderate level (60 to 80 dB(A) for example) or peak noise of short duration and often at a higher level. Despite a certain degree of acclimatization it is however certain that prolonged exposure to a largely constant noise level involves evident discomfort and fatigue and that the peak noises have a certain aggressive character that can disturb concentration and sleep and, if frequently repeated, affect the neuro-physiological balance of those persons subjected to them.

Let us quote another excerpt from Professor Wilson's report to the OECD:

"It is a problem that is linked with individuals and their feelings and it is defined more by human values and the environment than by precise physical measurements. These values and these environments are complex. Not only do sensitivity and adaptability vary according to individual but each of us may be annoyed by one noise and not by another possessing identical characteristics".

Faced by the difficulty of directly linking the discomfort to the noise which causes it, some experts have thought that a good way to approach the problem would be to fix noise levels which should not be exceeded in the rooms or in front of dwellings.

The same experts consider that the noise levels should not exceed 45-50 dB(A) in rooms for daytime use. However, there appears to be a danger that these levels might still be too high for understanding a telephone conversation or for teaching in a room.

Furthermore, the nuisance value indices drawn up during certain investigations show that the percentage of dissatisfied persons increases more rapidly when the noise level in front of dwellings exceed 60-62 dB(A). It would therefore be desirable if this level were not to exceed 60 dB(A) which will be very difficult to achieve as noise levels of above 70 dB(A) are often recorded at present.

Various attempts have been made to implement objective methods of predicting the reactions of a population exposed to noise.

Particular mention could be made of ISO standard R 1996 which can be applied to regular traffic noise - such as often occurs in the daytime.

In this case the varying noise is expressed by an equivalent continuous level called Leq. This equivalent value is calculated on the basis of a statistical analysis of the development in time of the weighted acoustic level A and of a formula based on the principle of energy equivalence.

Although there are other suitable methods, it is the Leq equivalent level method which is currently used the most and which gives results good enough to assess the nuisance value of continuous daily traffic.

The problem of noise at night is more serious; unfortunately few studies have been made of the subject and it would be hazardous to propose norms.

The nuisance value at night depends basically:

- on the occurrence of isolated peak noises, their intensity and frequency (in an extreme case, one passing vehicle can cause a peak, even when driven normally);

- on the period of sleep during which this peak occurs (peak noise is more disturbing at the beginning and the end of sleep than during the middle).

It must be noted that the levels recorded at night for an appreciable proportion of bedrooms are distinctly higher than the levels called for by specialists.

Despite the fact that a number of projects are in progress, it is not possible to quantify the problem of peaks. The reasons for the peaks also vary considerably and can most often be attributed to bad practices. Examples of some of the most frequently-quoted cases which occur either by day or by night are:

- the use of certain types of cars or motorcycles
- the slamming of doors
- the starting-up of engines
- gear changes
- a normal car driven like a sports car
- driving off
- braking
- heavy lorries travelling up slopes
- the horns, sirens etc... of priority vehicles

etc...

Thus it can be seen that it is almost impossible to fix maximum sound limits for vehicles on the basis of precise requirements, especially since such limits are largely dependent on the conditions under which the level of sound emitted by these vehicles is measured.

Consequently, the only possibility is to lower the upper limits progressively. The question then arises of what the lower level should be. Taking a very long-term view, it would seem that every effort should be made to take a value which is as near as possible to the sound level due solely to road noise, as we do not yet have sufficient knowledge of this field to enable us to do otherwise. That noise, the level of which is approximately 65-75dB(A) at a speed of 50 km/h, depending on the type of vehicle, is due solely to the contact between the tyre and the ground. Given the requirements as regards grip, reliability and safety which govern the construction of tyres and roads, it seems unlikely that any notable progress will be made, even in the long term, towards reducing the noise produced. This is therefore the ideal limit at present, irrespective of the method of propulsion used (internal combustion engine, electric motor, etc.).

RESEARCH IN PROGRESS AND DEVELOPMENT OF THE TECHNOLOGY

It must be pointed out first of all that the sound emitted by a vehicle is made up of five principal factors:

- the noise made by the engine and the gears
- intake noise
- exhaust noise
- the noise made by the cooling system
- the road noise made by the tyres on the ground when the vehicle is in motion.

We must not forget the noises due to aerodynamic factors, which are noticeable only at high speeds.

Numerous studies have been made both on the premises of the major car manufacturers and in specialized laboratories in order to assess the proportion of each type of noise in the overall noise produced by a vehicle. It is generally possible to block out all other noises except for the one which is to be measured. The noise made by the vehicle is then measured in accordance with the method set out in the Directive. This was how the level of each type of noise was assessed.

Generally speaking, although these values cannot be regarded as absolute, the acoustic energy can be broken down as follows:

- Engine noise 30%
- Exhaust noise
  - Radiated noise 20%
  - Orifice noise 25%
- Intake noise (orifice noise) 10%
- Ventilation noise 10%
- Road noise 5%

The breakdown is different in the case of heavy vehicles, where the engine noise is slightly greater and may represent 40% of the total acoustic energy used, as is the noise made by the cooling system, which may reach 20%.

Proposed Improvements

Intake and exhaust noise

It is in this field that the greatest efforts have been made during recent years.

As indicated already, the results are such that, compared with the noise emitted directly by the engine, these noises are not perceived particularly clearly, except in the case of certain silencers which are designed and sold with a view to emitting a noise similar to that made by a sports car. The noise emitted by such silencers is, of course, within the limits laid down by law.

It is a well-known fact that the effectiveness of such devices is linked to their volume. Any improvement in this field would therefore be bound to mean an increase in their size, so that it would be difficult to install them in vehicles. It may therefore be concluded that the progress made in this field is limited, particularly in the case of small private cars.

It must be noted that in the case of industrial vehicles the rational utilization of exhaust turbo-superchargers would improve the sound level very considerably.

Engine noise

Two possible ways of reducing noise are being considered:

- engineers have considered trying to enclose the engine in a sort of capsule which is as sound-proof as possible.

- a more rational way, but one which would require long studies, consists in studying all the causes of vibrations in the engine-block and trying to find ways of reducing them.

The "Encapsulation" method

It would be very difficult to apply this method. It is in fact difficult to find a reasonable compromise between noise reduction and the need to cool the engine.

It must be remembered that of the 100 calories contained in the fuel, at least seventy are discharged in the form of heat by the exhaust gases, in the cooling system, by radiation from the engine-block, the oil-pan, the manifold, the exhaust manifold and the silencers.

Most of the 70 calories dispersed in the form of heat are contained in the exhaust gases but a percentage is radiated through the exhaust pipes. According to motor specialists, it can be estimated that about 50% of the total quantity of calories is dispersed at the rate of 25% radiated through the exhaust manifold, 15% in the cooling system and 7% through the engine-block and the oil sump.

This illustrates the need for ensuring that the renewal rate for air around the engine is fast, which is obviously incompatible with efficient sound insulation.

Nevertheless, this line of enquiry is extremely interesting and has in some specific cases led to a considerable diminution of the total noise emitted. This is for instance the case with some types of buses with a rear-mounted engine, where thorough sound insulation of the engine compartment has meant a gain of the order of 8-10 dB(A) under type approval conditions.

It should not however be thought that it is possible to make general use of this technique which requires very intensive preliminary studies on the following points:

- a search for absorbent materials with good mechanical and chemical resistance to clad the interior of engine compartments without constituting a fire risk;

- engine cooling on streamlined vehicles should be carefully studied along the usual lines. In particular, the aerodynamics of air intakes and outlets should be studied again in this new context;

- a detailed study of the cooling fans in order to improve their performance without increasing the noise;

- it will also be necessary to check that any fairings used are compatible with the installation of automatic gear-boxes, superchargers and catalytic exhaust units as required by the anti-pollution regulations and which, when fitted, are likely to increase the problems connected with cooling.

It is probable that there will be a move towards limited solutions using shields and semi-fairings which are less effective but easier to use.

Finally, it should be remembered that improvements can also be achieved by placing shields around the manifolds and silencers.

Study of engine-block vibrations

Speaking very generally it can be said that in the most widely-used types of engine, acoustic energy is distributed as follows:

- low frequencies (below 500 Hz). These are emitted by the forces of explosion and the alternating forces of the moving parts of the engine. They are also found in the inlet and exhaust components.

- medium frequencies (500 - 1 500 Hz), which basically correspond to the resonances of the engine-block which are stimulated by the high harmonics of the explosive forces. They are also found in the exhaust components.

- high frequencies (over 1 500 Hz) caused by localized vibrations of the walls as a result of various stimuli: impacts caused by moving parts, valves opening and closing, etc.

A large number of studies on the reduction of these vibrations is currently being carried out by various bodies. It is likely that the result will be significant alterations in engine design but, of necessity, there will be a fairly long delay before new generations of engines are put into production.

Besides these two directions in research which are being followed simultaneously, attention should be drawn to the fact that there are two methods of obtaining a given level of power from an engine:

- either to use few cylinders and high engine rpm,
- or to use a large number of cylinders and lower rpm.

The noise produced differs depending on which of these two systems one chooses.

It is difficult to lay down strict rules because of the large number of parameters which have to be taken into consideration but the results of a great deal of statistical research would seem to indicate that the noise level varies with the rpm, undergoing an increase of approximately 3 for diesel engines, an increase which can be as high as 5 for petrol engines, and one of approximately 1.5 of the cylinder capacity in both cases.

It is immediately clear that from the point of view of reducing the noise level it is best to advocate the use of engines with a fairly low rpm and a large number of cylinders. Unfortunately this runs counter to the present tax policy of some countries.

Tyre noise

So far the noise level from this source has remained lower than that from other sources in urban traffic travelling at fairly low speeds. It seems that studies in this field have not been actively encouraged, since other requirements linked with safety have been the principal object of the research done by tyre manufacturers.

Of course it is impossible to consider the tyre separately from the surface of the road on which it is driven. This would therefore be a subject of research to be coordinated between the tyre manufacturers and those responsible for roads. It should be remembered that this raises a difficult problem of metrology in connection with isolating the noise under consideration from other sources of noise in the vehicle. Qualified bodies have plans for studying this important problem in the very near future.

New engines

Among the new types of engine planned are electric engines which would appear to represent the best hope of reducing the level of noise as well as the level of air pollution. This formula also appears to be the most attractive for vehicles of limited autonomy and limited performance, such as vehicles which might be used exclusively within an urban district. This type of vehicle exists already. So far developments have been limited because of the weight of the accumulators and the problems connected with charging. Here, too, important studies are currently under way and significant progress has been made. At present the amount of energy stored in lead batteries has risen from 20 Wh/kg to 35 Wh/kg. With new types of batteries it is hoped to be able to produce energy levels of 150 Wh/kg together with much more rapid charging methods.

Where utility vehicles are concerned, the power required is greater and beyond the scope of electricity as used in the above solutions.

Here research is being directed rather towards perfecting existing engines and the adaptation of gas turbines.

Three very important points should be noted:

- as mentioned earlier, there is currently a limit to the amount by which the noise produced by vehicles in traffic can be reduced. Thus under the best of all possible conditions, a car propelled, with engine stopped, at 50 k/h on a very good road emits a noise level of 60 dB(A) at a distance of 7.50 metres. Under the same conditions more than half of all existing models produce a level of 66 dB(A). These levels increase by 3-7 dB depending on the road surface and the type of tyres used;

- a breakdown of the general noise level into its various components shows that lowering the noise level by at least 5 dB(A) could only be achieved by replacing at least two-thirds of all existing vehicles by very quiet vehicles;

- the influence of the construction parameters for engines on problems connected with air pollution and energy consumption must also be taken into account.

Once again, taking all these realistic considerations into account, it might be possible to achieve a completely comparable lowering of the average level by means which depend on:

- traffic planning
- the way in which cars are driven
- town planning and architecture

DIFFERENT WAYS OF MEETING NEW REQUIREMENTS

1. It is imperative that above all a consistent policy should be drawn up designed to combat noise, pollution and energy consumption in the motor vehicle construction industry; the public authorities and manufacturers would work in close cooperation in this connection.

At the same time architects, town planners and sociologists should use all their resources and knowledge to afford town-dwellers better protection against noise in general and more especially traffic noise.

2. Secondly, more rigid rules should be drawn up governing the acceptance of vehicles, relating to both the method of measurement used and the permissible noise limits. The rules should be applicable first and foremost to public transport vehicles and delivery vehicles, and the use of large commercial vehicles could be regulated or even prohibited in urban areas.

3. An effort should be made to educate car users: by driving quietly it is generally possible to drive economically.

A vehicle may become noisy if it is not driven in a normal way or if its owner makes alterations to it which often lead to an illusory improvement in its performance but also to an increase in the amount of noise which it makes. Attention should also be drawn to the need to make at least a minimum amount of effort to keep a vehicle in good condition.

4. It is also important that the police and inspection bodies should be given simple, effective ways of assessing the degree of deterioration of the acoustic characteristics of vehicles on the roads by objective methods.

5. Governments should ensure that their tax policies encourage the construction of quiet vehicles.

PROPOSAL FOR A RATIONAL CHOICE WITH A VIEW TO DRAWING UP COMMUNITY RULES

The current method for measuring noises emitted by vehicles has often been reproached by being unsuitable for certain categories of vehicles.

However, it must be remembered that the various national or international rules in force lay down the same noise limit for vehicles with features which differ widely: in a ratio of 1 to 20 for the engine power, and of at least 1 to 3 for the maximum power rpm and the weight. It is also a well-known fact that the sound level of a vehicle depends on the mechanical power of the engine, which varies according to whether that power is obtained by varying the cylinder capacity or the maximum power rpm.

It is therefore clear that even if the noise limits are well suited to certain categories of vehicles, they are either too low or too high for others.

The authors of ISO Recommendation R 362 were aware of this. In view of the wide range of types of vehicle, the measurements were "adapted" to take into account the maximum speed which depends on the engine power.

It has now become clear that such adaptations are inadequate in view of the developments in the motor vehicle industry during recent years.

The ISO experts have, of course, examined this problem and have studied the actual conditions in which various types of vehicles run in an urban environment. Major projects have been carried out in France in particular, by:

IRT (Institut de Recherches des Transports), and

UTAC (Union Technique de l'Automobile, du Motocycle et du Cycle)

at the request of the Ministry for Supply and of the Ministry for the Quality of Life and by a group of motor vehicle manufacturers. Similar studies have also been carried out in Italy, Japan and the United States of America.

A number of conclusions can be drawn which we propose for use as a basis for a study to enable new Community rules to be drawn up.

1. The current method could be retained, with slight changes, for heavy vehicles, as the actual conditions of use of these vehicles have remained fairly similar to those laid down in the Directive. Furthermore, the simplicity of the method is an asset in the case of vehicles which are relatively less easy to drive than private cars.

Progress in this particular case will lead to a gradual reduction in the limits to match the potential of construction methods.

2. On the other hand, all the investigations relating to private cars have confirmed the fact that the conditions set out in the Directive correspond to the actual traffic conditions for no more than 1% of the total time.

The gap widens as the percentage of power used in relation to the maximum available engine power falls off, or the percentage of the engine power used in relation to the maximum range is low.

This implies that the method has much more stringent effects on powerful saloon cars than on small cars. It is quite clear that this is an anomaly which, in view of the fact that there is only one single limit applicable to all private cars, could mean that those vehicles which are most numerous are not subject to sufficiently strict rules.

It should also be pointed out that it is very difficult to make any judgement purely on the basis of the measurement results.

It would therefore seem much fairer to carry out two types of tests:

- a first test could be designed to reveal the maximum sound level when driving under extreme urban conditions but respecting the other traffic rules. In this case the current method in a slightly altered form could prove suitable.

- a second test could be designed to assess the degree of nuisance produced by a vehicle in normal urban traffic conditions. The degree of nuisance could be assessed by taking the equivalent Leq level corresponding to the acoustic energy produced by the vehicle during a typical town driving cycle; this is similar to the method used to measure amounts of gaseous pollutants emitted.

The studies in progress in this connection suggest that it would be possible to develop a method which would be simpler than referring to a complete typical cycle, which is quite a long experimental procedure. However, the method involving reference to the complete cycle, or another method producing equivalent results, could be suitable for measuring the amount of acoustic pollution produced by vehicles.

The result obtained would then be combined with the previous result relating to "maximum" noise in order to judge the vehicle's characteristics in a less arbitrary fashion than with the current methods, so that the authorized limits could definitely be adapted to the actual features of the various types of vehicle.

Finally, to enable the police to carry out objective tests on public highways on vehicle noise, we would recommend that the ISO draft standard describing a method for measuring noise, close to the orifice of the exhaust pipe and, in the case of a stationary vehicle, close to the engine, should be used as the basis for a future Directive of the European Communities. If this method were used, measures could be implemented when type approval of the vehicle is granted, to enable reference levels to be determined.

When a road check is carried out under the same conditions, the police measure the actual levels. A comparison of the results - taking into account certain tolerances to be laid down - reveals whether the vehicle is still in a normal condition. This method was devised to enable measurements to be made on public highways without excessive demands being made as regards environmental conditions and noise, and it is simple enough to be applied by policemen who have received very little training.

We consider that this is the way to improve the current situation, but, in conclusion the rapporteur would like to underline his desire to see the noise problem dealt with within the framework of a consistent, general policy which, for the sake of the well-being of town-dwellers, would be based on close cooperation, at the instance of the public authorities, industrialists in the motor vehicle industry, town planners, architects and sociologists.

DISCUSSION BY THE PANEL

Intervention of Mr. HÄRTING

As a representative of the automotive industry, I would like to congratulate Mr. Thiry on his report on vehicle noise. His report points out the problems of noise nuisance and related difficulties resulting both for the legislator and the manufacturer unusally clearly. If I return to some of the points in Mr. Thiry's report, I do so in the attempt to define the manufacturer's point of view on this subject.

First of all I would like to come back to ISO Measurement R 362. Mr. Thiry is undoubtedly right when he says that this method which is currently used in the whole of the EC and elsewhere, is one of the strictest measuring methods ever to have been used successfully. At the same time, we have heard that above all for private cars, this method only reflects the nuisance level of individual vehicles very imperfectly. I cannot explain why this is so because of the very short time available to me to speak; but the CCMC report gives a detailed answer. I would, however, like to point out the fact that 4 and 6 limits are set for utility vehicles and buses respectively, whereas there is only one official limit for all band for passenger cars has become even wider than that of utility vehicles. This necessarily means that heavy, high performance cars car practically never make use of their performance in normal town traffic and are therefore constantly penalised by ISO R 362 in contrast to the lower performance cars. This is true to an even greater extent for the completely unrealistic stationary measuring method used in Switzerland. Mr. Thiry has already given an account of this.

I think it is clear to all of us that with a single numerical value in dB(A), only a compromise will ever be possible for the environment. If we do, however, accept a compromise of this kind, we should make every effort to fix the limits to which every future design must be built around more realistic by using an improved method of measurement. Otherwise a technical mistake would be inevitable, which would neither be economically justifiable nor of any use to the public.

As regards the technology of vehicle construction, in many cases, if only for reasons of competition, especially in recent years, everything has been done to match vehicle noise as far as possible to the state of technology.

Detailed tests made by manufacturers show that effective noise level reductions in utility vehicles and buses can only be made by total encapsulation. But even with that, according to the latest findings, a noise level reduction of the order of only about 4 dB(A) can be expected.

For passenger cars, the problem has to be seen from two sides. It is completely wrong, from a purely technical point of view, to talk about changing limits before a method of measuring which corresponds to the nuisance level has been found for this category of vehicle.

If the legislator, using the ISO norm as a basis, where to set the limits lower, a paradoxical situation would arise, so that many objectively loud vehicles would pass the test without problems, whereas numerous other vehicles which have been favourably received by the public because of their quietness, would be classed as particularly poor by ISO R 362 judging standards. This would create pressure to take noise reduction measures exactly where they are not needed. This is particularly true of all vehicles automatic transmission because these, practically without exception are quieter in town traffic than those with manual transmission. A new method of measurement then must ensure these automatic vehicles are correctly classed.

I would like to emphasise at this point that it was not only after pressure from the legislator that manufacturers worked extremely hard on the noise reduction problem. However, in order not to place excessive strain on given capacity limits, manufacturers should be given the opportunity of studying these extremely complex problems first on those vehicles which are known to be especially noisy. If current work on vehicles and in development is to succeed, because of the complexity of the context, long-term planning of future noise limits is absolutely necessary.

Noise tests on vehicles show that - contrary to Mr. Thiry's comments - the engine only very rarely accounts for 30% of total noise. In most cases - and this is true above all of diesel engines - it tends rather to account for 50%, which however means that modifications to the exhaust or the fan are not very promising. I must also warn against the assumption that all vehicles can use electric fans. This design solution is not practicable either for utility vehicles or heavier private cars.

Studies by various research groups have shown that design modifications to engines for accoustic reasons can achieve a maximum 5 dB(A).
Built into the vehicle this means a reduction in the exterior noise level of about 1-2 dB(A). Here too it has been confirmed that only complete encapsulation is at all promising and for private cars with optimally balanced exhaust and fan the technically possible maximum would be about 2 dB(A).

The request repeatedly made by car manufacturers is therefore to get a representative method of measurement which will correctly classify the nuisance level of each vehicle. Only then can it be economically and technically meaningful to talk about new limits. Mr. Thiry has already reported on detailed tests made by UTAC and IRT in the cities of Paris and Lyons. As a result of these tests the well known UTAC cycle was developed. I would like to emphasise the point that the car manufacturers affiliated to the CCMC have made a considerably more detailed study on an international basis in various cities. You can refer to the study in the CCMC report which has been handed out to you.

At present various measuring methods are under discussion in the CCMC based on this report. These new measuring methods take account both of the maximum noise level of a vehicle as well as the normal noise level in towns. It is to be hoped that proposals can be submitted to the responsible Institutions by the beginning to the middle of next year. This amount of time has to be accepted in my opinion for this vehicle category since people, as has been shown by opinion polls in Switzerland, Sweden and the USA, feel irritated first and foremost by utility vehicles, motorcycles, sports cars and least of all by private cars.

Mr. Thiry has already mentioned that the personal habits of the driver, at least in the private car and motorcycle sectors have more bearing on the noise produced than any good and expensive technical measures. In town, top revs in low gears, racing starts, spinning the drive wheels, tyre squealing on bends, loud door banging can scarcely be affected by lowering noise level limits. This indicates a focal point for future specific education, which could begin immediately.

Mechanically neglected vehicles and vehicles which have been tinkered with are often the cause of excessive noise, which the public attributes to the make or model in general. We must therefore press very strongly for the proposed noise measurement procedure as laid down in the new ISO paper TC 43/SC 1/N 262 E of May 75 to be enacted as soon as possible. This ties in closely with an educative effect on the irresponsible sporty driving style of many car owners.

Allow me to remark in conclusion that the employees of car manufacturing companies feel disturbed to a greater or lesser extent by traffic noise as does anybody else.

We do however put forward our urgent request to the legislators, not to disregard our technical argumentation, so that our disturbed nights do not turn into sleepless nights, because the consciences of engineers who have acted contrary to their technical know-how, give them no peace.

Intervention of Mr. DONALD

Before I give you my views on the problems of motor vehicle noise emission and proposals on how these could possibly be dealt with, I must make it quite clear that on this occasion the views expressed are my own and should not be assumed to represent the official view of my Governement.

As Mr. Thiry has said in his paper, the urban communities of the industrialised nations are becoming increasingly aware of the annoyance caused by all forms of noise.

At this Symposium we are concerned with the contribution made by road vehicles to annoyance from noise and to solutions necessary to deal with this problem. There is no doubt that considerable annoyance is caused by noise from road vehicles both in the form of background noise produced by a stream of traffic and the noise emitted by an individual vehicle during some manoeuvre, eg starting, accelerating or changing gear. People associate differing degrees of disturbance with differing types of vehicle. The results of a recent interview survey, carried out in a large part of the United Kingdom, to obtain the individual's view of annoyance from vehicle noise show that the goods vehicle is considered to be the worst offender and that the annoyance caused by other vehicles can be ranked in the descending order of motor cycles, buses and private motor cars. This result is consistent with the results obtained from previous, but less comprehensive surveys.

The main concern of Government officials must therefore be directed to finding ways to reduce this annoyance. This concern need not be solely directed to the production of quiet vehicles; other solutions or partial solutions are available, and can also be considered.

In my country, L_{10}, the sound level exceeded for ten per cent of the measurement period, is used extensively as our index of the annoyance caused by the noise from free-flowing traffic eg. traffic using urban motorways. Legislation in the United Kingdom provides, in the case of new roads, for remedial action against noise where the L_{10} value at the facade of a building is in excess of 68 dB(A). The significant traffic parameters affecting L_{10} are the hourly flow of vehicles and the percentage of heavy goods vehicles in the traffic. Where the traffic does not flow freely, such as in the congested conditions that exist in city streets, the presence of heavy vehicles is the most important factor in the determination of annoyance. It has been estimated that heavy goods vehicles contribute at least an additional 3 dB(A) to the overall traffic L_{10}, at worst the contribution is 12 dB(A) and on average 6dB(A). Thus a possible method of reducing the annoyance from traffic noise is to place restrictions on the traffic flow and the types of vehicle using certain areas or routes. Such restrictions imply the loss of opportunity to use vehicles and perhaps a reduction in the demand for vehicles. L_{10} is also implicitly related to the noise emitted by the individual vehicle and an alternative, and I believe a more pratical solution, is the production and use of quieter vehicles.

The dominance of the heavy commercial vehicle in all surveys of annoyance from road traffic noise leaves little doubt as to the area in which the most benefit can be obtained by the production of quiet vehicles designs. Work is progressing in several countries with the aim of producing viable designs. The additional cost of such vehicles compares favourably with the overall costs of alternative solutions such as the re-routing of traffic or the extensive use of noise barriers. However, the benefits of quiet vehicles will not be fully realized until all vehicles are of the new design, due to the relatively slow rate of introduction of new vehicles into vehicle fleets this will not be achieved for perhaps a decade following the introduction of requirements for lower noise levels.

The methods currently used for assessing the noise potential of a vehicle are based on the ISO Recommendation R362. The measurement of vehicle noise potential during an acceleration test has proved a suitable means of statutory control of vehicle noise. This method is now widely used by countries as a basis for controlling vehicle noise. While not adverse to considering other means of assessing a vehicle's noise potential, it follows that any alternative method must be demonstrated to be superior to the present method and in particular to have characteristics which permit a more realistic control of the annoyance caused by the noise from motor vehicles. A great deal of investigation of the correlation with this subjective annoyance will be necessary before we can be sure that a radical change in test method can be justified. My own view is that there is little doubt that the acceleration type test is a satisfactory means of legislative control for heavy vehicles. I see little need for any other test method for these vehicles in the future although no doubt minor improvements may be desirable.

I am, however, less certain of the advantages to be gained by applying <u>only</u> the acceleration test to motor cars. As mentioned earlier, I would not myself be adverse to the consideration of <u>additional</u> forms of test for these vehicles in order to establish a traffic noise value for motor car types as well as the maximum noise values obtained by the acceleration test. I realise that this is a very controversial area of consideration and that much research and thought will be necessary to show the need and the advantages of any such change.

Once a vehicle is in service there is a need to ensure that the noise potential of the vehicle does not increase with age or by the use of unsuitable replacement parts. At present a great deal of thought is being given to controlling this situation by acoustic measurements. However, it is difficult to obtain accurate and effective control in the wide range of vehicles and conditions that exist in practice. Acoustic measurements also require a certain amount of investment in equipment and the maintenance of that equipment; together with some training for the operators of the equipment. An alternative or parallel means of control is the physical inspection of those components where a deterioration in condition will adversely influence the noise potential of the vehicle. Recent investigations suggest that quite catastrophic failures of exhaust and incert systems can occur without a significant increase in the noise level at the outlet of the exhaust. Thus physical examination of components may prove to be a more effective and economic way of controlling the in-use noise potential of vehicles than acoustic measurements.

In conclusion, it is my opinion that our priorities in the future should be

a) the reduction of the noise potential of commercial vehicles and buses by a considerable amount, such action to be taken very soon if the full benefit of these reductions is to be felt by 1990;

b) the development and introduction of effective controls of the in-use noise potential of vehicles;

c) a review of the methods used to assess the noise potential of vehicles when data is available to suggest that such a review is warranted.

Intervention of Mr. DE BRABANDER

I shall restrict myself to stressing two points which seem to me to be particularly important.

The first concerns the development, with time, of the irritation due to road-vehicle noise felt by the population. This irritation is primarily caused by the noisiest vehicles. It is unfortunate that the noisiest vehicles, namely lorries and motor buses, also have the longest operating lives.

It therefore follows that the persons affected will have to wait about ten years before the desired effect is achieved by reducing vehicle noise at the design stage.

Without such a reduction, an increase in irritation due to noise must be expected in the years to come because the number of vehicles on the road will increase, which in turn will break up the stability of traffic flows and therefore also have a negative effect on noise. The effectiveness of what can be done at the design stage, therefore depends greatly on the speed of implementation.

The second point,which seems important to me, concerns the assessment of irritation due to noise. Ten years ago the experts felt that such irritation due to vehicle noise could be measured during full-throttle acceleration at high engine speeds. Recommendation 1SO and the EEC directive currently in force were based on such an assessment and in any case always applied to commercial vehicles. The same situation does not apply to most cars since the increase in engine power and the matching of transmission systems have caused the measurements to be carried out at low engine speeds although the test requirements have been fulfilled. All the experts agree, moreover, that this method should be modified for cars, but in various ways.

As Mr. Thiry clearly illustrated, a sharp distinction must be made between day -time and night-time situations. I personally think that priority should be given to the fight against noise at night. This does not mean that very detailed studies have not recently been carried out on day-time urban traffic. On the other hand it seems as if little has been done to sound public opinion on irritation due to traffic noise and to formulate an objective assessment criterion which would correlate well with such irritation. One could indeed ask whether L10 or L1 (i.e., the level exceeded during 10% and 1% of the time respectively) are not more representative measures of the irritation caused by road traffic than L_{eq}, which would give rise to test conditions roughly similar to those set out in the present directive.

If I might express a wish it is that our psychologists and sociologists will shortly begin studies which would enable the necessary scientific investigations to be carried out in this area.

Since the subject has been broached I would like to add a comment on the measurements carried out on vehicles in service, even though this has nothing to do with vehicle design. In Belgium measurements of this type have been carried out according to three methods for more than four years :

1. Method one applies to vehicles powered by spark-ignition engines running at a constant speed, which is measured accurately with the aid of a tachometer;

2. Method two applies to vehicles powered by diesel engines which are run at maximum speed (limited by the governor);

3. Method three applies to two-wheeled vehicles whereby the throttle is repeatedly opened and closed without accurate measurement of the engine speed.

It must be pointed out that method three has proved to be the most effective in the fight against excessive noise since it is applied more extensively by the police. The effectiveness of measurements relating to vehicles in service is therefore above all a question of simplicity, even at the expense of accuracy.

Intervention of Mr. GARCEA

The picture given by Mr. Thiry on the problem of the noise generated by motor vehicles is so complete and clear that little room for further general and fundamental informations has been left. Anyway, as a technician in a car manufacture firm, I have first of all to declare to agree with the theoretical but, at the same time, practical formulation of the problem that Mr. Thiry gave starting from the historical remarks which justify the present situation. As a citizen of a European town, as well as a technician, I express the confident hope that, also so far as the noise is concerned, the urban environment be less and less polluted by motor vehicles and I look forward to such result being achieved thanks to the combined and concordant work of everyone who is responsible and interested in the solution of the problem : legislators law-enforcement authorities, and those responsible for road maintenance and traffic, city planners, and of course, car manufacturers.

Since many years the problem of noise has been the object of studies and researches from the car manufactures; that happened both for the need to fit the vehicles to the regulations (which therefore are meritorious also in this field) and for the increasing and lucky achievement of the concept that noise is a negative feature for the vehicle. On the basis of these studies and researches many improvements have been introduced in the vehicles design, as you know; which involved an obvious and justified increase in the complication and cost of vehicle itself.

In this connection I think it is worth drawing your attention to the fact that, among the various problems related to motor vehicles being treated during the various sessions of this Symposium, the problem of noise has difficulties which are less understood by non-experts : we are very grateful to Mr. Thiry for his underlining the importance of these difficulties which, the less the noise levels are reduced under the present ones, the more they increase.

In the case that these difficulties can be technically overcome, the problem of cost in relation to the obtained improvement is raised.

As in the case of air pollution and safety, for the noise too the modification of the vehicle will be justified only on the basis of the cost/benefit ratio: the cost finally weighs on the customer and on the community and contributes further burdens for the present economic situations of the motor vehicle industry.

While the cost, at numerator of the mentioned ratio, is easily definable, the same cannot be said for the benefit which should take into account also the results of serious medical researches on the effects of noise on the physical and psychologic health of man and, at present, such results are not yet available; hence it is reasonable to consider only the ratio cost/effectiveness of a modification which the reduction of the noise which the vehicle generates in its normal urban driving.

The noise of the vehicle must be therefore measured(to be accepted or rejected according to a given regulation, but also to evaluate the effectiveness of a modification) in condition of normal urban driving. It is wellknown that a vehicle can be used in many different ways according to the engine revolutions,to the position of the accelerator pedal and to the different gears.

Of all this very large use field only a very narrow band corresponds to the modality prescribed by the present ISO R 362 procedure to evaluate the vehicle noise; unfortunately in urban driving the vehicle is utilized only for 1% of the time according to the modalities of ISO R 362 procedure which therefore is not representative of the real conditions of use of the vehicle, and can not, at present, be considered valid neither to evaluate a kind of vehicle from a noise stand-point (that is to accept or reject it), nor to evaluate the effectiveness of a modification for the cost/effectiveness ratio, as I said over.

On the basis of this procedure, more severe law limits would lead, in many cases, to a remarkable increase in complication and costs, which will be absolutely unjustified; the noise reduction, in fact, would be obtained in a zone of the use field very seldom utilized, while in the actual normal urban driving condition the effectiveness of the modification can be null (and perhaps, really negative).
But the above mentioned considerable enforcement based on the present procedure could lead to the technical impossibility to meet the new limits with some present models.

In the worst condition some manufacturers could be forced to cease the production of certain models that are, in the real condition, the more noiseless.

The gravity of the situation and yet the will to make progress in the struggle against the traffic noise has lead many European manufacturers to join their efforts in carrying out researches in cooperation to determine with careful statistical analysis the real conditions of usage of the vehicles in the urban traffic : information on this activity is reported in the document that the C.C.M.C. has presented to the authorities at the Symposium; it is a long term work that has already confirmed that the ISO R 362 procedure does not represent the real conditions.

This work will provide in the end the elements to formulate a valid procedure to evaluate the vehicle from the point of view of noise emission.

Nevertheless the car manufacturers do not think to utilize these researches and all the other work necessary to formulate a new procedure as a barricade to avoid a short term reduction of the present noise limits : but they want to draw the attention to the part that this reduction band on the present procedure must not be excessive if we want to avoid the very heavy consequences above-quoted and connected with the lack of representativity of the present procedure.

The car manufacturers are therefore ready to collaborate at the reduction of the traffic noise both by short term modifications to their vehicles and by long term measures based on a new procedure : but remember that this reduction will not have practical effects if simultaneously the other factors are not considered which result from the organization of traffic, the behaviour of vehicles, town-planning and architecture.

I have already quoted the intense research activity of the car manufacturers to cooperate in the formulation of a new and realistic procedure for the evaluation of the vehicle from the point of view of noise : in one of these researches (quoted also by the C.C.M.C.) the noise emitted by more than 16,000 vehicles of all the types during their normal usage in the traffic of a large European town was measured : the recordings have been made in different points of the town and during a period of numerous days, identifying the type of vehicle that has caused the recorded noise, and the measurement distance.

The elaboration of the recorded noises related to the distance of 7.5 m (as provided by ISO standard) has lead to the conclusions that for the 80% of the vehicles the noise emitted during urban traffic does not exceed the level of 77 dbA. This level is, on the contrary, exceeded by the 70% of the public means of transport and the heavy vehicles (that numerically represent the 10% of the total registered vehicles); among the 16,000 vehicles in consideration 1,000 were of the same type, homologated with 80 dbA. For 500 of these the noise emitted was inferior to 72 dbA; only for 70% of them it was superior to 80 dbA.

On the basis of the mentioned C.C.M.C. researches the difference between ISO homologation level and the noise level actually generated by the traffic is essentially due to the fact that the ISO procedure prescribes an engine revolution number which is very much higher than the one used in normal traffic : and the engine noise very quickly increases with the number of revolutions.

In addition, the rate due to the engine (with respect to the noise generated by a complete vehicle) is very important : according to our recent studies, it is higher than what Mr. Thiry said, with a mean value of 50% and a maximum value of 80% for certain models.
Of course, these last models would be more penalized (with no technical justification) by a remarkable short term reduction of the limits utilizing the ISO procedure; the five gear models too (not overdrive) would be penalized if obliged by the rule to utilize, during the ISO test, the second gear at a number of revolutions of 1500 r.p.m. higher than the one corresponding to the third gear (which they normally utilize in urban traffic).
In relation to what I said, the car manufacturers forbade that in the possible short term reduction it will be possible to obtain exemptions for some models which, though being in practice as silent as others, or more, could be so penalized by the present procedure that the necessary modifications (essentially in the engine) would be very costly or really the homologation and hence the production, would be forbidden. About the noise coming from the engine (and about the means to reduce it) another remark appears suitable by which your attention is drawn on the interdependence among the various problems related to the vehicle : Mr. Thiry has mentioned that a reduction of the engine noise can be obtained decreasing the revolutions and, obviously, increasing this displacement, but that higher displacements can be obstructed by some in force taxations, which are based on the displacement itself.
We should add that the displacement increase could be conditioned also by the following situations :

a) in normal driving (city or highway at mean speed) the engine with larger displacement is utilized at a very low load and this can lead to an increase in the specific consumption and hence in the consumption per kilometres.

b) engine weight and volume increase with the displacement thus determining an increase in weight and maybe in volume of the vehicle, and so, once again, an increase in the consumption per kilometres.

Last but not least, I would point out the great importance attached by the manufacturers to the fact of having an homogeneous legislation in the Community as well as in third countries.

Intervention of Mr. INGERSLEV

Noise pollution produced by Motor Vehicles is a very important subject. A thorough description demands discussion of a great number of items.
My contribution will be restricted to one item only, namely noise criteria.

It is not sufficient to establish a noise criteria which ensure that the citizens accept the environment without complaining. The target should be to ensure a real favourable environment. In residential areas, the noise level due to road traffic should be under strict control. It should be possible to use important recreational areas such as gardens, terraces, and balconies without disturbance due to traffic noise. It is a human right to be able to relax in the garden, on the terrace, and balcony without interference from traffic noise.

According to the viewpoints of Danish Environmental Authorities, the environment can be designated as satisfactory when the outdoor equivalent, constant, A-weighted sound pressure level produced by road traffic is below 45 dB.

Such levels will not provoke undue annoyance and interference with normal activities in these areas. The indoor environment - with windows open - may also be designated as satisfactory since the indoor sound pressure levels in typical cases are 15 dB below the outdoor levels, i.e. The indoor equivalent, constant, A-weighted sound pressure level is 30 dB.

The environment is designated as unsatisfactory when the outdoor equivalent, constant, A-weighted sound pressure levels is above 55 dB.

It may be necessary to accept fairly high traffic noise levels in the main streets of a down-town area as well as in the main streets connecting suburban areas and the down-town area.

The necessity of allowing such high noise levels does not justify that the noise climate is described as satisfactory.

The extent of nuisance problems due to road traffic in Copenhagen has been subject to an intensive investigation. (1) (2)
960 persons living in 28 different residential areas were interviewed. Half of the areas have an equivalent, constant, A-weighted sound pressure level determined on a 24 hours-a-day basis which is within the range of 64-73 dB, and the other half have a level which is within the range of 46-58 dB. In the former group, the noise exposure was determined by road traffic noise, whereas the road traffic noise was only a more or less determining factor for noise exposure in the latter group.

TABLE 1 : RESULTS OF A DANISH STUDY OF NUISANCE DUE TO ROAD TRAFFIC NOISE

	$L_{A,eq}$ (24)		
Percentage of interviewed persons	46-58	64-73	dB
who indicated nuisance due to road			
traffic noise.	13%	83%	

This table shows that the percentage of interviewed persons who indicated that they were disturbed by traffic noise was 83% in the areas with a high noise exposure, whereas the percentage in the areas with moderate noise exposure was 13% only.

A detailed analysis of the situation in two corresponding areas, one in the group with a high noise exposure and the other in the group with a moderate noise exposure, is shown in the next two tables.

TABLE 2 : COMPARISON OF THE NUISANCE DUE TO ROAD TRAFFIC NOISE FOUND IN A DANISH STUDY

	$L_{A,eq}$(24)		
Percentage of interviewed persons	72	56	dB
who indicated nuisance due to road traffic noise	97%	37%	
having a high degree of physic well-being.	30%	63%	
who used sedatives	43%	23%	
who consulted a doctor due to physical reasons	30%	3%	

TABLE 3 :

Percentage of interviewed persons		
having interference problems when using the telephone	80%	3%
Having interference problems when reading	70%	10%
Who did not open windows (often or occasionally) due to road traffic noise	93%	17%

This analysis proves that an outdoor A-weighted sound pressure level of 55dB does give an environment which it is justified to call unsatisfactory in a residential area.

The Danish authorities have taken the consequences of this fact when drawing up guidelines for evaluation of community noise. (3)

TABLE 4 : THE TABLE STATES WHEN THE ENVIRONMENT CAN BE CONSIDERED SATISFAC- OR UNSATISFACTORY USING $L_{A,eq}$ ON A 24 HOURS-A-DAY-BASIS AS A MEASURE OF THE QUALITY OF THE ENVIRONMENT, ROAD TRAFFIC NOISE

Urban area or buildings	Satisfactory environment in case $L_{A,eq}$ (24)	Unsatisfactory environment in case $L_{A,eq}$ (24)
Rural, residential and recreational areas	40 dB	50 dB
Suburban residential areas, recreational areas in urban and suburban zones, hospital zones	45 dB	55 dB
City areas with business, administration,etc...	50 dB	60 dB
Industrial areas for trade and lighter industry	55 dB	65 dB
Industrial areas for heavy industry	70 dB	80 dB

Table 4 shows the Danish guidelines with respect to evaluation of road traffic noise as a community noise.

The table defines when the environment can be considered satisfactory and when it shall be considered unsatisfactory - the difference between the two limiting values being 10 dB.

The general spirit of guidelines is that the goal for all planning of new projects should be to observe the low limits in column 2. Sometimes it may, however, be necessary to accept values between the low values column 2 - and the high values - column 3.

This should be permitted only if it is economically or technically impossible to carry out the project observing the values in column 2. Noise exposure above the values column 3 should be accepted for new projects in very rare cases, and only if other considerations make it imperative.

It should be realized that it is difficult to-day to observe these values, in any case in rural and suburban residential areas.

All possible measures for noise reduction should be applied. (4)

Priority should of course be given to reducing the noise level of every vehicle : this measure should indeed be utilized to the utmost. This is the only measure which is of a general nature and which will be to the benefit of all citizens.

Measures such as traffic regulations and town planning are useful and should of course also be utilized but the effects of such measures are naturally restricted to the area where they are introduced.

It should be emphasized that town planning is a very useful measure. Noise oriented zoning, use of acoustical barriers and noise oriented layout of the various rooms in flats and houses should be used. An example which demonstrates that it is possible to obtain very good results under difficult circumstances shall be given.

A new 6-lane motorway was built outside Copenhagen a few years ago. This motorway is expected to be one of the most busy Danish motorways in future with at least 50.000 cars during a 24 hours period, 20% of the cars are trucks, buses, and other heavy vehicles.

Figure 1 shows a map of a building site along this motorway.

A 10 M high eashern barrier was built close to the way. The eashern barrier and the area behind the barrier are planted with proper trees and bushes. The houses are 2-storey non-detached one-family houses. The equivalent, constant, A-weighted sound pressure level is predicted to be below 55 dB at a distance of 150 m from the center line of the motorway.

The houses situated nearest to the motorway have their facades 150 m from the motorway.

Fig. 2 and 3 show that all rooms facing the road are non-sensitive rooms such as bathrooms, stairways, and kitchens. The lay-out is justified by the fact that the front is facing North.

The terraces and gardens are facing south, and the houses act as noise screens. The screening effect is fairly high since the houses are undetached. $L_{A,eq}$ (24) is estimated to be 45 dB on the terraces and in the gardens.

This example demonstrates that it is possible in many cases to fulfil the Danish Guidelines when handling new projects.

The situation in connection with existing projects is of course much more difficult. It must be realized that it often will be impossible to obtain a satisfactory environment. It may even be necessary to accept an unsatisfactory environment. This circumstance does not justify that new projects are established which have an unsatisfactory environment.

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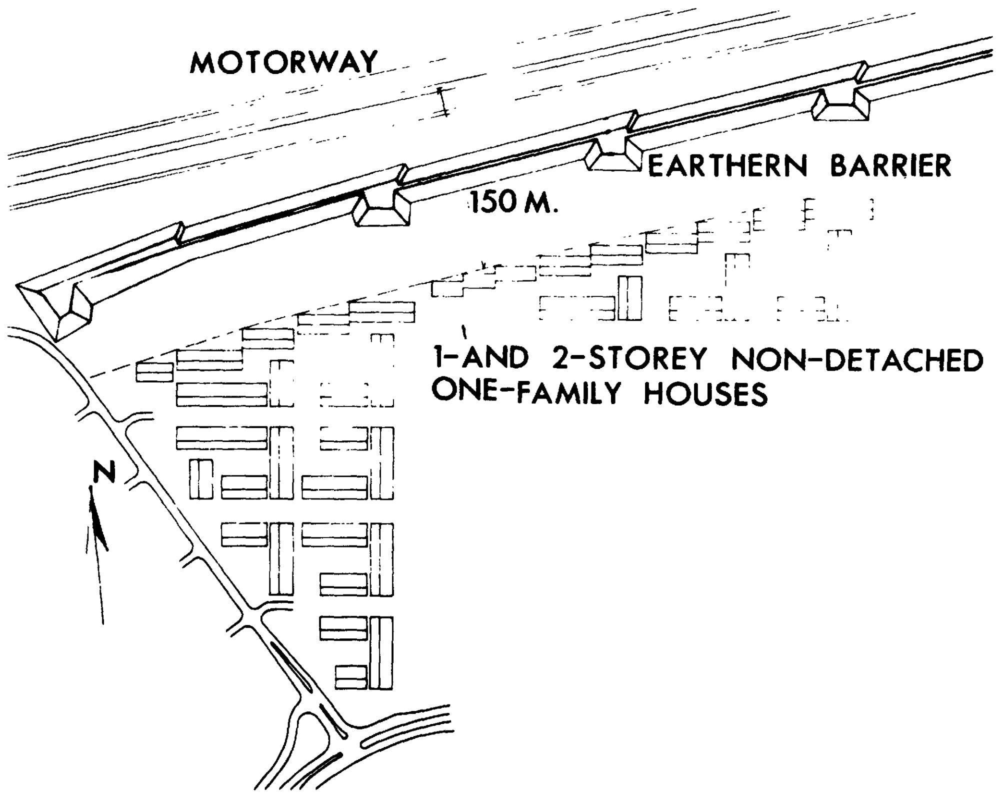

Fig. 1 A building site close to a motorway.
A 10 m high earthern barrier is placed close to
the motorway.

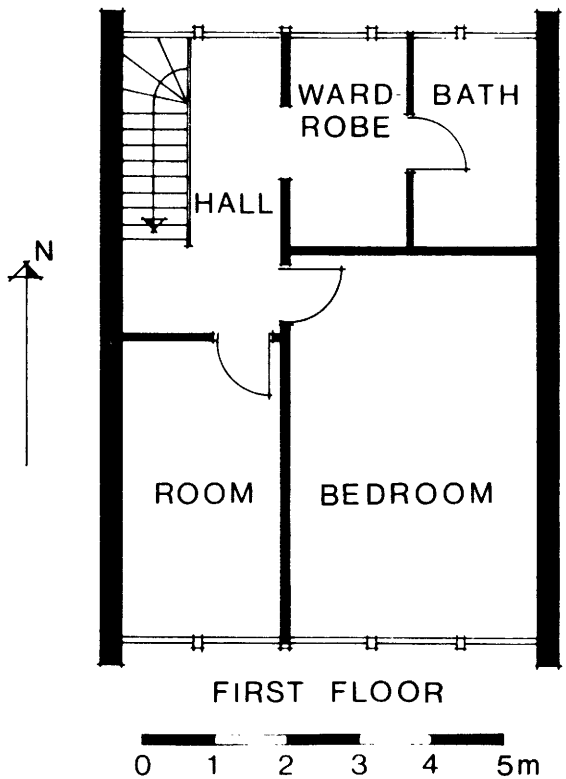

FIG.3 First floor of a two-storey
non-detached one-family house.

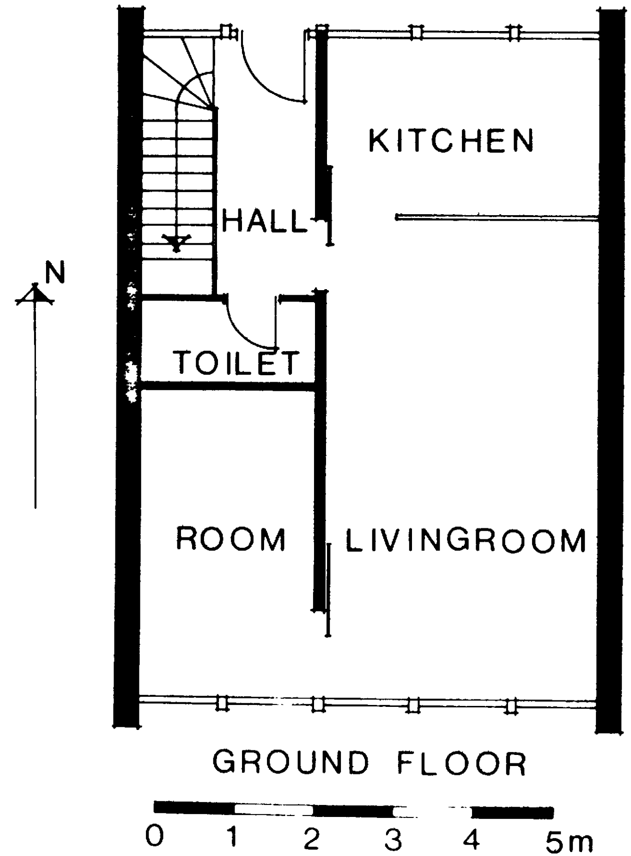

FIG 2. Ground floor of a two-storey
non-detached one-family house.

Intervention of Mr. EGGELMANN

In my intended role on this stage, namely that of a compiler of regulations I can not actually add anything to what Mr. Thiry has said. He has, in fact, mentioned to perfection everything relevant to the rule maker. Perhaps I can add a tiny little bit on the time-scales for the proposals which Mr. Thiry has made on the future regulations linked with EEC type approval. It would certainly be very interesting to hear the cristicisms of the other participants.

The expected attitudes of the rule makers seem to have caused a certain emotional flurry among some of the participants in the panel discussion originally arranged. Until now I had always, in fact, had the impression that in all the EEC negotiations on noise all government representatives had clearly said that the general view was that passenger cars were not all that noisy and that omnibuses and lorries were the sources of unpleasant noise. The next reasonable meaningful steps should therefore be to match the noise level of commercial vehicles and omnibuses to that of passenger cars. The vehicle manufacturers and experts always comment that the ISO method of measurement is appropriate and reasonable - and will be in future also, at least for the forseeable future. However, the complicated test on passenger cars under discussion here, is, so I understand, not so. I do not understand how, if passenger cars are to be the datum for potential noise levels and other vehicles are to be adapted to these, that so much effort is being expended while the ISO method, which has proved itself over the years, is under criticism. Passenger cars are in my view currently treated liberally under the ISO measuring method and do not justify at all those explanations which always state that we must still carry out an enormous amount of research before we can judge them properly. It seems to me that this discussion - if anything like today's events should be held again would be more appropriate to the next but one of them. For the moment I do not know whether it has been stated in any of the Commission study groups that something drastic must happen as regards passenger car noise. I would therefore be very pleased if in the subsequent discussion the other participants would perhaps throw further light on this aspect. I believe that it would be useful to clear the air a little. We would then certainly achieve sensible further development of existing Council Directives on noise within the forseeable future.

Thank you.

Intervention of Mr. LEMAIGRE

Being the last to speak is very difficult since most things have already been said. The Chairman said just now that he would try to include representatives of the manufacturers, design offices, administrations etc. in the panel. In my case this will be difficult because I am a fugitive from the motor industry. I have been President of the Permanent Manufacturers Bureau but I now represent the users. I represent 15 million motorists who belong, I believe, to 80-90 organizations in 60 countries. I therefore feel that I can to some extent put forward the users'point of view. How can I do this ? I can do so by taking up two very fashionable ideas, namely cost and effectiveness, by basing myself on Mr. Thiry's report, which I agree with except perhaps for one very small point. I shall divide this up into paragraphs as follows :

1. Physiological studies
2. What are you aiming at ?
3. What are your absolute limits ? How far can you go ?
4. Cost effectiveness.
5. Parallel measures.
6. Alternative power sources.
7. Repercussions on all of the other problems which we are to study and which we will examine during the next three days.

Physiological studies :

We all agree that the medical aspect of this sector is imprecise. There is often talk of neuro-physiological complaints, which are highly variable, and I have just heard for the first time a figure of 43% which relates to a group of people who use sedatives. You know that we are in the age of tranquillizers and sedatives, so that the figure of 43% seems low. Medical studies should therefore be carried out in this area and I feel that we could be helped by the WHO, not only on the problem of noise but on all problems concerning safety in general. For the time being we are adopting regulations based on medical opinions concerning the physiological and psychological effects of noise which are inaccurate and should be withdrawn. A lot of work therefore needs to be done.

What are you aiming at ?

Briefly, 45-50 dB(A) inside rooms and 60-62 dB(A) in the frontage walls, as opposed to the 70 dB(A) applying.

What is the absolute limit ?

Mr. Thiry recalled to mind just now that, under ideal test conditions, 60 dB (A) should be recorded but he added that in actual fact the current figure is 66-70 dB(A) - a difference of 10 dB(A). The limits which one would like to see applied are contained in the Wilson Committee's report (50dB(A) in towns) and in some Swedish studies (55 dB(A) for 24 hours without interruption). I shall not take account of the limits asked for in Switzerland since they seem a little too stringent.

Cost (cost/effectiveness ratio).

It can be seen from American studies on the diesel engine that an outlay of 3-5 cents per hp is needed in order to reduce noise by a few dB(A). For 10 dB(A) the cost is 4-6 dollars and for 15 dB(A) its is 6-18 dollars. If we consider a 300 hp engine this would mean an outlay of 15, 1500 and 4500 dollars respectively.

Parallel measures

I am convinced that we will be able to do nothing as regards noise without, as Mr. Thiry has said, resorting to parallel techniques, namely better town planning etc. We have just heard the figures provided by Mr. Ingerslev and have seen that it is possible to achieve an average of 45 dB(A).

However, experiments like those carried out in Denmark are also in progress elsewhere and it would be interesting to know what the relationships are between decibel reduction, cost and traffic conditions.

Other points with which town planners are concerned are the synchronization of traffic lights (which would affect not only noise but also consumption and pollution) and the replacement of road junctions. In Paris, for example, apart from the improvements made to vehicles themselves there is no explanation for the reductions in pollution recorded over the last 10 years other than the replacement of several road junctions.

Architects should begin to take account of the problems raised by noise in their arrangement of living accommodation and in particular that of the bedrooms, since we want things to be quieter at night.

Another problem to be solved, since it is responsible for a large proportion of the noise generated at night is that of refuse collection. The resultant noise is produced not only by the engines of the collection vehicles, but also by the refuse compactors and dustbins.

Finally regulations should be introduced which, for example, prohibit traffic at certain hours or in certain areas while providing diversions for heavy traffic etc.

Alternative power sources

This is where I don't entirely agree with Mr. Thiry. He mentioned electric motors and business I can't remember whether he also mentioned the Stirling engine. I believe that the turbine could be used in 400 hp vehicles, but I do not think that it will be able to be fitted to private motor cars for a long time yet. For me electrical power is not an overall solution. It could be used in certain sectors such as high-density, city-centre bus routes, refuse collection vehicles or certain delivery vehicles, but not for much more.

Repercussions on all of the other problems with which we must deal

Here are a few examples :

(a) lead traps. These seem effective but they need to be subjected to a noise study.

(b) cylinder capacity. I think that action in this area will yield improvements with regard to noise and the fight against pollution.

(c) types

(d) five-speed gear boxes. Here also satisfactory solutions can be found as regards reduced consumption and noise.

(e) cooling fans which can be disengaged and temperature of cooling system.

I will conclude by saying that the problem with which we are dealing shares several aspects in common with the other problems which will be dealt with during the days to come and in particular the problem of energy. It will therefore be necessary for us to prove that we are realistic in all of the measures which will be adopted in future.

GENERAL DISCUSSION

INTERVENTION OF MR. FACHBACH

For more than ten years we have been working on the problem of engine noise reduction and we have some experience in this field. I should like to ask Dr. Härting how he arrived at the value of 6 db(A) total vehicle noise reduction.

REPLY BY MR. HARTING

The figures I mentioned of 4-5 dB - and not 6 dB - are based on studies carried out by my own firm and other firms. We know - and, Mr. Fachbach, you know too - that the encapsulated engine of AVL gave a noise reduction of about 18-19 dB as a "base" engine without the other units already mentioned by Mr. Thiery : radiator system, fan system and exhaust. In the meantime, this AVL engine has been mounted experimentally on a chassis by MAN and is being used to carry out tests. A distinction must be made between what has been described by a research body - even with this laboratory vehicle the 20 dB is no longer being obtained in motion through a better figure was attained than the 4-6 dB I mentioned - and what can reasonably be expected from a new generation of vehicles which has not yet reached the same stage of refinement as in your case. I believe that in many discussions prevailing opinion was that it will be years before the work leads to a result on which series production can be based. I think that that has answered the question. I see that you have some slides. Maybe you would like to show them.

INTERVENTION OF MR. FACHBACH

The fact is that the noise reduction of approximately 15 dB(A) or more applies not only to this completely new design of low-noise engine but also to conventionally built engines to which a dry encapsulation is later fitted. The limiting value you mentioned is not really due to the encapsulation and the encapsulation technique but presumably to the fact that the other sources of noise are not adequately sealed off.

INTERVENTION OF MR. HARTING

It goes without saying that in all these considerations we can only look at other vehicles as a whole. If we assume from the outset that no standard solution has yet been found to the fan problem in commercial vehicles and that fan noise and exhaust noise are equally important, then in most cases it is not sufficient merely to be able to achieve in the laboratory a noise level reduction of 20 dB for the engine alone.
For all other noise sources, we must obtain improvements of at least the same order of magnitude in order to attain greater value overall than the 6 dB I mentioned. In this connection, the subject of rolling noise, which has already been mentioned several times, must also be taken into consideration. For commercial vehicles, the rolling noise is about 65-73 dB as measured by the ISO method. According to the ISO method these measurements are taken with the vehicle empty, not loaded. At the same speed of approximately 50 km, the noise level of a loaded vehicle is on average higher by some 8-10 dB. Since commercial vehicles, however, are usually loaded, the lowest level of rolling noise would have to be put at 80-84 dB. Does that answer to your question ?

REPLY BY MR. FACHBACH

Yes, that does answer my question. I simply wished to prevent the impression from being gained that the limit of the attainable improvements are set in this case by the capsule. They are set in fact by the other components. It is clear that in the case of encapsulation the demand for noise reduction and that for engine cooling must lead to a compromise. That is certainly true of the conventional encapsulation method, i.e. a capsule through which the full flow of engine cooling air is passed. But there is another method of encapsulation, whereby the radiator-fan unit is mounted in front of the capsule and the gap between capsule and engine is swept only by a relatively small quantity of cooling air which is nevertheless sufficient to meet the cooling requirements.

INTERVENTION OF MR. WEIGHELL

We heard that the noise from the commercial vehicles is a principal source of noise in traffic and that its reduction is very difficult to be achieved. I think that it would be very helpful if the EEC draft directive on dimensions and weights of commercial vehicles is adopted. In my view this will be the best opportunity for industry to introduce on to the market a new generation of commercial vehicles. Could we have a date when this directive is likely to be adopted ?

ANSWER OF MR. VERDIANI

I hope that we will be able to give you an answer on Friday, after the Council session of the Transport Ministers.

INTERVENTION OF MR. CLIFTON

Tyres are frequently quoted as a significant source of vehicle noise, particularly on commercial vehicles. The measurements made by a number of authorities suggest that the tyre industry is likely to be faced with extensive re-design of tyres and particularly of tyre trade patterns. It is a general tyre industry belief that the apparent contribution of tyres to total vehicle noise is exaggerated in relation to the other sources of vehicle noise. I think that, to get a perspective on this, it is always interesting to listen to the noise test on one of the several quiet vehicles which exist. It is surprising to see how quiet these vehicles are when tested on the standard conditions and, if you have in mind the sort of noise levels which are quoted to be produced by tyres, these figures become quite impossible. I think that this situation is partly due to the generally accepted dBA noise scale which is used and to its method of interpretation which does not reflect accurately the real extent of tyres'noise. I was therefore delighted that Mr. Thiery payed very little attention to tyre noise in his report and also that in the table that he gave of energy values, he indicated that the total road noise contribution - which of course is the combination of tyres and road interaction noise - was about 5%. This rather suggests that this aspect is relatively insignificant. I was also pleased to hear Mr. Donald and Mr. De Brabander state very similar conclusions about the fact that the method of measurements must give a realistic assessment of the subjective annoyance level of noise. In the particular case of truck tyres, industry could in fact, from a technical point of view, re-design tyres in order to make them quieter, but to develop this type of tyre in order to comply with future requirements which are foreseen by some authorities would be economically catastrophic to the vehicle users.
I would therefore ask for an insurance that the tyre industry will not be faced with legislative noise level requirements which would dictate a need for radical tyre re-design, until the correlation between scientific noise measurements and subjective effects has been established.

INTERVENTION OF MR. HARTING

Your question can be split up into several parts. The standard conditions you mentioned are not known to me personally. You speak of possible misinterpretations. Sufficient data are available concerning measurements performed this year on commercial vehicles, in which the values I mentioned were attained with fully loaded vehicles, the measurements being carried out not according to the ISO method but with the vehicle on tow, fully laden and without engine noise. I think we all agree here that in this field a lot of work must still be done before an objective assessment of the problem is possible.

In my opinion, the matter of tyre noise was not exaggerated; on the contrary, it was played down by saying that we must attain the values for tyre noise because this is the least of the noises produced by the motor vehicle. Thank you very much.

INTERVENTION OF MR. MÜLLER

I should like to begin by expressing my warmest thanks for being given the opportunity to take part in this Symposium as the representative of a country which is not a member of European Economic Community. This has long been our wish, for, as you no doubt know, most of Switzerland's imports from the EEC countries pass over the Alpine roads, and we should therefore establish closer contacts with those countries than in the past. Thank you once again.

Since Switzerland has been referred to a number of times during this session, there are two or three points I would like to go into briefly. Noise abatement in Switzerland is a highly topical subject, as various events have probably brought to your notice. Popular action and parliamentary pressure have brought matters to the point where the Swiss Government is preparing very strict measures to combat noise, particularly in road-vehicle construction. These measures will also be put before the international committees on which we are represented. The noise abatement drive in Switzerland is not a new phenomenon - the campaign against road traffic noise has been going on for the past 25 years, and I would perhaps go so far as to say that Switzerland was one of the first countries to carry out noise measurements on motor cars. At one time or another we have tried out every likely method of measurement, and we finally opted for the static method in its present day form, because it is simple, because it can be applied anywhere, and because it is easily reproducible.

I think therefore, that before going over to a new method the present ISO method must be eradicated. Once this has been done, I can happily give an undertaking that we, too, will adopt it, although this does not mean that we should necessarily accept the limit values as well. I would like to congratulate Mr. Thiry on his very interesting observations, which I found convincing and with which I am in broad agreement on practically all points. There was only one remark that I found somewhat disappointing, namely that we have to come to terms with the fact that the noise level in many bedrooms is higher than the experts consider reasonable. This comment is in much the same vein as the similarly disappointing remarks by the last speaker Mr. Lemaigre, in which I detected a note of resignation which I do not consider justified. He is indeed putting the case for the road users, but since these people, too, are affected by noise whenever they are sleeping or not actually sitting in their cars, I see no reason for resignation. Can it really be the case that, when the last word on motor car design has been spoken, we must look forward to a future in which people have to live underground, dare not open their windows when sleeping or working, and perhaps have to put plugs in their ears and gas-masks on their faces before they venture on the streets. Well, yes, perhaps I am exaggerating a little, and I hope it will never come to that extent thanks to the engineering skill of the motor car manufacturers who have been rather over-cautious in what they have said today.

Finally, I should like to assure you once more that Switzerland, too, is more than willing to adopt international rules wherever possible. The requirement is, however, that they should provide not merely greater safety, but also better protection for the public from nuisances caused by motor traffic such as noise, exhaust fumes and the like. This aspect must be given much more attention than in the past, and it can be achieved if full use is made in the future of all available technological potential, and if progressive international rules and government regulations provide the necessary spur to the motor manufacturers to push their technology to a yet higher level of development. For today this is all I have to say. I hope to have the opportunity of speaking to you again when we come to discuss the question of exhaust fumes.

REPLY BY MR. VERDIANI

Mr. Chairman, I should like to thank Mr. Müller for speaking at this session. It has given us great pleasure, on this occasion, to be able to comply with the wishes so often expressed by Switzerland to be allowed to take part in the discussions of our experts on the preparation of Community regulations and improvements to them. I can only repeat what Mr. Gundelach said in his address this morning : we in the EEC are always willing to enter into discussions with other countries so as to find, from the start, ideas on approximation that can be applied in the widest possible framework. We hope that Mr. Müller's contribution will not be the last, but will be the first in a dialogue that will be as constructive as possible between non-member countries and the Community.

INTERVENTION OF MR. WELTER

1. In the fight against noise the "energy equivalence level" L_{eq}" has proved to be unsuitable for determining noise pollution.
As Mr. J.P. Thiry, whom I would like to congratulate on his presentation, quite correctly pointed out, man is able to bear noises at a constant pitch and level quite well, e.g., background noise in which the noise of tyres running on a rough but very even road surface is barely discernible.

Nuisances on the other hand are generated by variable noises such as information carriers. Predominant among these are the high spots or peaks which interrupt one's sleep and constitute prolonged signals under all circumstances. Prime examples which one can quote are engines rotating at high speeds and fairly aggressive pitches. The strident noise from small model aircraft engines, the shattering sound of motorcycle or car competitions, the equally irritating sound of roaring motorcars and that of mopeds whose exhausts have been tampered with. Finally, we can include the noise of changing gears, squeaking brakes, squealing tyres, banging doors without of course mentioning horns and radio sets.

2. The design of vehicles is of course at issue : induction and exhaust noise, noise radiated by the engine block and transmission, the pitch of high rotational speeds, squeaking brakes, whirring starters, in short, all noises not deadened by cowlings or shields.

States are generally considered to be poor designers; and they do play a part in design, i.e., by means of their methods of taxing vehicles according to engine capacity they force the designers to design their engines to run at unreasonably high crankshaft speeds. The States are therefore jointly responsible for the noise nuisance inflicted upon those whom they administer. Why do the States not promote the production of acoustically acceptable vehicles by favourable taxation treatment of pleasanter, quiet, large-capacity engines operating at low speeds through automatic transmissions ?

Obviously not everything can be attributed to automobile design; there are other factors which contribute decisively to exaggerating noise !

3. Roads also come under fire : poor surfaces, potholes, cobblestones, rocking or projecting manhole covers are also sources of noise. The narrow "channels" formed by roads passing through built-up areas are enclosed by rows of building unyielding, smooth and acoustically reflecting façades; owing to the lack of green spaces roads actively contribute towards the transmission of noise to every corner of an area.

4. The extent of noise nuisances is primarily due to the lack of user education. Such education has been totally neglected in the past and has not kept pace with the development of the means of generating noise made available to road users.

How can we regain lost ground ? Controlled driving must also include control of noise e.g., one should change up as soon as possible without overworking the engine; there must be no "full throttle, flat out" driving, training for sports involving powered machines on public roads, particularly at night, must stop, nor must there be any racing starts, excessively hard braking or taking corners at the limit of adhesion !

Despite the acoustic differences between categories of vehicles (lorries, buses, trucks, cars, motorcycles, mopeds) the noise due to the use of a vehicle could serve as a criterion for assessing driver behaviour. Noise could act as an indicator of road speed or excessive engine speed or of a lack of driver competence.

A person proving to be incapable of controlling noise does not deserve a driving licence.

5. In order to impose the penalties which are the essential prop of any education it should be sufficient for the law enforcement agencies to judge excessive noise with their own ears. There is no point in asking policemen to operate unfamiliar instruments in order to try to record absolute noise values which are rarely measurable. It is better not to give in to instruments with which the police could make themselves appear ridiculous. It should be sufficient for them to pick out from the "silent mass of good road users" those who simply by comparison stand out as noisemongers.

6. Finally, education in quiet driving should not dispense with the support and understanding of the courts which to date have tended too much to consider noise, however superfluous and avoidable, to be a "gentleman's misdemeanour", and to turn their backs on their faithful servants the police and gendarmerie by nobly acquitting offenders for lack of proof.

COMMENTS OF THE CHAIRMAN MR. JOHNSON

Very briefly it seems to me that we can deduce from the previous discussions some priorities to be respected. Firstly we should know much more that we know about the actual annoyance that is caused by vehicle noise; this means more researches on phisiological effects, it means the assessment of this effect relationship to definition of criterias. Secondly we must define quality objectives, particularly noise quality objectives and I think that it can probably be done on a Community level and on the level of the Member States. A third conclusion which results from the discussions is that there is a general feeling that it is still advisable to take action on that source of noise which is represented by the motor vehicle. Where the participants to the discussion diverge is which category of motor vehicles is the most likely candidate for this action (there is a certain tendency to regard heavy vehicles as the most likely a candidate for action). Within that choice we have to make a sub-choice : what particular parts of the vehicle are the most suitable for particular action (tyres, engine, exhaust systems).

The next main problem and perhaps the more controversial to be solved is the measurement method. There is one school which considers ISO method as a good one and that on its basis we can achieve a reduction of the noise levels. The other school affirms that ISO method is not satisfactory because it penalizes certain vehicles and does not represent the pattern of ordinary circulation. Some of us finally would suppose that the ISO method might be satisfactory for heavy vehicles but that for light vehicles it might be appropriate to go further and define an alternative or supplementary method of measurement. This question has not been clearly solved as result of this question has not been clearly solved as result of this debate but some light has been shed today.

The fourth point is represented by the necessity of controls in order to ensure that noise standards are fixed and actually applied on the existing vehicles. There was a precise proposal in Mr. Thiry's report and I think that the Commission will need to consider it.

Last but not least, we must consider all the other actions which are designed to achieve the quality objectives but which are not actions on the motor vehicle itself.

Finally, the intervention of Mr. Müller reminds us that we work in an international context that Europe is not an island and actions taken here, particularly when they concern products specifications, have international consequences.

FINAL CONCLUSIONS OF MR. THIRY

The debate which followed the report in session 2 means that certain general considerations can now be emphasized and that proposals, as a basis for improving current Community regulations, can then be made.

The present Community rulings, as set out in Directive No 70/157/CEE, are the strictest of all regulations currently in effect in Europe and the rest of the world.

This Community action has helped step up existing improvements to the environment and to motor vehicle design. There has been a drop in noise level of between 6 to 10 dB (A), according to the category of vehicle (passenger and commercial vehicles), over the past few years.

The effects on vehicle design can be gauged by reactions within the car industry : there is an awareness of the problem of noise and manufacturers have set up investigation services and research laboratories to study the sources of noise, their origines and the means of reducing them.

It is reasonable to suppose that traffic will go on increasing in heavily populated zones and that urban areas will also extend; it may therefore be concluded that an increasing number of wayside dwellers will be exposed to traffic noise over the coming years. It is thus vital to take all necessary steps to restrict and, if possible, reduce the nuisance which results. One of the measures must be to bring the noise made by each vehicle as low as to have a negligeable effect on man - in so far as this is technically possible and economically reasonable. Our currently very limited knowledge of the physiological effects of noise must therefore be stepped up.

In a word, a correlation must be established between the noise and the discomfort it produces. The Member States should therefore be encouraged to carry out joint studies with this in view. Until these specific tasks have been accomplished, the only possible course is to regulate permissible levels in an attempt to bring the present level of noise made by vehicles on the road, whatever the means of propulsion envisaged, as near as possible to the ideal target.

The above considerations deal directly with vehicles, which is the object of the Symposium. However, the need for parallel efforts along other lines should also be mentioned; for example bringing into play all the resources of architecture, town planning, sociology etc., organizing campaigns to inform and educate the user and introducing methods of checking vehicles on the public highway.

We will now give some suggestions for improving Community regulations.

At the first stage : actions requiring no prior research must be taken, such as the reduction of the noise levels of various categories of vehicle stage by stage, on the basis of the same principles adopted for methods of measurement.

At the second stage ; changes in the method of measurement must be foreseen for passenger vehicles.

The method laid down in the Directive is based on the result of a single measurement, not always corresponding to the actual traffic conditions for the various types of passenger vehicle. Present studies suggest that it would be fairer to evaluate the degree of noise for this category of vehicle by using two types of test : a first test to reveal the maximum sound level under extreme urban driving conditions (the current method laid down in the Directive could be used if minor modifications were made) and the second to assess the degree of nuisance produced by the vehicle in normal urban traffic conditions (e.g. a complete run over a typical route).

The results of these two tests would be weighted so as to provide a better idea of the accoustical properties of the vehicle and give values that most closely reflect the noise pollution produced during urban driving.

For commercial vehicles

The method laid down by the Directive reflects common driving conditions fairly well. It can thus be retained if one or two small changes are made.

Finally, it has been suggested that a new method of monitoring, whereby police or supervisors could carry out road checks on all types of vehicle, be introduced in addition to the reception method.

Such a method could be based on a comparison of the noise level recorded near the o rifice of the exhaust pipe during the type approval tests (reference level) with the level recorded on the road.

THIRD SESSION

PROTECTION OF VEHICLE OCCUPANTS

PROTECTION OF VEHICLE OCCUPANTS
BIOMECHANICAL ASPECTS, PERFORMANCE
OF VARIOUS RESTRAINT SYSTEMS

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REPORT OF Mr M. MACKAY

INTRODUCTION

The practicality of packaging the car occupant, so that in a collision only tolerable forces are transmitted to him, has only become generally accepted within the last decade. Up to that time the traditional solutions for car accidents were thought to rest on the modification of road user behaviour and improved environmental design.

The United States Federal Highway Safety Act of 1967 challenged that traditional thinking of the 1960s, and was instrumental in introducing the first comprehensive occupant crash protection standards. Thus we are examining a relatively new subject; the last decade has seen a tremendous surge of interest in occupant protection. A great deal has already been achieved, but its promise is still enormous.

Within the nine countries of the European Community, representing a population of 242 million, there are annually some 58,000 fatalities and 1.6 million other casualties. Of the fatalities, 28,500 are vehicle occupants, and almost one million of the casualties are within vehicles (1). Just for the sake of putting the question of occupant protection into perspective with the other subjects being discussed at this symposium, one might suggest that if the protection offered by present day restraint technology was available to all vehicle occupant fatalities, then within the Community the number of lives saved might be approximately 17,000 this year. Because the vehicle population replaces itself every ten years or so, the benefits of improved crash performance can be obtained relatively quickly, in comparison to behavioural and environmental solutions, which may well take a generation or more to implement. We are therefore discussing today the possible solutions to a major public health problem; an endemic traumatic disease which can in large part be controlled through the modification of the collision phase, by good packaging of car occupants.

The parallel with other public health problems is appropriate because accidents of all types are the fourth leading cause of death within the E.E.C. The administrative, legislative, research and development effort which is put into the testing of a new drug for example, before it is released for general use, can be contrasted with the absence of detailed evaluation and testing of many national and international requirements which influence car occupant injuries.

Perhaps this symposium marks the end of the first generation of vehicle safety regulations. Up to now the process of legislation has been a linear one. A problem has been identified, a solution proposed, a test procedure specified, the necessary legislation enacted, and then the problem is supposed to go away. What we are now learning, from the application of more scientific principles, is that it is very necessary to estimate the consequences of specific legislation beforehand, and monitor its effectiveness afterwards. No-one can hope to produce the exactly optimal solution first time. Further, we have now realised the interdependence of one set of conditions on another. What may seem to be the ultimate in occupant protection for one kind of accident, turns out to have unfortunate effects in another impact configuration.

Legislation for occupant protection started off as a set of isolated design rules. Most of the obviously beneficial rules have now been adopted, or will be by next year, in E.E.C. Directives. What is required now is a plan for the next ten years of legislative action. With this symposium there is now an opportunity to apply the most recent research findings to existing legislation, pin-point areas where further research is needed before legislation can be enacted, translate the present set of design rules into more scientific performance standards, and carefully monitor new legislation as it is introduced, so that optimal performance in the real world of accidents can be achieved.

OCCUPANT PROTECTION CRITERIA

In essence the aim of good occupant protection is to specify "acceptable" levels for forces and their time durations. By "acceptable", various meanings are implied, such as:

1) Voluntary tolerance,
2) Minor injury thresholds,
3) Minor injury only,
4) Severe but reversible injury,

or 5) Fatal injury to a percentage of occupants at risk.

The chosen type of tolerance level will depend on the segment of the body being considered. In practical terms it is necessary to accept some degree of injury. This has been well illustrated by Patrick (2) who has examined the required stopping distances for two given approach speeds, assuming an idealised constant deceleration. Table 1 gives stopping distances for various tolerance levels at 48k.p.h. (30m.p.h.) and 80k.p.h. (50m.p.h.)

TABLE 1 - Stopping Distances for Various Assumed Tolerance Levels.

Tolerance	Initial Velocity		Stopping Distance	
Level (gs)	k.p.h.	m.p.h.	cms	inches
20g	48	30	46	18
	80	50	127	50
40g	48	30	23	9
	80	50	64	25
60g	48	30	15	6
	80	50	42	17
80g	48	30	11	5
	80	50	32	13

This table shows that if a 20g level is specified, then a 48k.p.h. impact requires a stopping distance of 46 cms. An 80k.p.h. impact requires 127 cms, which clearly becomes an impractical proposition, particularly because in practice a constant deceleration cannot be achieved, and thus the stopping distance would be at least 50% greater. That would mean that a 20g tolerance level for an 80k.p.h. impact would require an actual stopping distance of almost two metres. That would be impossible if cars are to remain anything like their present day size and weight.

20g is possibly equivalent to the voluntary tolerance level for a distributed chest impact. 60g may well be equivalent to the minor injury level for the bulk of the population at risk. This value of 60g for a constant deceleration gives stopping distances of 15 cms at 48 k.p.h. and 42 cms at 80 k.p.h. It would therefore appear possible to design realistically for 60gs, but not for 20 gs for the chest.

At the present stage of vehicle development, it seems appropriate to design the major occupant protection systems primarily so that under the most severe design conditions they cause serious but reversible injuries to the occupants. It would seem appropriate to accept this condition, which of course will result in savings in fatalities, even though under the more frequent minor impact conditions, the protection systems may well generate some moderate or minor levels of trauma. In essence, only so much useful stopping distance is available before bottoming out occurs; that distance should be used firstly for protecting against fatal injury in high energy situations.

In developing a rational policy for occupant protection standards therefore two sorts of data are needed. Firstly one requires to know the input conditions; the frequency and severity of different collision circumstances for which protection is to be offered. Secondly it is necessary to know the tolerance levels for the population at risk, the appropriate injury criteria, in engineering terms, which can be applied to the occupants.

Before reviewing these two requirements it is important to appreciate the method of application of occupant protection legislation. This can be done either through design rules or by performance standards.

DESIGN RULES AND PERFORMANCE STANDARDS - COMPARISONS WITH OTHER COUNTRIES

Historically vehicle safety regulations began with design rules. These rules specified that certain components should have certain strength requirements or particular geometrical properties. Most of the current safety requirements presently in force are essentially design rules, which specify for example, the amount of rearward movement of the steering wheel relative to the passenger compartment in a standard crash, or the braking strength of seat belt webbing.

Unfortunately, such a procedure does not result in optimal crash performance. Design rules might be acceptable if all vehicles had the same mass, the same geometry and the same dynamic stiffness characteristics.

In reality however, the market place requires a range of vehicles from 500 kgm minicars to 3,000 kgm large cars, to the even higher masses of the commercial vehicle range, with corresponding variations in geometry and dynamic stiffness. In consequence the loads applied to an occupant can be limited for a given input crash condition by an infinite number of combinations of the component parts of the protection system. The same ride-down distance can be achieved with a very stiff seat belt system, operating in a very small passenger compartment, attached to a soft front-ended section which gives a large crush distance. Alternatively, the same peak loading of the occupant can be achieved by putting him in a soft seat belt system with load limiting devices, inside a large passenger compartment attached to a very rigid front structure. A design rule which standardises the properties of the seat belt isolation, and ignores the realities of these two situations, obviously results in conditions in the real world which may be far from optimal.

Hence we are now entering a transition period; passing from the design rule era towards performance standards.

The ultimate in a performance standard is embodied in the proposed American FMVSS 208 regulation. This requirement specifies the forces, decelerations and time histories on a test device, a dummy, which is meant to exhibit all the relevant dynamic response characteristics of the human frame under crash loading conditions. Such an approach eliminates all reference to the vehicle structure as such, and allows the manufacturer the choice of combination of restraint characteristic, vehicle geometry and vehicle stiffness appropriate to his particular product; therefore this allows him to meet the safety requirements and at the same time satisfy the other functions of the vehicle most efficiently.

The consequences of FMVSS 208 are far reaching. If the test dummy really does reflect human response, and if tolerance levels on the dummy can be specified for all loading conditions in all three major planes and combinations of loading conditions in these planes, then all that future legislation has to do is specify the input crash conditions under which those tolerance levels must not be exceeded. Such a performance standard eliminates all reference to specific contacts by the dummy on particular components of the car. Therefore, logically all separate legislative specification of contacts with the instrument panel, windscreen, steering wheel, seat belts and seat contacts and their loadings becomes obsolete. Such a performance standard should therefore lead to the removal of all regulations which specify the various sub-system contacts and loadings.

Unfortunately, the concept of legislation akin to FMVSS 208 presupposes a test device which can exhibit correct human responses in all directions and combinations of directions of loading. Further, FMVSS 208 presupposes a knowledge of the correct tolerance levels for the populations at risk for those various loading conditions. At this point in time, it seems premature for such a large legislative step to be taken, in the light of the present state of knowledge on human tolerances under crash conditions, and dummy fidelity in reproducing human response; but this is very much a matter for debate, as is currently taking place in several places, including the courts of the United States.

One might propose as a suitable strategy for legislation in Europe, an interim phase. At present we have already enacted and have in operation, a set of design rules. The next generation of regulations should be seen as a transition, a change from the present requirements, going towards performance standards, but still taking account of specific contacts which occupants have with the several sub-systems of the car. In other words, existing standards should evolve over the next ten years to take into account the most recent advances in biomechanical knowledge, but that knowledge must be seen as a prerequisite, and not anticipated with educated guesses. The ultimate result may well be a total performance standard along the lines of FMVSS 208, with the elimination of all requirements for sub-system specification. However, in my view, it would be foolhardy for us in Europe to attempt to go immediately for a total performance standard at this time, with the elimination of all the regulations which specify the various sub-systems. We should see the next ten years as the second generation, evolutionary period, leading to the final phase of a total performance standard when the state of scientific and biomechanical knowledge can justify it, by specifying accurately both the input conditions and the appropriate, allowable human responses.

Therefore, if this approach is accepted, it is necessary to review each existing regulation to decide how it can best be improved in the light of evolving biomechanical knowledge and accident frequency data, with the ultimate aim of integrating each requirement into some total performance package.

Lead Times - It is perhaps instructive to consider the timing of legislative action. Up to the present, existing regulations have, broadly speaking, reflected the current levels of design. The present regulations have had very early dates applied to them, and in a sense therefore the only influence which the legislation has had is to regularise already existing designs.

If in the future, regulations are to reflect the latest scientific knowledge, it is inevitable that existing designs will be shown to be less than optimal. Therefore new regulations, if they are to both reflect the most up to date knowledge and at the same time be acceptable to the manufacturing industry, must allow longer lead times before they become applied to new vehicles. Only then is it possible for legislation to reflect new knowledge, and also for the manufacturer to avoid being put into a short-term defensive position because of his committment to specific models which will run for several years. For this problem the Australian policy is of interest (3). There, legislation attempts to reflect the best that current scientific knowledge can offer, but allows long lead times so that industry can respond constructively. For fundamental elements of the motor vehicle, which may involve the specification of the basic collapsing elements of the main structure, such lead times for future legislation may well be of the order of five to ten years. This problem is likely to be even more acute in the future, when the other constraints on vehicle design, energy and material conservation considerations, may well lead to longer model runs and longer individual vehicle life than at present.

COST/EFFECTIVE AND COST/BENEFIT CONSIDERATIONS

It is fashionable at the present time, to apply these terms to decisions in the vehicle safety field. It is important therefore to be clear as to the differences between cost/effective analyses and cost/benefit equations, and their underlying assumptions.

A cost/effective analysis presupposes a certain target; for example a reduction in fatalities in frontal impacts of 20%. A cost effective analysis then examines the alternative solutions which are available to achieve that target, and shows how that target can be achieved in the cheapest manner. In other words, it is an internal comparison procedure, aimed at producing an optimum solution, and it does not involve assumptions about the money values of life and limb.

In contrast, cost/benefit equations balance on the one hand the costs of introducing a particular feature into cars, head restraints for example or seat belts for rear seat occupants, with the savings, in money terms, of the fatalities and injuries which will be prevented. This second procedure is much more debatable, and the technical and legislative communities present a range of divergent views as to the appropriate use of these techniques in safety matters (4).

There seems little doubt that internal cost/effective comparisons are useful, indeed essential, if a rational list of priorities for improved occupant protection is to be achieved. What is much more debatable is the use of cost/benefit equations to demonstrate that certain improvements should not be introduced because their costs cannot be justified in terms of the money values currently assigned to fatal and non-fatal injuries. Such a procedure needs agreement as to what those money values are, and at present there is great divergence of views. O'Niell (5) has pointed out the difficulties of implementing a policy based on external cost/benefit considerations. It is also interesting that for example a retrospective study of the fitting of seat belts to front seats in the United Kingdom in 1967, showed that their installation was not justified in cost/benefit terms (6).

Nevertheless, some nations have made overt decisions not to implement certain regulations which are applied elsewhere, strictly on the grounds that the expense does not justify the injury savings in money terms. The fitting of rear seat belts is an example. In the future it is likely that these decisions will be questioned increasingly, because in other areas of public health, expenditures of several orders of magnitude greater than those values used in traffic safety are thought to be appropriate for savings in life and limb, and the general public is now becoming more aware of this fact.

The problem is particularly acute when non-fatal injuries, which do not cause loss of function, are being considered. The windscreen question is one such area, because as a rule toughened glass merely lacerates the face, causing disfiguring injuries but little else, unless the eyes are involved. Thus the additional cost of laminated glass which reduces the frequency of lacerations, has to be balanced against the value of the injuries saved. The equation can go either way depending on the assumptions made.

A preferable procedure therefore in establishing priorities for occupant protection standards, would appear to be to establish targets in the future for the numbers of fatalities and injuries which might reasonably be prevented, and then, using internal cost/effective comparisons, establish the cheapest means of achieving those targets.

INPUT CONDITIONS

As mentioned earlier, fundamental to the development of effective occupant protection standards, is a knowledge of the frequency and severity of crash conditions. Only with this knowledge can one estimate the savings which can be obtained by offering protection up to certain specified levels in certain crash types, and the potential gains which would be achieved by increasing those levels. This is no simple question, because increasing the available protection level in one situation may well have disbenefits in another area. An example of this problem is the suggestion that frontal impact protection levels should be raised, in that the same injury criteria must be met in an 80 k.p.h. barrier collision as are now met in a 48 k.p.h. one. A consequence of such a proposal would be to make the conditions of a car-to-car, head-to-side impact more unfavourable for the occupants within the struck car. Only frequency and severity data from field accident investigations can logically provide the answers to these conflicts; and a tentative analysis of European accident data suggests that an increase to 80 k.p.h. for the frontal barrier condition would not be appropriate here, irrespective of the North American scene (7).

The whole question of specifying the appropriate types of tests and their severities; whether to use symmetrical, angled, offset or deformable barriers for frontal impacts; pendulums, mobile barriers or standardised cars for side impacts, and the impact speed levels to be used in each case; all need to be based on carefully structured field accident research, where representative sampling is carried out and the conclusions are appropriate for the European environment. I will not discuss further these general considerations of the difficulties of specifying the appropriate tests, i.e. the impact conditions for occupant protection, because these have been reviewed by Mr. Taylor at this symposium. I should merely like it to be noted that a comprehensive, European field accident investigation programme is very necessary if these frequency questions are to be answered satisfactorily.

NEW DEMANDS TO BE MET - TOLERANCE LEVELS AND INJURY CRITERIA

Given the definition of the appropriate conditions to be imposed on the vehicle, the next problem is to define the tolerable levels of the loadings on the populations at risk, and the specification of injury criteria in terms of the response of a test dummy.

In general the tolerance of the human body to impact depends on:

1) The shape and size of the striking structure,
2) The direction of the applied acceleration,
3) The magnitude of the applied acceleration,
4) The duration of the applied acceleration, and
5) The rate of onset of the applied acceleration.

Hence to specify injury criteria it may well be necessary to define all these conditions separately for each situation.

Also there are certain population considerations. Tolerance to impact data come largely from three sources; accident reconstructions, volunteer tests and cadaver studies.

If the data are at the volunteer level, then mostly the work will have been performed on young, healthy, male, military volunteers. If the data came from cadaver studies, then they represent a predominantly old and infirm population. The translation of results from such studies into injury criteria for the general car occupant population still represents a considerable problem, because little is known about the variation of tolerance levels across the population. Car occupants range from the healthy young male to the old infirm female, passengers include the youngest of children.

Certain basic characteristics are relevant to illustrate this problem. Eighty three per cent of drivers are male, 70% of front seat passengers are female, perhaps 40% of rear seat occupants are children. Such factors severely modify the distribution of tolerance levels for the populations at risk in the various seating positions in vehicles. To illustrate the importance of this point, one can reasonably suggest that any given injury tolerance level is likely to vary by a factor of at least two for 80% of the population at risk.

There are a number of documents which review in detail the state of knowledge of human tolerance to impacts (1, 8, 9, 10), and it would be inappropriate to catalogue here all the findings and references. I therefore propose merely to comment on the most important questions for each body region and type of loading.

The Head - Head injury is still the most frequent of serious injuries to car occupants in Europe (11). Head injuries can be grouped as soft tissue damage (to the scalp and face), boney fracture, intracranial haemorrhage and brain injury. For skull fracture and brain injury, a proposed criterion is available which may be applicable for flat, short duration contacts in the anterior to posterior direction. This is the Head Injury Criterion (the H.I.C.) a modification of the Gadd Severity Index, as measured in the Hybrid II dummy. In spite of the absence of any data, it has also been proposed that the H.I.C. can be used in lateral impacts, and this is perhaps not unreasonable in view of the great biological variation of the population at risk around the fixed limit of 1,000. It is worth noting that the original Gadd Severity Index involved specifying a limit which was thought to be close to the survival level for 50% of the people exposed, analogous to the rating of a drug dosage as being lethal to 50% of the population (LD50) (12). This concept in itself raises the question of the appropriate level of risk to which any given proportion of the population should be exposed. More fundamentally it also appears that separate tolerance levels for the brain to linear and rotational accelerations are desirable. However because the nature of injury to the brain is not yet thoroughly understood, it is not yet possible to specify an appropriate agreed tolerance level for contact loadings.

Recent tests on volunteers using airbag restraints (13) and accident investigation studies (14) suggest that if no specific blow to the head occurs, then H.I.C. levels greater than 1000 can be exceeded without head injury occurring. Therefore, if no contact occurs, no injury criterion needs to be specified.

Face Contacts with soft tissue injuries or facial bone fractures are frequent. No satisfactory tolerance levels or dummy analogues are available for simulating the soft tissue condition. For specific contacts with glass, an injury scaling procedure has been developed in the Triplex

Laceration Index (15), but there is a need for a more generalised means of assessing the risk of facial damage. This is particularly needed because a driver restrained with a seat belt, usually has a face contact with the steering wheel. In Gadd's original paper he suggests that the Severity Index can be used for a tolerance level against facial bone fracture, if the loading area approximates to 19 sq. cms. (12). He suggests that a S.I. value of 500 should be specified for such contacts.

More recently Schneider and Nahum (16) recommended 890N applied over 6.54 sq. cms. as an appropriate tolerance level for an impact with the zygoma. Current dummy technology cannot measure such an impact and a specific sub-system test would be needed.

The Neck appears to be so vulnerable to direct loading that a practical policy of applying no load at all seems most realistic. With regard to angulation of the neck, accident data suggests that hyperflection is of no consequence as a source of injury. Likewise, there does not appear to be any evidence that injuries occur because of hyperextension in lateral flexure. If a specification is required for that mode, a figure of 60° has been suggested (17). For hyperextension posteriorly, the classical whip-lash condition, a limit value of 80° appears to be generally accepted, although Mertz and Patrick demonstrate that at that amount of extension, the torque and moment across the neck rise rapidly, so a conservative approach may be appropriate (18). As with the head the rate of loading is likely to be important, but further research is necessary.

The Thorax, after the head, ranks as the most frequent body region receiving severe injury. The specification of the correct parameter and its level for the chest, is probably the most important single biomechanical question at the present time because perforce, all occupant protection systems, be they seat belts, airbags, steering wheels or instrument panels, apply loads to the chest directly. If no head contact occurs, the critical body segment is the chest. It appears that for most loading conditions, rib fracture is the primary injury, although in the case of airbags, damage to the heart or the great vessels may occur first. There is no clear concensus as to what parameter, measured on a dummy, most accurately reflects human response; whether it is total load, load per unit area, deflection or some index derived from the time/deceleration curve taken from a tri-axial accelerometer inside the chest of the dummy.

Sixty g for 3 milliseconds for frontal loading has been thought reasonable for some time, but recent cadaver work has raised doubts about such a limit. A 60 mm deflection limit is proposed (19) from cadaver work, and much development time is being given to producing a dummy with the appropriate response. At this time there is no general agreement.

Wall and Lowne (20) have pointed to a significant rate of clavicle fracture for belt wearers, and suggest limit values for belt loads at a specified belt/torso angle. Also those authors suggest limits for side impacts on the rib cage, clavicle and pelvis, together with a specialised dummy for measuring those loads. Such a procedure seems appropriate for the future, but further validation of the dummy with human response, and testing of the limit values is needed, before those proposals are demonstrated to be superior to the deceleration-oriented view of American legislators.

The Abdomen, like the neck, is vulnerable to direct load. Current opinion suggests that the only realistic specification is to define where the abdomen is on a test dummy, and permit no loading at all. Whilst perhaps satisfactory for seat belts, as a performance standard such a requirement may be inappropriate where very uniform loading takes place, as with airbags for example.

The knee/femur/pelvis combination is a segment of the body where specialist workers are almost agreed as to the appropriate tolerance level. Here only two values are suggested and they vary by only a factor or two. Present American regulations specify a maximum permissible femur load of 7.65 KN (1700 lbs.), whilst work by Lister and Wall (21) suggests that a lower limit of 4KN (900 lbs.) would be more appropriate.

In summary therefore this brief review of human tolerance data shows, for the head, chest and femur, the three main body regions which are injured most frequently and which require tolerance levels to be specified, that at this time there is no clear agreement on any of the values.

However, a considerable amount of research effort is being concentrated on accident reconstruction and cadaver studies at present, and it is reasonable to assume that the chest and the femur tolerance levels will be agreed soon. The head is more complex, and although in the United States H.I.C. values may well be used in legislation within the next few years, it is likely that both the level and the contact conditions to which the H.I.C. is applied, will require modification as new research findings are made.

It is impossible to divorce any discussion of tolerance levels from the test devices which will be used to establish compliance with those levels. An ultimate performance standard on the lines of FMVSS 208 requires a dummy, with appropriate human response characteristics, for all the impact forces and directions considered to be important. In addition the dummy must not fail, as the human does, during overload, but must remain intact, giving repeatable results. Presentday dummies cannot satisfy all the requirements of a comprehensive performance standard, although the next five years may produce acceptable devices.

In the interim, and also because of the unrestrained occupant problem discussed below, it is appropriate to consider sub-system testing, using head-, torso- or knee-forms, and to specify load or deceleration/time history requirements for each specific impact. Such an approach would allow the transition to be made from existing design rules towards the goal of performance-oriented legislation.

The restrained and the unrestrained occupant demand different characteristics of the vehicle, and therefore it is important to establish the priorities between the two conditons. Fundamental to this problem is the question of active and passive restraints, and if active restraints are used, what usage rates to expect over the next ten years. Within the nine member countries there are great differences in national policies on seat belt use.

Following the initiative of Australia and New Zealand, France demonstrated great leadership by enacting compulsory seat belt use legislation in rural areas in 1973. That requirement is now being extended into urban areas. Holland, Belgium and Denmark have now introduced compulsory belt use this year, whilst outside the Community, Sweden and Norway have enacted similar legislation. Germany is due to introduce compulsory wearing on 1st January 1976; and to require the fitting of belts to cars retrospective to production extending back to 1972.

It is possible that Britain may within the next two years enact legislation for compulsory belt use. If that occurs, then the benefits achieved are likely to be especially good in the short term, because that country has required the fitting of belts (albeit in front seats only) on models from 1965 onwards, and thus some 95% of the total car population are equipped. It is very doubtful however, that Ireland and Italy will pass compulsory belt usage legislation.

Even with compulsory belt use legislation, data from France, Australia, New Zealand and Sweden where such laws have been in effect for some time and surveys of usage rates conducted, suggest that actual usage rates range from 60% to 90%, depending on the environment and the time of day. There is a suggestion in the data that belt use drops at night; and it is a reasonable hypothesis to estimate that even with a compulsory belt use law, the usage rate for people involved in accidents is likely to be no higher than 80%, with a lower rate for higher speed nighttime collisions.

Within the Community therefore, in the transition period of the next ten years, two factors are present which suggest that belt usage will remain low enough for the unrestrained occupants still to be of some consequence. Requirements for contacts by unrestrained occupants with steering assemblies, windscreens, seat backs and instrument panels still need consideration in this interim period.

A corollary of the above situation is that even in countries with compulsory belt usage, but particularly where a legal sanction is not likely to be introduced, there is a compelling need to make seat belt systems as acceptable as possible in normal daily use. Fortunately the demands of comfort and good ergonomics of normal use do not run counter to good crash performance characteristics, but if there are conflicts, then acceptability is perhaps more important than the ultimate in protection. There are still difficulties however, in developing performance standards for acceptability, comfort and convenience of operation.

The following sections of this paper will now review briefly the main occupant protection systems which are subject to legislation, with particular reference to how their technology may evolve in the future.

OCCUPANT RESTRAINTS

Community Actions - Seat belts are by far the most important factor in planning occupant protection for the future. They have been used extensively for over ten years; their actual performance in the real world has been examined thoroughly, and their limitations are well understood (22). That cannot be said yet for any of the other alternative systems which are proposed. In essence, 100% use of seat belts saves 50% of car occupant fatalities. I refer of course to the lap/diagonal type, almost universally adopted in Europe.

Most members of the Community have had national regulations on seat belts and anchorages for a number of years, and the E.C.E. recommendations attempted to produce some international conformity in its Regulations 14 on anchorages and 16 on seat belts.

In the last four years technical knowledge has evolved, with the result that the E.C.E. Regulations 14 and 16 have been shown to be unsatisfactory in a number of respects. The E.E.C., taking the E.C.E. recommendations as a basis, have developed proposals for Directives on anchorage points and seat belts. These have been agreed at the technical level and await adoption by the Council. These two draft Directives represent a very significant contribution to vehicle safety by the Community, because of the great importance of occupant restraints in reducing the frequency of traffic injury.

The present limitations on belt performance can be summarised as:

1) Loss of compartment space due to crush of the vehicle structure,
2) Belt or hardware breakage due to detailed design deficiencies,
3) Overload due to rear loading usually from unrestrained rear seat occupants,
4) Excessive forward movement due to slack and less than optimum performance from some automatic locking retractor systems.

Evolution of Restraint Technology - Bearing in mind the acceptability question, it would seem appropriate that the main effort in evolving the existing Directives on belts and anchorage points, should be concentrated on improving the comfort and acceptance of belts. The obvious immediate developments are:

1) An adjustable upper mounting point and/or belt guides on the seat back - no one single point can accommodate adequately enough of the population using the systems,
2) Lower mounting points moving with the seat,
3) One-handed operation for the whole process of putting a belt on and off.

These improvements could be brought about through the medium of performance standards which would specify acceptable geometrical positions for the applied loads on dummies. This does require however, further definition of performance for comfort, fit and convenience factors.

Regarding crash performance, there is a need for an appropriate test condition to be specified. As mentioned earlier there are an infinite number of combinations of interior geometry, belt elongation and frontal deformation, and therefore a performance standard should be evolved in which each model's crush characteristics are incorporated in the dynamic testing of that model's restraint system. Further work is also needed to define the severity and type of simulated impact as has been discussed in Session 1 of this symposium. Undoubtedly the symmetrical barrier test represents only a minority of frontal impacts, but likewise no other single test can claim to be markedly more representative.

A future performance standard should allow both belts and other alternative systems which meet the specified requirements. A reasonable starting point would be to have specified chest, femur and abdomen injury criteria for a frontal test of the restraint system in the passenger compartment with its seat, on a sled, tuned for the correct pulse of that model in the appropriately chosen impact. Such a test procedure would allow more sophisticated belts to develop, particularly pre-loading devices which hold special promise for improving belt efficiency.

The cost/effectiveness of belts over other systems, if wear rates exceeding 50% can be achieved is compelling (23). This is a further argument for having a very high standard for acceptability and comfort. Three point belts for rear seat occupants, although presently considered not to be worthwhile by some people, are likely to become more important. The obvious inequality of protection with only front seat belts fitted is not lost on the average member of the public. Also the effectiveness of front seat belts themselves is compromised if the rear seat occupants are unrestrained.

A comparison of different strategies for occupant restraint systems in cost effective terms is discussed at some length in (1, 23, 27). For example (27), some predictions for the likely performance of a number of options in restraint system development are given. These predictions first examine the likely performance regardless of cost. The factors considered are the effectiveness of the various systems in the range of different crash configurations and severities which exist in reality, the reliability of the systems, and their expected usage rates (if active systems); all applied to the appropriate frequency of occupancy for the several sitting positions in the car. That analysis produced the following ranking order of performance for front seat occupants:

Passive 3 point belts,
Mandatory use of active 3 point belts,
Airbags,
Active inertial reel 3 point belts with a warning system,
Active inertial reel 3 point belts with ignition interlock,
Active inertial reel 3 point belts,
Active static 3 point belts with pre-loading,
Active static 3 point belts with load limiters,
Active static 3 point belts.

The same study then went on the consider how overall strategies would vary if the costs of the systems were balanced against the savings in money terms of the trauma. That analysis is shown in Table 2, and illustrates how the ranking order of the systems proposed changes when costs are taken into account. That analysis is summarised below, and shows how the ranking order changes greatly:

		Cost/Benefit Ratio
Cost Effective	(Mandatory use of active 3 point belts	8.3 : 1
	(Inertial reel 3 point and warning system	3.4 : 1
	(Active 3 point belts	3.0 : 1
	(Inertial reel 3 point & ignition interlock	2.7 : 1
	(Active 3 point belts & load limiters	2.3 : 1
	(Passive 3 point belts	2.3 : 1
	(Inertial reel 3 point belts	2.0 : 1
Not Cost Effective	(Airbags	0.7 : 1
	(Active 3 point belts and preloading	0.6 : 1

There are obviously gross assumptions made in conducting such predictive analyses, particularly in estimating system costs, usage rates and effectiveness factors of untried systems. However, it perhaps illustrated the importance of at least examining carefully the consequences of the various strategies for occupant restraint systems which have been proposed.

One simple fact illustrates some of the difficulties of such analyses when they are conducted across national boundaries. The following table shows the number of car occupant fatalities per million cars for five countries, for 1971:

Country	Deaths per Million Cars	Ratio to Britain
France	605	2.3 : 1
Italy	499	1.9 : 1
West Germany	677	2.6 : 1
U.S.A.	435	1.7 : 1
Britain	261	1 : 1

These ratios show that the exposure to risk of fatal injury for car occupants per registered car vary by factors up to 2.6 within the Community. Therefore the data given in Table 1, which is a projection from the U.K. situation, would be severely modified by these basic differences in exposure to risk which prevail elsewhere in the Community. That study illustrates the great amounts of uncertainty in such analyses, so that although useful in comparative terms, absolute cut-off levels based on Cost/Effective Ratios can be misleading.

Child Restraints - The adult world is at present an area where performance standards are difficult to specify, but there are a number of additional problems which arise in attempting to define the appropriate parameters for child restraint systems. This is an important area because the driving public appear to be not only aware of the risks, but willing to take considerably more trouble, and spend more on protecting their offspring, than they will spend on protecting themselves.

A number of national standards exist, and actual experience with systems which meet those standards suggests that in the real world of accidents the protection offered is very good. However, because of the particular consequences of injuries to children, there is a very understandable tendency to try and evolve extremely high performance requirements which cannot be justified on present biomechanical knowledge. The practical consequences of such requirements may well be to discourage manufacturers from entering that market, to reduce the size of the market by requiring very expensive child restraint systems, and ultimately therefore reduce the overall protection which is offered to the population at risk. That is based on the assumption that the fitting of child restraint systems would be an optional fitting. This problem perhaps illustrates the difficulties presented to the Community in developing legislation which is both technically advanced but also publically acceptable. It suggests that there are potential dangers in going further than present biomechanical knowledge can justify.

STEERING ASSEMBLY REQUIREMENTS

The E.E.C. has adopted the same regulations as were developed in the United States on the crash performance of steering wheels and columns. Recent research in both Europe (24) and America (25) indicate that the requirements are not in practice producing optimal conditions. With greater use of seat belts, steering wheel crash performance needs change, because the driver who is restrained by a belt system, no longer has a chest contact, but instead has a head or face impact with the wheel. These two conditions are not completely incompatible, and because of the unsatisfactory nature of the present regulations, there is a good opportunity of evolving a performance standard more in line with current knowledge. This will involve an unrestrained impact test, perhaps an improvement on the existing Black Tufy procedure, where the approach angle is varied, and also a minimum effective contact area is specified. For the restrained configuration, the wheel and column should be present in the restraint system dynamic test, and suitably instrumented so that a maximum permissible face loading is specified if such a contact occurs. Obviously more detailed development is needed before such a legislative procedure can be enacted.

DOOR LOCKS AND SIDE STRENGTH

With the greater use of restraint systems, the side impact configuration will become a more important accident type in the future. Here again there is a need to develop a total performance test for the door, door frame, hinges and door locks as a unit. Recent accident studies suggest that to specify the latch in isolation, results in door openings still occurring, due to failures of other parts in the total door system.

In addition, when dummy technology and injury studies are sufficiently well developed that injury criteria can be specified for lateral loadings, a side impact test procedure will be necessary. This is complex because arriving at optimal compatability for the mass distributions of the car population is as yet an unsolved problem. North America and Europe show significantly different populations at present, but in the future, these differences may diminish as the small car becomes more attractive to the consumer.

HEAD RESTRAINTS AND SEATS

Head restraints are not used yet in sufficient frequency to allow any statistical field studies in Europe, but in the United States their performance has been evaluated. In America, adjustable restraints are fitted almost universally on domestic models of cars. Both accident and survey data show that between 73% and 90% of head restraints are not adjusted correctly, nearly all being in the fully-down position. Reductions in the frequency of cervical spine injuries were found in the accident studies, but on the numbers available the results were not statistically significant. In the case of insurance claims, significant reductions in claims (up to 30%) were detected in comparing cars equipped with head restraints and cars not so equipped.

Based on these reports there appears to be a case for non-adjustable head restraints. It is worth noting that a rear seat occupant is present in some 25% of impacts, and a front seat passenger in approximately 50%. Of impacts on cars at least 55% are frontal, whereas only 8% are to the rear (22). Therefore, it appears that head restraints in reality will be struck more frequently by the faces of rear seat occupants in frontal impacts than they will be used to prevent whiplash in front seat occupants when struck from behind. The design of head restraints in the future should take this into account.

For a head restraint to be effective, the seat must withstand the forces of collisions. It is also important for the seat to remain in place under collision forces applied in a variety of directions. Seat mounting failures in fact are frequent, and they may increase the loads applied to the occupants, compromise seat belt geometry and allow rear seat occupants to apply loads to those in the front seats. Field studies suggest that the existing 20g standard for seats does not prevent seat mounting failures in reality even at equivalent barrier speeds below 15 m.p.h. (6.7 m/s). Any future performance standards related to both front and rear seat positions should recognise these points and incorporate them in future test procedures. Like other parts of the vehicle interior, the seats constitute part of the total occupant restraint package and should be viewed in that light.

INSTRUMENT PANELS AND THE INTERIOR

In the long term the use of restraints may well rise to a high level, and the restraint systems themselves be of such a form that interior contacts are essentially eliminated. In the interim transition period from the present however, it seems likely that interior contacts with instrument panels, roof rails, cant rails, A and B pillars and other parts will occur.

Whole dummy testing cannot adequately examine such a range of situations, and therefore it is appropriate to evolve a quasi-performance standard, using a head-form impact to specify loading limits. The test conditions will have to be specified for the different impact directions, based on accident data.

WINDSCREENS

Like almost all other parts of the car, the desirable windscreen characteristics are influenced by the use and effectiveness of occupant restraints. However, in thinking of an integrated system for decelerating the occupant, measured by a performance standard, one should include the windscreen as a component part of the total restraint system. Laminated glass provides a very tolerable head deceleration, and with a performance standard it becomes perfectly reasonable for part of the deceleration of the head to occur on the glass. The specification of a head injury criterion in the side impact mode, may well result in an energy absorbing side window, whilst if an airbag restraint is chosen by a manufacturer as his means of satisfying the occupant protection standard, then a laminated windscreen becomes necessary.

The technical superiority of laminated windscreens appears to be generally accepted in view of both extensive laboratory work and field accident studies, but cost/benefit equations can produce answers in favour of one or other type of glass, depending on the assumptions made for the costs of facial lacerations and the projected levels of seat belt use in the future. It is likely that soon special windscreens with a crash performance significantly superior to conventional H.P.R. laminated glass will be used more extensively, and therefore from the legislative standpoint the windscreens situation will require frequent review, particularly as the windscreen, with increasing performance standards, will perforce become a component part of the overall restraint system.

FIRE, SUBMERSION AND OTHER SPECIAL SITUATIONS

There are a number of low frequency occurrences which cause death and injury, such as fire and submersion. From the legislative point of view, each situation must be examined on its individual merits, because, although such events may occur with relatively low frequency (for example less than

0.3% of car occupant fatality cases involve fire), it may well be that significant improvements can be brought about at essentially no cost, provided that sufficient lead time is given. On the other hand, it is especially important to examine critically the likely effectiveness of legislative action in these marginal areas, because, if its effectiveness is doubtful, then the cost penalties may be significant for no gains in reduced deaths and injuries. Careful research to establish frequencies and severities of these events is essential.

COMMERCIAL AND PUBLIC SERVICE VEHICLES

All of the foregoing has considered the car occupant. Commercial vehicles contribute significantly to the overall accident situation, but the characteristics of these vehicles result in accidents which are different in many ways from car occupant collisions. Therefore, it is not appropriate to merely apply the same requirements to commercial vehicles as are specified for cars. Different priorities pertain, and a good knowledge of the actual accident characteristics and their frequencies is necessary before realistic legislation can be introduced. Certain factors are known to be of consequence; the under-run of the small car into the rear of a truck is established as a frequent condition of car occupant factalities. The provision of anti-burst door locks, which is a relatively cheap requirement, is another example where legislation might be initiated, but the fundamental need is still to define the actual circumstances before rational requirements can be specified.

SUMMARY

There is one major thread running through this review. That is the pressing need to obtain a better knowledge of the situations, in frequency and severity terms, which vehicle safety legislation within the Community is supposed to influence, prior to the enactment of regulations; and then, once regulations are in force, their actual effectiveness must be assessed. The necessary supporting research programme for achieving those ends is discussed cogently in the report of Working Group 1 of the E.E.V.C. Report of 1974 (26). The first generation of legislative action within the Community is now over. It seems to this author, that the time has now come for a pause in legislative action; and in that pause the energies of the Commission, the member governments, the European car manufacturers and all the associated research and development establishments should be directed at actually carrying out the necessary research which the European Experimental Vehicle Committee outlined as a prerequisite for the next generation of legislative action.

Most of the obvious design rules have been enacted. But in making the transition in the field of occupant protection from the present situation to the goal, ten years away, of a total performance standard system, there are a number of fundamental conflicts to be resolved. Only carefully structured research will solve these conflicts and allow legislation to evolve to optimum levels of protection. Many specific problems will require international collaboration in the research field, and in that area more programmes along the lines of the C.C.M.C. co-operative projects are required.

Present dummy technology and our existing knowledge of injury criteria are insufficient to allow performance standards for occupant protection to be drafted at present.

In essence therefore there are two sets of priorities. In the legislative area, there is a great need to examine retrospectively existing standards and to correct deficiences which are detected, and a need to examine prospectively proposed standards to establish their likely effectiveness in advance and resolve conflicts with other requirements. Lead times for the application of future standards will have to be much longer than has been the case in the past, if future requirements are to do more than merely regularise existing designs.

The second set of priorities are in the research area. Here there are conflicts to be resolved in specifying the appropriate test conditions; what speeds, what types of barriers, compatibility between cars of different masses in various crash configurations and between cars and pedestrians. The second, and more pressing area of research, is to develop better dummy technology and specifically to improve our knowledge of injury criteria, and how these criteria vary throughout the actual population at risk.

Occupant Restraint System	Estimated Wear Rate (U.K.) Front	Estimated Wear Rate (U.K.) Rear	Reliability Factor	Effectiveness in reducing fatal and serious injuries Front	Effectiveness in reducing fatal and serious injuries Rear	Performance Factor Front	Performance Factor Rear	Adjusted Rear Seat Factor	Savings per car life in pounds Front	Savings per car life in pounds Rear	System Cost per car Front	System Cost per car Rear	Benefit: Cost Ratio Front	Benefit: Cost Ratio Rear
									£	£	£	£		
Normal 3 point front, lap rear	25%	7%	99%	55%	30%	.136	.020	.025	20.0	0.61	6.8	5.4	2.96	0.11
Normal 3 point in 4 seats	25%	5%	99%	55%	60%	.136	.029	.034	20.0	0.84	6.8	6.8	2.96	0.12
Normal 3 point in all + load limiter	25%	5%	99%	60%	65%	.149	.032	.038	21.9	0.93	9.5	9.5	2.31	0.01
Normal 3 point in all + preloading	25%	5%	97%	65%	70%	.158	.034	.040	23.2	0.97	36.5	36.5	0.64	0.03
Inertial 3 point in 4 seats	35%	10%	97%	55%	60%	.137	.058	.065	27.5	1.59	13.5	13.5	2.04	0.12
Inertial 3 point + light + buzzer	70%	60%	97%	55%	60%	.373	.349	.364	55.0	8.95	16.2	14.9	3.39	0.60
Inertial 3 point + interlock	60%	60%	97%	55%	60%	.320	.349	.362	47.1	8.90	17.6	14.9	2.69	0.60
Passive 3 point in front, active rear	98%	20%	96% 97% rear	55%	60%	.517	.116	.137	76.1	3.36	33.8	6.8	2.26	0.50
Passive 3 point front and rear	98%	90%	96%	55%	60%	.517	.518	.539	76.1	13.24	33.8	32.4	2.26	0.41
Airbags front, active 3 pt. rear	100%	10%	95% 97% rear	40%	60%	.380	.058	.073	55.9	1.80	81.0	6.8	0.69	0.27
Airbags front and rear	100%	100%	95%	40%	40%	.380	.380	.395	55.9	9.71	81.0	67.5	0.69	0.12
Mandatory use 3 pt. front and rear	70%	70%	99%	55%	60%	.381	.416	.431	56.0	10.58	6.8	6.8	8.30	1.57
1	a)	b)		a)	b)	a)	b)		a)	b)	a)	b)	a)	b)
Column Number	2		3	4		5		6	7		8		9	

TABLE 2 - RESTRAINT SYSTEM ANALYSIS

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DISCUSSION BY THE PANEL

Intervention of Mr. FURNESS

Whilst I accept the scene as having been set by the papers presented and agreeing in principle with the suggestions for the future, I would like to make some comments.

These are my personal views and not necessarily those of the UK Government.

1. We should not lose sight of the fact that the main purpose of the first generation of Motor Vehicle Directives under Article 100 of the Treaty of Rome is to remove technical barriers to trade. In this context the environmental and safety aspects are important but secondary objectives. However, the production of a Directive or Regulation which meets the objective of removing barriers to trade without taking into account safety and environmental parameters is largely a waste of time and expertise. The whole subject of the protection of occupants of motor vehicles is emotive and systems must therefore be produced which afford an acceptable degree of protection, whilst at the same time, are comfortable and convenient for the user. In my view, the standards adopted must in this case be biased towards the safety aspects and not commercial exploitation.

2. Limited experience with the first generation technical directives in the motor vehicle field suggests that any future requirements in relation to-safety, given appropriate lead time, should be considered as an extension of the minimum enforceable requirements set by the Community's system of type approval. I agree that the next generation should be based on performance criteria rather than design, if significant advances in occupant restraint are to be made. To this end, it is essential that a concentrated effort be made to establish such criteria by research into human response and tolerance level capabilities in real world accident situations. Investigation into, and analysis of real accidents needs to be accelerated and used as a stimulant to further scientific research using living and cadaver forms. There is a need for urgency in this work which is at present conducted in a fragmented way. There is also a need for a focal point to co-ordinate and report at an early stage any significant information which may assist the experts in their deliberations concerning occupant restraint systems. Moreover, in this field some indication of the findings of research should be given, without necessarily awaiting positive scientific proof before further action is taken.

3. The second stage of the work of the ad hoc group was intended to consider alternative and more advanced means of occupant restraint. The question arises, should we await full data on human performance characteristics before we consider such systems, or do we make the best available judgement, bearing in mind inevitable design limitations. My answer is - we should not wait, but go ahead with the second stage as soon as possible. I believe that we have the opportunity now to make significant strides forward in a comparably short space of time even though the results may be short of ideal. This challenge must be accepted and met in full by all who profess to be safety conscious. Later on I will expand my thoughts on what the second stage work might cover.

4. So far I have only made reference to the protection of adult occupants of motor cars. There are however, other classes of vehicle such as goods vehicles and public service vehicles (buses and coaches) which must also

be given careful thought. In the last two years we have touched very lightly on this subject at international meetings, but to date very little real progress has been made. This is a field in which there are difficulties in assessing the requirements and the priorities, but these must be overcome - again with a minimum of delay by using good sense and agreeing some compromise when necessary. The Public Service Vehicle and especially the touring coach, presents a challenge with regard to passenger protection and is highlighted by the considerable number of occupants involved, should an accident occur. Recent investigations have shown that it is highly desirable for the occupants to be retained within the vehicle in such an accident situation. Work is proceeding in this area which should lead to an acceptable set of parameters on which the experts can build a safety requirement. In this case there is the opportunity to produce a standard based on performance criteria from the outset.

5. I now turn to a subject which, in my view, should have the highest priority - that of providing protection for children carried in motor cars. Work is proceeding in this field with the object of producing a Directive or Regulation at an early date. Some degree of priority has already been given to this work, but the original target dates have not been met due to the complexity of the bio-mechanical considerations involved. Whilst it would be nice to produce the 'perfect' Directive or Regulation, I am of the opinion that we should go ahead and produce a standard which can be implemented in the near future even though it might not be ideal. The UK experience in this field has already shown that there are acceptable restraining devices on the market for the child occupant and I strongly advocate the very early production and implementation of a standard to regulate their construction and use. We can always adapt such a standard to technical progress in the light of operating experience and in the meantime we would, at the very least, be giving the child occupant the greatest possible chance of survival in an accident. We need to dispel any possible suggestion that experts are only interested in indisputable fact and scientific perfection, and will only act when surrounded by these unassailable walls. We must show that both research workers and legislators are human with a real interest in safety and well-being, and have a desire to get things done quickly. Let us not forget that if we regard the safety of an adult occupant as important, then the safety of a child occupant must surely be paramount.

6. With regard to the compulsory wearing of seat belts, and using the assumption made by Murray Mackay that compliance may only be in the order of 70-80% at best, I consider we are under a moral obligation to introduce requirements which lead to maximum flexibility, convenience, comfort and optimum performance in relation to occupant restraint systems generally. Encouragement to the wearer must be given in a way which shows that the system offered is reasonable in the mode of use and provides answers to problems raised by earlier systems. These requirements for adult restraint systems underline the necessity for work on a second stage directive to proceed forthwith. Experience gained by those countries already operating a system of compulsory wearing indicates that whilst the present generation of safety belts are generally acceptable, they are far from satisfactory for a minority. Little is achieved by attempting to educate users along the lines that it is desirable to wear a safety belt at all times if there is no tangible evidence that active steps are being taken to solve the existing problems by improving design and installation. Even though these problems may only be affecting a minority group of wearers, it is imperative that solutions are found quickly if the risk of occupant

restraint systems being discredited is to be avoided.

7. What do I mean by the second stage directive and what is its purpose ? the second stage must continue and improve upon, the work already carried out and in addition, look at alternative occupant restraint systems not necessarily using a belt concept. Considerable work has been done and, indeed, is still in progress on the development of the airbag concept. Many difficulties were encountered during the early days of experimentation. Most of these problems have now been resolved, but there is still the need for continuing development of these devices if they are ever to become a serious competitor to well-engineered safety belts. Whilst they are satisfactory for forward impacts, and of doubtful value in side impacts or roll over, they are of little help if there is a second impact. Nevertheless, airbags may have a role to play in the field of motor cycle safety and possibly in accidents involving pedestrians. There are also passive restraint systems which make use of chest pads and knee bolsters, and of course, a system of straps which follows closely the conventional lay-out of the present generation of safety belts. It is imperative that all known alternatives to the conventional safety belt are studied, their advantages and disadvantages analysed and their full potentialities explored if the next stage of our work is to be of any practical use. I do not wish to underestimate the very real problems which lie ahead in this field but we must accept the need for improvement and meet the challenge with a determination that will ensure success. Some of you may consider that in reaching this stage in the state of the art there will be more time available for research, etc. before we need to produce a revised standard. I believe that the second stage work must be treated as a matter of some urgency. This must not be let up. We should all be striving to accelerate the application of the lessons learnt from research into accident injuries. The end of the "Technical Barriers to Trade" era is in sight, and the way forward should be clearly indicated by sound technical development and innovation in the field of occupant restraint.

8. Unfortunately there have been regrettable delays in finalising some of the present Directives and it is therefore my opinion that no time should be lost in asking the ad hoc group or some similar body to formulate the requirements for the next stage, if we are to give manufacturers ample lead time and wish to see substantial progress by the mid 1980's. The mid 1980's sounds reasonably far away, but experience shows that projected dates usually get extended. When dealing with matters of safety we should look upon the target date as the ultimate date when the proposed standard is to become enforceable or published, as the case may be. I submit that it should include the time necessary for consultation and the lead time required by manufacturers to comply with. To enable a target date to be met, it is of utmost importance that all the manufacturers likely to be involved in designing, producing and installing the end product be kept fully informed and, where necessary, consulted on specific points as the standard evolves - this will help to obviate objections which may be raised at a late stage in the development of the directive or regulation which necessitate going over the same ground again and again. We should not waste our energies on repetition but use the time wisely and our expertise to good effect and by doing so achieve our objectives without undue delay.

9. When dealing with the protection of occupants of motor vehicles - large and small, we must be able to recognise and respond to some order.

I suggest that this order is a list of priorities and it is here that very careful thought must be given to all the items on the shopping list and an attempt made to get the order right. My order of priority, arrived at after very careful consideration is as follows :

i. Standards for restraint systems for child occupants.
ii. Stage 1 standards for safety belts in Goods Vehicles up to 3 1/2 tonne gross weight and Public Service Vehicles (buses and coaches) with up to 17 seats.
iii. Stage 2 standards for adult restraint systems.
iv. Stage 1 standards for safety belts in Goods Vehicles over 3 1/2 tonne gross weight and Public Service Vehicles with more than 17 seats.

10. I appreciate that some will disagree with the above order of priority but I support my choice by pointing out that at the present time there is no International Standard applicable to restraint systems for child occupants, an omission which I have already indicated should be of the utmost concern to us . The smaller type of goods vehicle and public service vehicle has been put in second place because these vehicles are primarily used domestically and are often not required to comply with international regulations. Furthermore, these vehicles are probably more easily adapted to accept the existing car type of safety belt than the larger vehicles. Stage 2 standards for adult occupant restraint systems is in third place, but my intention would be to continue this work concurrently with items (i) and (ii). With regard to the heavier goods vehicles and the larger public service vehicles and especially touring coaches, the problems to be overcome may take some time to resolve. For instance, the driver compartment layout and method of construction of the current design of many goods vehicles present difficulties in satisfying the requirements for anchorage strength and location.

11. In conclusion, I would like to remind you that every life saved and injury reduced is a commendation to those who strive to achieve a satisfactory standard of protection for the occupants of motor vehicles. To continue to earn such a commendation we must recognise the need for soundly based Directives or Regulations to be produced and made effective in the shortest possible time. This requires a lot of good will and understanding, a willingness to agree to sensible compromise and a sense of urgency. We must however, take care, because over-standardisation can lead to stagnation.

Intervention by Mr. CHAPOUX

The protection of vehicle occupants has until now been resolved piecemeal, depending on the technical knowledge available to governments and engineers. It has been above all the concern of automative technicians and the nature as well as the aims of the international regulations published in various countries proves this.

When imposing design regulations on vehicles, governments have ceded to the most pressing things first and in the case of the majority of regulations on occupant protection, their action has had a beneficial effect.

For example : it is not remarkable that in making the fitting of anchorages compulsory, not always in places which are suitable as yet, either for maximum retention or comfort, that in fitting to an achorage belts which are not always easy to adjust or to open, that in encouraging occupants in spite of these universally known faults, to wear these belts or even as in France, making it compulsory to wear them, this package of measures has resulted in a spectacular reduction of the consequences and the seriousness of accidents, notably those which are basically head-on collisions, which are the most common.

Certainly, the "anchorage" regulation led in a good number of cases to the provision of an abundance of structural reinforcements, the specification in Regulation 16 for judging the quality of the restraint in motion is arbitrary and bears no relation to the available space in the vehicle, the environment of the occupants, test seats, etc. are non-existant or unmodified, and yet the result is the proof of the effectiveness of these incoherent measures.

Do the authorities have the right to wait for better knowledge of the problem? My reply is : No, because every day people are killed or injured on the roads and a sufficient number of them can be saved to justify the cost of the measures taken, even if the necessary expenditure is sometimes high.

It must be said that governments have often been obliged to follow the advice of specialised laboratories which attach great importance to the reproducibility of tests whose results are crucial to the acceptance or refusal of a road vehicle. It is a serious responsibility, because certain tests cannot be made until a very advanced stage of the prototype where the point of no return cannot be passed without disastrous economic consequences for the manufacturer. This quest for reproducibility involves a simplification of the real process and to conventional rather than realistic work, the connexion between the two, if any, being neither always clear nor even properly understood. For example, the dummy currently used for seat-belt tests is very simple since it became apparent that a highly sophisticated dummy was fragile, that is, had a very high utilisation cost and its complexity was an obstacle to easy reproducibility in terms of the required criteria whether for judging the retention (absence of breakage) or whether for its effectiveness (displacement of hips and thorax between two given values).

Examples of "conventionalism" could be cited in each regulation. They are the result of compromises often reached after long discussions first among technical experts, then among government authorities since finally it is the latter who decide what the regulation should be. To want to avoid conventionality in testing would not be realistic, but should we continue in the direction in which we are heading, or on the contrary, steer a new course owing to the fact that the regulations relating to the safety of car occupants taken together, if I may say so, lead to more expensive vehicles than those from which they have developed and do not ensure optimum protection in relation to their extra cost.

Can we state definitely that a vehicle which complies with safety regulations for frontal, lateral or rear impact will provide better protection for its occupants in real accidents ? It is not certain. It is even to be feared that this could lead to more "agressive" cars vis a vis each other, notably in lateral impact. The desire to retain certain of the dimensions of the passenger compartment measured after testing, which has no great significance, encourages the designer to strengthen the front of the vehihicle. Moreover, testing of residual dimensions after lateral impact is made by using a movable barrier whose effect on the sides of a vehicle (notably the doors) does not correspond to that of a vehicle reinforced at the front.

From one stage of reinforcement to the next, vehicles are becoming heavier, more expensive, heavier on fuel and unsafe for the occupants as a result of the acceleration forces resulting from the reinforcement.

What proposals can be made to achieve in the shortest possible time more satisfactory safety doctrine, effectiveness and justifiable cost ?

The studies made in different countries on the science of accidents and on human biomechanics should be the base for any future action on safety. It is more satisfying to take a direct interest in the occupants, rather than trying to persuade oneself that one is concerned with them in setting limits in vehicle design by imposing dimensional or rigidity criteria. The USA opened this avenue with Standard 208 which has been the subject of much controversy until now. Perhaps this was because the objective was too ambitious or because it did not meet with general agreement, as the Standard would lead to the installation of a special safety system for each vehicle. As far as I am concerned, I would only keep the principle of evaluating the protection afforded with the chosen criteria leading possibly to different systems according to the design or interior fittings of vehicles.

In Europe the ESVC (European Safety Vehicle Committee) has worked out certain recommendations to government departments, based mainly on the results of multi-disciplinary accident enquiries and on currently available biochemical data.

Certainly there are still some problems with the test dummies, but there always will be, for no dummy however sophisticated could reproduce the reactions of individuals facing in the fraction of a second preceding impact, an unvoidable accident. Surely every individual is different and even when so-called "special" dummies are used, the reactions differ greatly from one text to another.

Reproducibility must take precedence over the desire to reproduce reality. And instead of trying to make dummies more complex so as to resemble human beings more closely, it would be preferable to simplify them by adapting them to specific tests (frontal impact, side impact, etc.)

The dummies occupying various seats in the vehicle would be equipped to permit measurement of the protection criteria which Mr. McKay spoke of : Head, thorax, femur, neck, facial laceration and, for sub-abdominal seat belts, abdominal organs.

The limits, at an early phase, would have to take account of the uncertainties in measuring and in knowledge, even if it means improving them later.

The test procedure would have to be chosen from among those selected by the ESVC.

The French Government has proposed an action programme which can be applied to car construction as from 1980, provided that no great length of time is wasted in futile discussion and that the other governments want to go as far as possible in finding the best kind of protection for car occupants. At the present stage, some improvements are possible at an economically acceptable cost. It is utopian to want to try and save some vehicle occupants when one knows that in other respects protection criteria, whatever one tries to do to cars, cannot be respected because of the circumstances of the most serious accidents.

On the other hand, it "pays" better to concentrate on the most representative accidents in reality and to try and minimise their consequences.

Having taken account of the foregoing, France considers that the ad hoc study group on passenger restraints in the Commission of European Communities should be r evived in order to :

1. undertake as of now a study of new provisions which could be applicable to private cars in the 1980s, taking as a basis the report of the ESVC 5th Conference on experimental safety cars;

2. to include in these provisions and to study as a priority a frontal impact test, a lateral impact test and possibly a rear impact test as well as an overturning test;

3. to study with the same priority as collision tests the special requirements which could be imposed on the means of restraint;

4. to study the ways of a plying these measures and notably the withdrawal or modification of certain current tests.

In order to orient this work on a concrete basis the French government has proposed the following procedures : (See Appendix Impact Testing).

When the problem of protecting occupants is solved or even in parallel with the work of the special working party, the problems of pedestrian protection must be examined and the limits of this protection defined - impact speed most usual circumstances and the criteria to be imposed in relation to the desired protection.

The problem of cyclists and motorcylists is more difficult. Information needs to be gathered on the conditions of impact of a two-wheeler on the vehicle depending on the type of two-wheeler, to specify the movements of driver or passenger and notably the points struck by the head and the relative movements of head and trunk, in order to improve the protection given by safety helmets.

But as of now there is every reason to make vehicles less "aggressive" by applying as rapidly as possible the Geneva regulation on vehicle exterior fittings.

And finally, this survey would not be complete without studying means of making heavy vehicles less dangerous for private cars. We have to try and go further than anti-devices but it has still to be proven that more sophisticated devices could be of some use in absorbing the energy of private cars by decreasing deceleration values to make them compatible with human tolerance levels.

There is important work to be done, all the more reason to start quickly with the will to arrive soon at provisions which would guarantee better protection for the people involved in road traffic accidents - imperfect protection to be sure, but perfection is not of this world.

APPENDIX

IMPACT TESTING

I. PERFORMANCES FOR IMPACT TESTING

1. The observance of biomechanical tolerance limits.
2. The exclusion of spontaneous door opening on impact.
3. The possibility, after impact, of opening at least one door without resorting to tools.
4. The possibility, after impact, of removing the dummies intact.
5. The absence of fire or permanent fuel leakage.

II. FRONTAL IMPACT

Test method

There is a provision for asymetrical impact which is more representative of actual condition in an accident than pure frontal impact. Impact against a barrier at 60° to the vehicle axis has been retained.

Test speed : 50 km/h

Test conditions : Vehicle in working order, with two 50th centile-man dummies in the front seats, with the seat belts in normal position and conditions so that they act on the dummies.

Required performances : as specified in paragraph I, indented lines 1, 2, 3, 4 and 5.

III. LATERAL IMPACT

Test method

The test vehicle is struck on the side by the front of an identical vehicle, moving at a relative speed making an angle of 75° (value to be specified) with the axis of the first vehicle. At the moment of collision the longitudinal median plane of the striking vehicle must pass through point H relative to the driver's position of the struck vehicle.

Test speed : the relative speed of the two vehicles should be decided by the end of 1976.

Test conditions : vehicle is running order with two 50th centile-man dummies each seated in front facing seats on the impact side, the seat belts being in the normal position and conditions so that they act on the dummies.

Required performances : as specified in paragraph I, indented lines 1,2,3, 4 and 5.

IV. OVERTURNING

At least one complete roll at 50 km/h with two 50th centile-man dummies placed as for frontal impact must be carried out according to an operating procedure which has to be precisely specified.
The performances required are specified in paragraph I, indented lines 2,3,4 and 5 with, in addition, no partial ejection of the dummies and no roof collapse.

V. REAR IMPACT

Empty vehicle, stationary is struck in the rear by a barrier of 1100 kg moving at 35 km/h. Required performances are specified in paragraph I, indented lines 2, 3, 4 and 5.

Intervention by Mr. SEIFFERT

1. Introduction

Although the safety regulations are now enforced since approximately ten years the term "occupant protection" is still not defined. Occupant protection means the reduction and/or prevention of injuries during the accidents. The amount of protection might be measured by criteria on the dummy during accident simulation tests.

2. The Unrestrained and Restrained Occupant

Current regulations are dealing mostly with the unrestrained occupant. They can be summarized with the following regulations ECE Regulation 12 and EG 74/297; ECE R 21 and EG 74/60.
With the mandatory seat belt use, this group will decline because the seat belt usage will increase up to 80 percent.
Beginning with January 1, 1976 the following countries will have mandatory seat belt usage.

Country	Date of introduction
Australia	January 1, 1972
New Zealand	June 1, 1972
USSR	January 1, 1974
France	January 1, 1975 outside cities
	January 1, 1976 general
Sweden	January 1, 1975
Spain	August 1, 1975
Austria	August 1, 1975 indirect through insurance.

Country	Date of introduction
Belgium	June 1, 1975
Luxembourg	June 1, 1975
Netherlands	June 1, 1975
Swiss	January 1, 1976
Federal Republic of Germany	January 1, 1976

From the standpoint of occupant protection in Europe the seat belts today have to fulfil the ECE R 16 "Seat belts for adults". This test was developed, when the seat belts had been accessories in the cars. Because in most countries we have seat belt installation requirements, more and more cars have factory installed belts. These belts are very often designed directly to the cars used. It is therefore time to reanalyse the total system of occupant protection based on experience received so far.

3. The necessity to restrain the vehicle occupant

It is a proven fact, that the impact speed of the unrestrained occupant at higher speed frontal collisions is nearly as high as the velocity change of the vehicle.

Through this fact, the occupant does not take part on the vehicle deformation and has only the deformation of the vehicle interior, dash board, steering wheel etc., available. With a restraint system the occupant takes part much earlier in the crash event and therefore consequently he will participate on the vehicle deformation and deceleration. The main protection through the restraint system like seat belts is given in frontal impacts and rollover. For the other impact directions like side, rear collision other vehicle components have also a significant influence for the occupant protection. In side collisions the side interior of the car and the door locking mechanism, in rear end collisions the seat back and the head-rest are part of the restraint system.

4. Future requirements to testing the level of occupant protection

It is necessary to establish performance criteria for the total system of vehicle-occupant -restraint. The design criteria for example which are incorporated in the EG Directive 74/60 are not sufficient in respect of occupant protection. On the other hand the amount of specific requirements will be very costly in respect to change in the vehicle interior.

Although I agree with the rapporteur, Dr. MacKay, that at this time it is too early to establish injury criteria measured on the dummy we think that for the time until this requirement can be established an interim requirement should be used. As pointed out in our paper which is added to the material by CCMC to this symposium we recommend a sled test at 50 km/h where the sled pulse is different to the ECE-pulse and where the following criteria with a US Part 572 dummy should be used.

Head : if there is an impact, the 80 g limit with the EG 74/60 head impact requirements should be the upper limit.

Chest : 60 g, for certification 70 g.

Femur : 765 kp, for certification 850 kp.

The lower part of the seat belt should not move above the iliac crest. The difference in requirements for tests done by the vehicle manufacturer and by an outside laboratory will eliminate the problems which exist in the United States where the question of reproducibility between different dummies is not taken into account.

In respect to the question whether active or passive belts or other alternative systems should be used we have the following opinion. If the protection level between the various systems is equal then if the belts are used it is not a question of safety, it is a question of comfort.

For the reason of comfort, the consumer should have the choice to select the system he wanted. The ranking of the system which has been chosen by Mr. MacKay in respect to the effectiveness of restraint system the passive 3-point belt is better than mandatory use of the active 3-point belts cannot be suggested by us. It is a well-known experience, that the passive 3-point belts are technically much more complicated than the seat belt developed today. The usage rate will therefore vary specifically if the car is several years old also drop down, so that the same usage level like through an enforcement of appr. 80% might be reached. From the table at page 22 I think the wording must be benefit/cost and not cost/benefit. It is then clear that the mandatory use of active 3-point belts gives the highest benefit/cost ratio. We support this statement and understand that alternative systems which are fulfilling the performance criteria might be used.

4.2. Steering Assembly Requirements

The ECE R 12 to-day is not sufficient enough to cover all requirements for a steering assembly design. In respect of the restraint vehicle occupant the kinematic of the head is quite different. This means that for the development the head contact has to be taken into consideration. The further development also for the unrestrained driver for the reason of surface-pressure reduction seems possible.

4.3. Door locks and side strength

We agree with the rapporteur, that although some improvements have been made in the past we will have no possibility to establish in a short period performance criteria for the total system in hinges, door, lock, door frame, etc.

4.4. Head restraints and seats, instrument panels and windscreens

As for the point above all subjects need further in-depth investigation before final conclusions are reached.

4.5. Prevention of Fire

The event of fire has a low priority because of the low frequency. The frontal barrier crash used today and a collision with 35-38 km/h of a rigid moving barrier, as specified in ECE R 34 for a rear end collision test could be used, if the accident analysis shows a need for such a test.

4.6. Rollover protection

From the tests, which have been done and from the accident statistics it has been shown that it is of high importance, that the doors stay closed during a rollover accident. A dynamic or static simulation test, which simulates this situation might be developed for the future.

5. Conclusion

The proposed seat belt test could be adopted in a short time after the European community has laid down the specific requirements which do not leave room for different interpretation and has uniform effective dates, so that we will leave not nine different requirements instead of one . The two requirements above should be fulfilled for all future standards including a sufficient lead time.

Thank you.

Intervention by Prof. PATRICK

Automotive safety during a collision is simply a matter of reducing the relative velocity of an occupant with respect to the interior of the vehicle to zero without injuring him. Of course, reduction in velocity means a change in velocity which infers an acceleration. Acceleration from Newton's Laws can be considered in terms of a "force". However, for most automotive safety problems, "acceleration" is usually the term used.

Let us consider an automobile in a forward force collision with a barrier. In a car of the size that is very commonly used in Europe, we might have a 60 cm crush at 50 km/h, a 40 cm distance inside, and a 10 cm crush of the interior by the occupant. If we consider the barrier collision without a restraint the occupant generally hits the interior at about the original velocity and the front-end crush and the interior space has done him no good whatsoever. If we are to take advantage of the available crush distance to stop or decelerate the occupant without exceeding the tolerance limit, we must, somehow make use of this available stopping distance, and obviously a restraint system is the best way. One way would be to bolt the occupant to the seat so that as soon as the collision occurs and the vehicle starts to decelerate, the occupant will also decelerate. But we cannot do that, obviously. Unfortunately, even the best restraint systems lose much of the available stopping distance. However, if we can use even half of the available stopping distance, we can protect the occupant against a substantial impact severity.

In order to protect the occupant from the highest collision velocity possible, we must apply as great a force as possible without injury. Some of the variables are :

1. Relative velocity
2. Impact site
3. Area of contact
4. Mass of impactor
5. Geometry of impactor
6. Surface hardness
7. Surface roughness
8. Direction of impact
9. Impact duration

Fortunately, there are many fundamental rules of safety that apply simultaneously to several of the variables. For example, load distribution affects area, impactor geometry, surface hardness and direction of impact. For many of them we can tell intuitively the type of protection required.

The number of types and complexity of injuries complicate the protection of automobile occupants. The general types of injury listed in the usual order of increasing severity are :

1. Contusion
2. Abrasions
3. Lacerations
4. Bone fracture
5. Internal organ damage
6. Brain damage

Contusion, probably, we are willing to accept. Abrasions can be eliminated by use of smoother surfaces. Elimination of sharp edges will eliminate lacerations. Bone fracture can be minimized by distributing the force and keeping it within tolerable limits. Internal organ damage is controlled by distributing the force and applying it to the strong skeletal structure. Control of brain injury is achieved by distributing the force to eliminate skull fracture and controlling acceleration.

Much has been said about the lack of a suitable dummy. Also much has been said about the requirements of a dummy to reproduce exactly the human. But when we say that a dummy must reproduce human reactions, we have to realize that there is no such things as a human reaction. In a collision population there are <u>many</u> human reactions. So which one are we going to choose ? Are we going to choose the relaxed or the tense or the upright seated occupant which most of us seldom are ? Just what are we going to choose ? I think that to try to make a dummy reproduce the dynamics of a human is unrealistic. The human body is too complex.

How can we get the best results ? By going to a restraint system, and obviously the belt system is the one that is currently available on almost all cars. In my opinion, not to make use of it is almost criminal. If we are going to insist on automotive safety, then we should insist on the use of the safety belts that are presently available. If we can come up with a better system in the future, then let us phase it in when that system is available and proven. In the meantime, we must save as many lives and injuries as possible with the systems that are available. And how do we do that ? At Wayne we had a recent program with Volvo in which we investigated accidents and measured the severity of the collision by measuring the vehicle deformation accurately and actually crashing vehicles so that we knew what that deformation meant in terms of severity. The injuries were investigated very accurately and then we could tell from the injuries and the severity what the conditions of accidents were. I reproduced these in the laboratory so that we could measure the reactions on a dummy. If we do it this way, I do not think it is so important that the dummy be realistic as far as a human is concerned.

We know that for a particular condition the response of the dummy corresponds to a given injury. It does not have the same response that we would see in this system if we had a human in that car, but the measurement corresponds to known injury. So that, perhaps, this dummy problem has been overemphasized.

Figure 1 is a graph of injury severity in terms of the Abbreviated Injury Scale (AIS) as a function of Barrier Equivalent Velocity taken from our accident investigation program with Volvo to show the variation from individual to individual. The thing I want to point out is the AIS-3 which is the severity level that I think is the maximum we can accept. Note that even at 10 mph we have some AIS-3 injuries, and they occur across the velocity range up to almost 60 mph. So when we are talking about tolerance we have to realize that tolerance varies from individual to individual.

Figure 2 shows the difference in tolerance to rib fracture for males and females in the Volvo study just completed. Note that the female is much more prone to rib fracture than the male for the same severity of collision. We have to decide whether to design for the male or female, or make some provisions for changing the system so that it protects both.

What we have to decide is that, for a given collision severity, the average individual would be protected. The one that is the weakest in the population will probably have a severe injury. The one that is the strongest will probably have no injuries whatsoever.

Figure 3 illustrates the range of tolerance for safety belted occupants in forward force collisions. For example, if you look at AIS-3 at the bottom and then go up to the 50% injury, we find the intersection at about 45 mph, and certainly if we can protect the average occupant in forward force collisions at 45 mph, this would represent a very substantial number of the injured vehicle occupant population.

Out study shows that, for the dummy we used, rib fractures started at about 2,000 lb. belt load. In addition to the belt loads, I think we have to make use of the knee for decelerating the occupant. We can put a very substantial load into the knee to decelerate the occupant. Also, it will improve the system by minimizing the sumarining or the abdominal injuries from the belt. So it is very important to include knee loads, either with or without the lap belt.

Certainly we need the upper torso portion with some knee load assistance where the lap belt has been removed. I am not sure whether it is necessary to require a lap belt in addition to a knee bar. I think we have to find out from actual performance whether that is the case. We have to reduce the relative motion of body parts. For example, the head moving with respect to the body under the deceleration conditions. I think that with adequate design, if we know that a harness is going to be used, this can be incorporated. We have to improve side impact protection : this requires the optimizing of the relationship between a rigid side and a side that does allow a controlled deceleration or crush.

Another very important point that can be worked on is to utilize the full available distance regardless of the velocity. We can design a visco elastic like system so that in a 10 mph accident, the occupant will travel the full distance of the interior of the vehicle, and at 30 mph he will also travel the full distance, but no further. This will then protect those who are weaker at the lower velocity levels and still give us maximum protection at the higher velocity levels. We have to obtain a better crush distance utilization; we have to use more of that front-end crush, if it is a front-end impact. We can do this by preloading the belts.

Finally, another area that can be investigated in the future is the anchor locations, and choose the anchor locations so that we have the optimum restraints system.

Thank you.

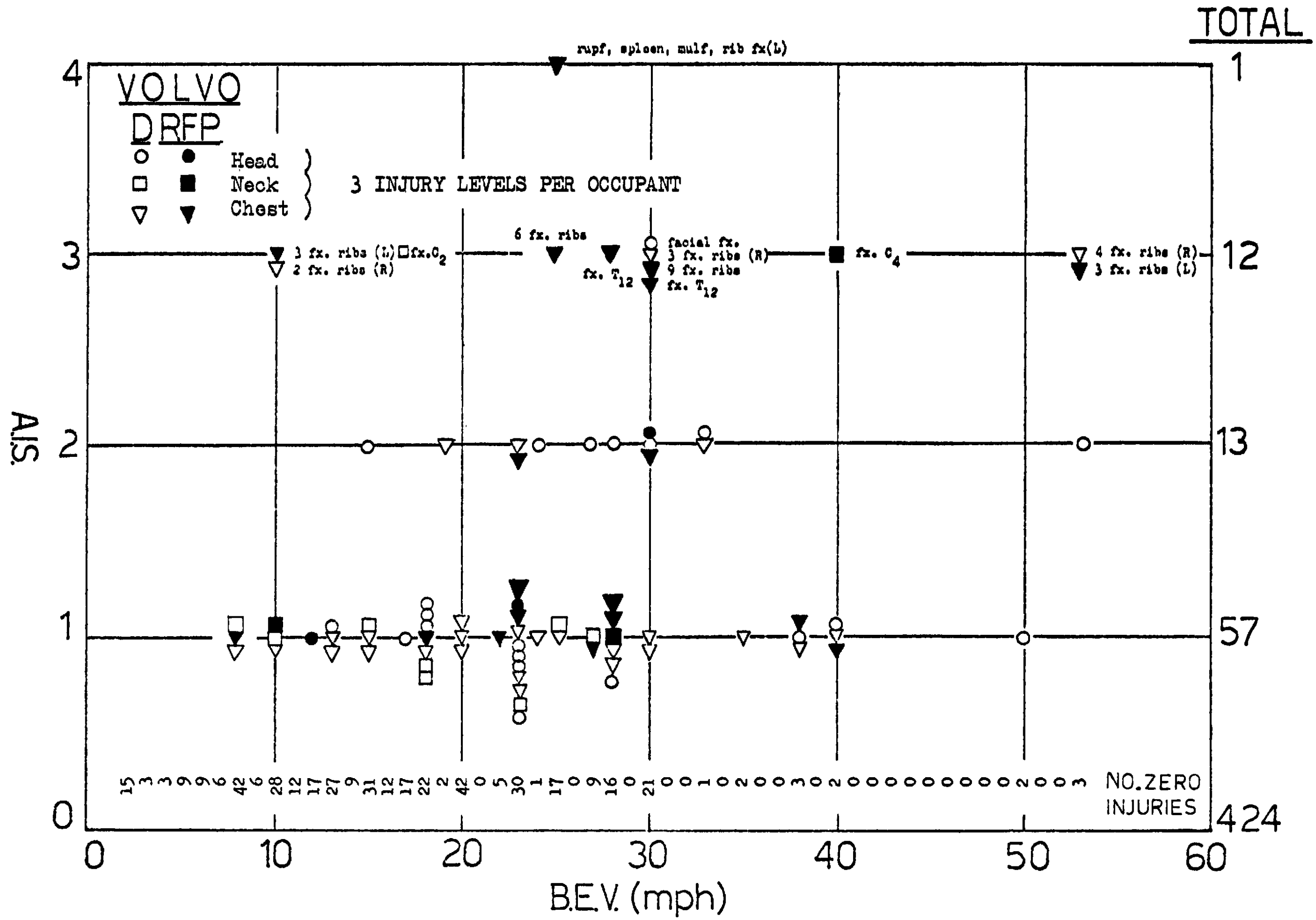

FIGURE 1 – THREE INJURIES PER OCCUPANT (HEAD,CHEST AND NECK)AS A FUNCTION OF B E V

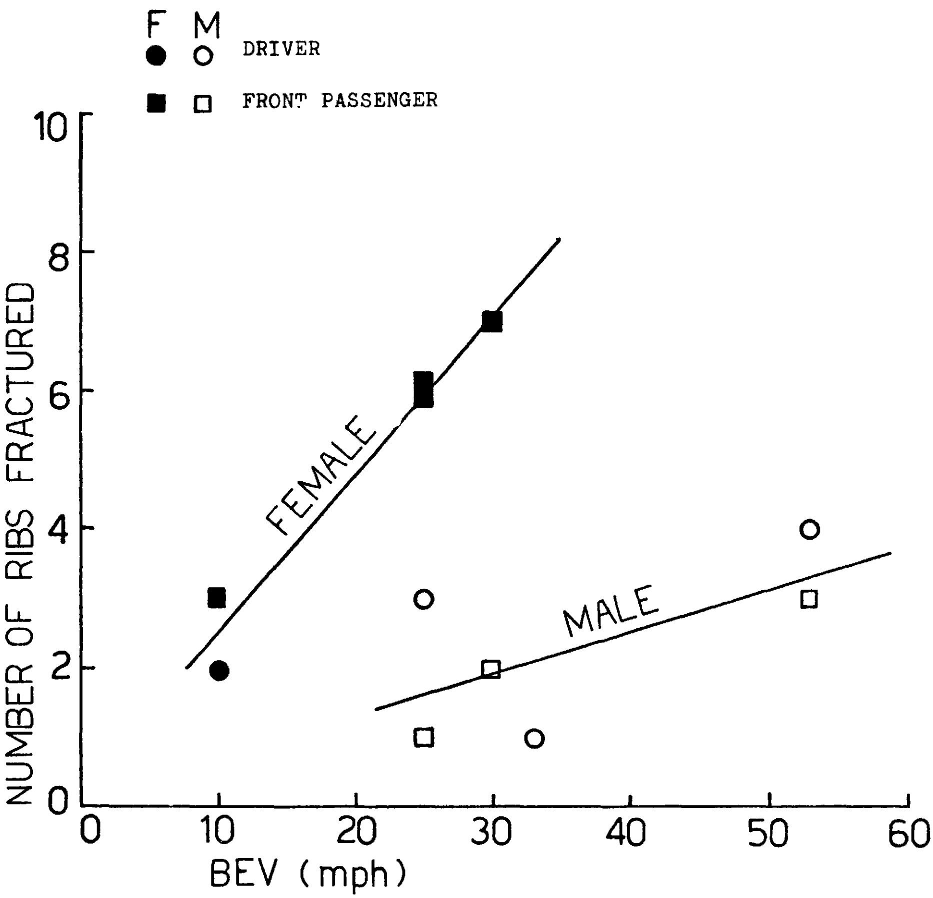

FIGURE 2- RIB FRACTURES FOR MALE AND FEMALE OCCUPANTS AS A FUNCTION OF B E V

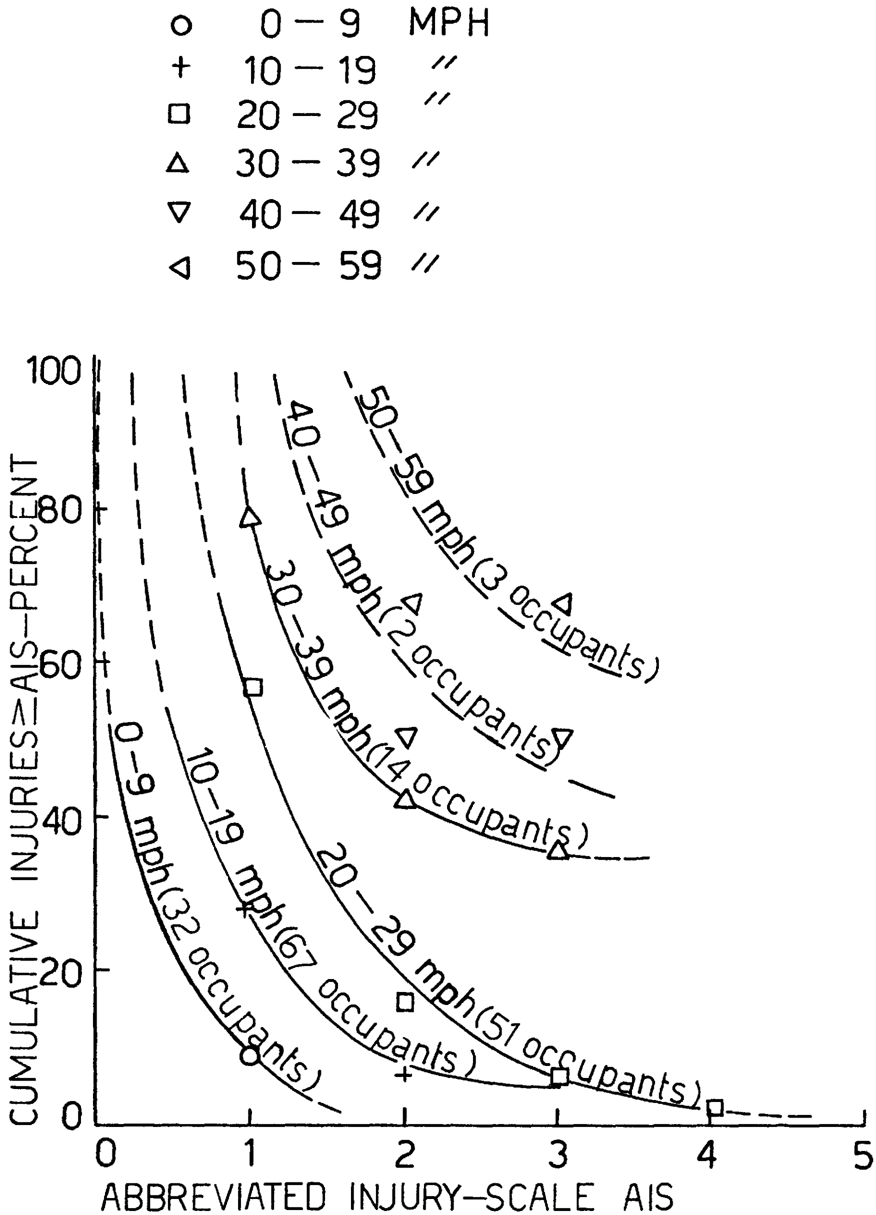

FIGURE 3 - PERCENT OF CUMULATIVE INJURIES, EQUAL TO OR GREATER THAN, GIVEN A I S LEVEL FOR 10 MPH INCREMENTS

Intervention by Mr. Y. GEORGES

The proposals made by the EEVC at the London Safety Conference in 1974 were oriented towards the performance of synthesic tests allowing global evaluation assessment of the protection offered to car occupants.

These proposals were supported by Mr. Sharp for the United Kingdom and by Mr. Osselet for France.

The French position has not changed since. M. Gauvin has written in April 1975 : "France agrees with the main lines of these proposals about crash tests and restraint systems; the resulting regulation could be applied to the new cars manufactured in the early 1980's".

In our opinion, this could only be applied to new types of cars that will be homologated after the date of application of new regulations.

Scientific specialists show concern for the current level of knowledge regarding protection criteria, and it is quite understandable. Of course, it is difficult to precisely define the safeguard limits in case of complex collisions. But the valuable knowledge gathered along the many years of research in biomechanics and in accidentology should not be underestimated. Accident surveys have shown that current regulations based on subsystems and design criteria cannot ensure a real protection for occupants. It seems quite unauspicious to try and improve standards established on such debatable bases. They were made, in fact, at a time when no accident survey or statistics existed, for non belted occupants, or for lap belt wearers, and yet, lap belts were forbidden in the front seats. These rules were made at the time when no efficient judging criteria for occupants protection were known.

Now the only test simulating a collision of a complete car is the 90° collision against a fixed and rigid barrier. This test is not only performed without occupants, but carried out within an unrepresentative configuration of road reality. Any expert will now say that an asymetric frontal shock is the most typical case met in real front collisions.

Moreover, in the 90° test crashes against a barrier, belt efficiency evaluation would rather be pessimistic in opposition to what is observed in real road accidents.

This is because the dynamic conditions met during a collision test for a given speed do not correlate with what really happens on roads. This has been exposed and published earlier this year by Renault.

After having performed many tests at different configurations, we think that frontal collision on 60° angle fixed and rigid barrier is the dynamic condition (body distorsion and deceleration) most representative of what is experienced in real road accidents.

In this test a judgment will be made according to the protection criteria defined in the second CCMC memorandum, measured on anthropomorphic dummies.

For roll over accidents which require particular care against ejection and frontal collision, the change from sub-systems rules to global assessment based on synthesis tests seems now advisable and feasible in the near future (five years at least should elapse between decision and enforcement).

Right from now, an intermediate step consisting of a catapult test with the car inside environment such as proposed by CCMC- could be undertaken.

About other road safety problems, lateral collision, compatibility between vehicles of different masses and pedestrians protection, current studies to define precisely future actions must be carried out.

These will be presented as they come, as well as the new protection criteria which will also arise with the progress of biomechanical research. But an adequate industrial dead line is imperative between decision and application.

In conclusion, we would like to state again our certitude that the global approach for occupants'protection, started right now and based on to-day's knowledge, is the only efficient way to assess real protection offered by cars to road users.

Comments from Mr. **BARKHOF**

It is very important that vehicle occupants should be well protected if the number of victims of road accidents is to be reduced. Although they should not think about them every day each driver and passenger must realise that the measures taken in order to make vehicles safer from the inside are in their own interests. They should therefore be prepared in principle to react positively to such measures. Prerequisites for this are that they must appear reasonable are little or no trouble and these must be an acceptable compromise between the anticipated effect and the price to be paid for it. In short the motorist himself must to a certain extent appreciate the usefulness of certain measures and this requires a realistic approach to the whole problem. I feel that this approach follows the lines along which, in Mr. MacKay's opinion, legislation aimed at making vehicles safe for their occupants would have to develop.

The gradual approach towards the development of - to use the English expresion - "performance standards" which always keep abreast of the state of the art, unhurriedly but step by step, appeals to the consumer. This process offers him a useful guarantee that at any moment there will be a reasonable balance between the safety gained and the price to be paid in monetary terms, since in the final analysis any measure which the motor manufacturers have to introduce is reflected in the price of their products and the consumer wishes to be able to continue driving and buying cars which he can afford.

It is clear that in future more time will elapse between the moment when agreement is reached on any regulations and their actual implementation. We feel that this must be accepted and a selection approach should take priority over the quick introduction of measures which are not certain to have a beneficial effect and which might later have to be withdrawn.

In addition their credibility in the eyes of the motorist would definitely not be enhanced (e.g., the mudflap affair in the Netherlands). In order to be able to introduce - to use the term again - "performance standards", far more data will have to be available in future on the forces and decelerations which the various parts of the human body can withstand and on the various types of collision which actually occur. One of the things required here - as mentioned by Mr. MacKay - is a comprehensive record of accidents on a European scale.

Full integration of accident recording systems will possibly not get off the ground but if the records and analyses are to yield internationally viable data the same standards must be laid down throughout the EEC. An example which can be quoted here is the different criteria used for Belgian and Dutch accident statistics, in that in Belgium the term traffic fatality is only used if the victim of an accident dies either on the spot or on the way to the hospital, whereas in the Netherlands victims who die in hospital thirty days after an accident are also counted among accident fatalities. Consequently a few years ago, for example, the English publication "The Economist" gave a completely false impression of road safety in these two countries. If they are to be protected in the event of an accident vehicle occupants must be held in place so that in one form or another a (safety) belt system will always be needed. The total effect on road safety is likely to depend completely upon the frequency with which the belts are worn, so that it is very important that belts are accepted by the public. This means that great stress must be laid on their comfort and ease of handling . It is also important that the belts should be worn reasonably tightly about the body or else their credibility will be undermined.

Examination of the results of a survey carried out by the ANWB early this year into the comfort, ease of handling and range of adjustment of belts fitted as standard to new vehicles has shown that there are many improvements which still must be made in order to increase both their safety and their acceptance by the public. Sixty five different types of car fitted with three-point belts and sixteen fitted with lap belts were examined.

In at least 25% of the vehicles examined the belts proved to be quite difficult to adjust or their adjustment required a certain skill on the part of the motorist. 15% of the belts were fairly difficult to fasten and another 15% were difficult to hang up or stow after being unbuckled. Ease of handling and use could be improved in about 50% of cars. It emerged that the diagonal belt in vehicles fitted with three-point belts often does not lie correctly across tall (95 percentile) persons. In 40% of these vehicles the diagonal belt barely fitted and in at least 20% it did not fit at all. In eight types of car (12%) the diagonal belt did not lie across the shoulder even of persons of medium (50 percentile) stature. The failure of the diagonal belt to fit 95-percentile human guinea pigs often proved to be accompanied by slipping off the shoulder, in this case 20%. In the case of the three-point belts the lap restraint often left something to be desired.

This applied to 5, 50 and 95-percentile persons in about 30% of the vehicle types in each case. In the case of lap belts the lap restraint almost never gave rise to cristicism. The survey has shown that improvements should in fact be made to existing belt systems reasonably soon , whereas in the rather longer term it must be possible to eliminate practical shortcomings entirely.

It can be expected that automatic seat belts incorporating emergency locking and one-hand operation will have a rosy future. Points to which initial attention can be paid in order to make improvements are as follows :

(i) the provision of all cars with several attachment points for the diagonal belt so that this belt always lies across the shoulder in the optimum position, regardless of seating position and tallness;

(ii) the attachment points for the lap belt should be on the seat frame so that there is always optimum lap restraint;

(iii) the buckle straps should have greater length adjustment so that lap restraint is also improved;

(iv) attention should be paid to the position of the centre pillar in small four-door cars since these are frequently located so far forward that the diagonal belt does not fit. In this connection I should also like to point out the desirability of not introducing a general ban on lap belts - partly because it must be taken into account that several years will elapse before all vehicles on the road have been replaced.

Finally I would like to endorse the need for every car in every country always to be fitted with the optimum seat belt system for that car and for other belts not to be fitted in various other countries. This also means that belts must always be fitted at the factory and not by the importer or dealer, thereby ruling out faulty installation.

Intervention of Mr. GÖGLER

The first generation of safety regulations in many, and I believe too many cases have met with failure. This applies,as you will know, especially to construction regulations which contain many details without incorporating a real overall concept. I refer here only to passive safety. This failure has taught us all, legislators, manufacturers and scientists, much of a practical and theoretical nature. Often I have shocked manufacturers, engineers and law-making technocrats with the results of sometimes very defective safety designs which have produced a large number of stereotyped and sometimes almost planned injuries and analyses of these injuries and perhaps I have also managed to motivate some of these people. Therefore, I come here as an outsider, as a surgeon acting on behind of those victims of accidents that are preordained by design and legislation.

Although it is true that we are about to receive the second generation of safety regulations and are witnessing the changeover from construction regulations to performance regulations, this does not mean that the construction regulations of yesterday can simply be swept under the carpet. We must continue to live with them, improve them, adopt them, cut down on their number. Nor does it mean that we can go to the other extreme and establish performance regulations in vacuo without defining particular components in terms of passenger deceleration and injury prevention characteristics.

Of course automobile technology will change, but in the foreseeable future current designs of supporting structures, steering assemblies, safety glass, impact-absorbing interior fittings and restraint systems will remain valid with respect to passive safety. But although the way in which yesterday's construction regulations were conceived made it possible to lose oneself in a mass of details such as the radii of curvature of individual control knobs, without ECE regulations on structural distortion being produced, one can now (perhaps) say - thank God - that performance regulations are based on an overall conception set out systematically in a safety catalogue. As long ago as 1968 I put forward some ideas on :

1. load-bearing structure and passenger compartment design
2. vehicle interior, steering assembly, glass, surfaces and seats
3. restraint systems, including head restraints and specific safety equipment for children which must form an integral part of this concept.

While analysis of actual accidents, which are of course to be accompanied by many necessary experiments, are to serve as a basis for and check on performance regulations, unambiguous classifications are indispensible both here and with respect to the testing regulations to be applied. For accident analysis we need manufacturer's specifications for each type of vehicle : original dimensions and vehicle damage index specifications and also comparative measurements from standard crash tests on vehicles involved in accidents in which impact has caused distortion, with particular reference to the equivalent experimental speed of collision which would serve as an objective and standardized input condition.

Yesterday we heard a phrase from the Bible, "Knock and it shall be opened unto ye". Well, I have knocked often enough. And if we are not eventually to see performance regulations founder in the way that construction regulations have done, partnership is now indispensible and must replace timorous mystery-mongering. Without specific experimental data on typical accidents we cannot classify vehicles involved in accidents exactly and any comparison becomes difficult.

I should now like to use the example of the steering assembly to explain the process of changing over to performance regulations via design aids. Because ECE Regulation Nr 12 does not take into account the distribution of forces per unit area, it does not exclude horizontal penetration of the steering column into the passenger compartment and does not mention vertical and lateral displacement because no effort has been made to imitate real accident kinematics in the test regulations , the latitude of ECE Regulation nr 12 is so broad that even the most dangerous steering systems are allowed by it.

In such a system suffers impact the values measured remain within the limit under ECE-12 permitted of about 1 300 kg and the injury caused by this skewer like object is just disregarded in the figures. In other words, pinpointed forces such as occur for example when a spoke breaks and when contact is made with a boss having a small area can cause injuries without necessarily overstepping the prescribed limits. The high central position of the steering wheel makes it come into contact not with the thorax but the abdomen, and particularly liver and spleen so that values measured for the chest cannot be applied.

The rearing up of a steering column with impact absorber causes it to hit the face, that is : both the soft and the bony parts of the face, whereas it hits possible impact with the thorax or head.

2. Impact-absorbing consistency of the steering wheel plane before, during and after impact with the thorax or head.

3. Prevention of upthrust, lateral displacement or rotation of the steering column.

4. Covering of the part of the steering column inside the vehicle with impact-absorbing material.

For the valuation of accidents in which structural distortion has taken place it is essential that the manufacturer provide information on how far the part of the steering column bearing the steering wheel extends in front of the scuttle and on the nature and position of any special safety design features of the steering assembly.

I have only used steering assembly as an example to demonstrate that performance regulations are always connected with working design characteristics and the results of analyzing actual accidents. We must and are already able to begin to do this now, at least as far as the most obvious first experimental steps are concerned; Mr. Seiffert, Mr. Patrick and Mr. Georges have already said something about this. And as we begin we must realize that we cannot attain perfection immediately.

Thank you very much.

Intervention by Prof. Antonio DAL MONTE

It may perhaps cause some surprise that sport medicine can throw light on the problem of the protection of motor vehicle occupants.

Most people think that the sport doctor is simply the doctor who sits at the edge of the games field ready to intervene if an accident occurs. But sport medicine is more than this : institutes of sport medicine are attended by appreciable numbers of scholars studying the biomechanics and physiology of maximum human performance, and it is precisely in the study of maximum human performance that problems relating to the human body's resistance to stress are covered.
Obviously, sport medicine is a branch of study which embraces problems, such as the protection of the occupants of racing cars and the resistance of the human body to impacts, which may be the same as those that occur in any traffic accident.

In the car industry the human body's resistance has been studied with the aid of dummies , corpses and animals; but none of these lends itself really satisfactorily to the simulation of the human body's behaviour under impact. In particular, when corpses have been used it was expected that their behaviour would be very similar to what is observed in the case of living victims. Unfortunately, these expectations were not fulfilled, mainly at the neck when there is no impact absorber. In neither case are thorax measurements applicable. No values have been obtained for rotation. The part of the steering column inside the passenger compartment comes into contact with the knee, that is, the kneecap and the knee joint and it is not sufficient to determine the force of impact from figures obtained for the thigh.

Performance regulations for the above-mentioned phenomena should specify the following :

1. No thorax injury. The maximum parameter of 60 g does not exclude substantial injuries. Differences in people should also be taken into account. You have heard enough about this but we know too little about the differences between man and woman, child and adult, old and young.

2. No abdominal injury. There is no maximum for this.

3. No injury to soft and bony parts of the face. There are a few parameters for this but they have not been tested with sufficient reproducibility on dummies.

4. There are no maxima for injuries caused by rotation.

5. As I said before, injuries caused by penetration of an unpadded steering column into the passenger compartment affects not so much the thigh as, more particularly, the knee-joint area for which there is no parameter.

Finally, performance regulations must also take into account passengers without seat belts and differences in the kinematics of seat belt wearers without falling into the event of thinking that the problem is solved by the compulsory wearing of seat belts. If a pessimistic overall view is taken of the situation it might be said that performance regulations cannot work. Today,after fifteen years of discussion during which time researchers manufacturers and advertisers as well as national and international licensing authorities have talked design safety, licensing authorities are in fact putting it into effect, although only fairly well, so that it is rather fragmentary and insufficiently researched. Essential scientific and statistical basis for the type of design safety and performance regulations desired are still lacking . However I do not subscribe to this attitude of resignation and believe that performance regulations based on previously acquired knowledge and in particular FMVSS 208, however fragmentary and questionable such knowledge may be as regards individual parameters,are better than the construction regulations used hitherto. They are better than no performance regulations at all if one is not afraid to use, instead of still non-existent parameters, working design arrangements, whose injury prevention characteristics are known and, for purposes of large scale experiments, do not need to be based on data which are still of an experimental and statistical nature. One must also be prepared to improve the analysis of actual accidents by means of open partnership and exchanges of data between surgeons and vehicle manufacturers and from this analysis to determine the consequences as far as design and legislation are concerned.

Without claiming that they are perfect, the following working design charcateristics for the steering assembly, in addition to the 60 g parameter for the thorax, could be defined as follows :

1. Use of the whole area of the steering wheel plane by adapting it

would seem because of the unfavourable conditions of ossification and preservation of the corpses, which usually came from severely diseased, wasted and elderly subjects and were therefore substantially more fragile than healthy subjects in crash conditions.

When volunteers are used, the test obviously cannot be carried to the limits at which serious lesions might be caused.

Moreover, in Italy, since the use of human subjects (even volunteers) in experiments which could in any way damage the integrity of the human body is prohibited by law, the only possible source of information lies in the analysis of actual events; these obviously include some casualties in the various sports which are particularly suitable for study, especially as they concern healthy subjects whose anthropometric and constitutional data may be regarded as statistically fairly homogeneous and representative of the motorized population, i.e. mainly young subjects, rarely exceeding 30 years of age, in good physical condition and a sound state of muscular efficiency. Even so, and I wish to stress this point, the response of the human body to damaging events and impacts of entirely similar intensity has proved to be extremely variable.

I will cite some examples to illustrate this point. In offshore speedboat racing, the pilots - of which there are usually three for each boat - steer side by side, in which position the stresses caused by wave movement (mainly strong vertical oscillations) cause identical accelerations for all three subjects. Furthemore, the pilots are housed in cabins equipped with protective upholstery which is the same for each man.

And yet, in offshore competitions, there have been cases in which one of the pilots has suffered bilateral femoral fracture (in other competitions there have been breakages of the acetabulum) while the co-pilots, who are, as already stated, subjected to the same acceleration, have suffered no injury.

Still in the world of open-sea motorboating, there have been cases where seated subjects have suffered wedge-shaped fractures of the spinal column, in the thoracicsection between the eigth and twelfth vertebrae, whereas, significantly, the impacts which proved so traumatizing for some passengers caused no damage at all to the fellow passengers seated nearby. Incidentally, the impacts caused by wave movement and the subsequent accelerations suffered by the hulls of these craft caused no structural deformation or damage to the boats, only injuries to the passengers.

A similar phenomenon to that which occurs in open-sea motorboating was observed with the first type of ejector seats with built-in parachutes (Martin Baker type) for fighter pilots. At the time of ejection, triggered by an explosive charge, a high proportion of these aircraft pilots suffered fractures of the upper part of the spinal column and particularly between the eigth and twelfth thoracic vertebrae : fractures occured in 45% of parachuted subjects. But, in 55% of the subjects, who were attached to the same type of ejector and therefore subjected to the same acceleration, no injury occurred. This is another illustration of the different responses of the human body to accelerations.

As a matter of interest, it should explain that the reason for the fracturing of the spinal column was the excessive elasticity of the flat surface of the seat which consisted of a small rubber lifeboat folded up to be used as a cushion for the pilots to sit on. At the time of ejection, the seat was propelled at high speed by an explosive charge and had already gained a certain velocity before reaching the pilot's buttocks, through which the energy acquired by the seat was applied to the rest of the body. It was sufficient to remove the rubber dinghy from that position and to have the pilot sit directly on the seat in order to overcome the problem of fracturing of the spinal column.

Another example which may be more relevant to the problem of impacts on motor vehicles is that of circuit speedboat racing in which the pilots steer in a prone position and therefore have the thoracic cage resting on a suitable cushion. In this position, the accelerations and impacts occur in a front-to-back direction, as in frontal car crashes. In cases where this steering technique has been used, some pilots have suffered fractures of the ribs whereas others have incurred no damage although competing in the events where accidents have occured, with identical hulls subjected to absolutely similar impacts and with exactly the same conditions of water movement for all pilots.

Still in the world of sport, many events hav been observed and reported in which the responses of bodily structures to similar impacts and accelerations affected the complete organism in entirely different ways.

The factors which modify a person's resistance to input forces are age, sex, race, body composition, genetic constitution; another point is that in the case of subjects who practise the same sport for many years and are constantly subjected to impacts of a similar nature and intensivity the passage of years brings changes both in the scale of the lesions caused and in the elements of the locomotor apparatus which are injured : for instance, fractures are more frequent at an advanced age, whereas sprains and dislocations are more frequent, for the same impact, in young subjects, who may indeed remain quite unharmed by impacts which prove highly injurious for older subjects.

Another perplexing factor in the assessment of results obtained in the study of the human body's resistance to impact is that of the numerous methods used and the various units of measurements.
Typical of the present state of divergence of opinion, not to say confusion, is the investigator's approach to a measurement of the behaviour of the thoracic cage under impact. The unit of measurement used in the past was deceleration, nowadays the methods based on bending on the rib cage is becoming more widespread.
Both methods have their advantages and disadvantages, but it must be borne in mind that bending is strongly influenced by age.

During the life span of a human being the composition of the thoracic cage changes from being mainly cartilaginous with a high elastic content to gradual ossification of the ribs and transformation of the costal element from an elastic to a rigid state, which is why an impact in a baby could cause very serious lesions to the internal organs and major vessels, with severe bending of the thoracic cage but no rib injuries whereas elderly subjects would immediately suffer numerous rib fractures without corresponding lesions in the internal organs.

Still with reference to the thoracic cage it must be remembered that as regards the resistance of human structures, the response may vary according to the surface against which the impact occurs. Obviously, these different types of behaviour must be used to guide and influence the design of devices to restrain the human body inside motor vehicles.

At this point we might conclude that in our understanding of the human body's resistance to impact we are completely in the dark, and that the experimental results and knowledge acquired to date have therefore been disappointing in their practical application.

In fact this is not true : biomechanical studies have undoubtedly made an important contribution to our understanding of the behaviour of the human machine under impact. But, as is often the case in science, there has been a sharp rise in the number of phenomena studied and a tendency for measuring techniques to become differentiated and personalized.

Consequently, instead of producing a simple equation with a final result, the process of investigation has so far provided us with an almost infinite variety of results which often conflict with each other. If an equation has been obtained today, it is an equation in which the unknown factors, i.e. the x's, are more numerous than the known factors. It is now time to be realistic and logical and to start on the opposite process - a process in which we begin to cut away the deadwood, i.e. the superfluous methods, and endeavour to arrive at a unified assessment of the human machine.

This critical reappraisal is absolutely essential because if we wanted to determine experimentally all the possible responses of the human body to the various impacts and then correlate these responses with all the various tests proposed for inspecting motor vehicles, both for their structure and for passenger protection, and also verify the data obtained statistically, then in all probability the entire output of mass-produced vehicles would not be sufficient, it sacrificed in crash test conditions, to provide us with absolutely certain answers.

On the other hand, it seems to have been overlooked that some outstanding results have been obtained in the sports world by using some simple safety devices that were proposed and immediately brought into force by sports regulations. Sports legislation bodies have not waited to obtain precise answers from biochemical investigations, nor could they do so because of the uncertainties which have always existed and still exist in the sector; they have simply applied anything that was relevant on the basis of straight forward good sense. I would like to refer to some results which have been obtained in motor racing, in which it has been possible to apply and enforce a restriction on the mobility of the human body inside the vehicle.

In production car racing, which involves factory-built cars both in the United States and Europe, the only standards which have been laid down by law are the adoption of particularly efficient safety belts and a supplementary tubular framework to strengthen the driver's cab.

Even a cursory and incomplete investigation reveals that, in relation to the gravity of the impacts, the number of lesions is such as to prove that a significant advance has been achieved in driver protection with very simple devices.

In production car racing there have been frontal crashes, crashes against the guard rail, lateral impacts, collisions, etc. But spectacular damage to vehicles, with severe structural deformation, has been accompanied by driver injuries much less serious than would have been expected and infinitely less serious than would have occurred, under equal intensity of impact, if the same models had had no tubular reinforcement and the occupants had been either not attached or improperly attached with belts.

There is another fact which should be pointed out, namely that in sports such as speedboat racing or motor-cycling where it is not possible to apply the same system of driver protection, that is to attach the driver to the vehicle, the degree of safety in accidents in recent years has not improved but has remained virtually the same.

However, perfection in systems for restraining the human body, i.e. by belts, has today reached a level which may be regarded as optimum, as demonstrated - still in the sports sphere - in delayed-drop parachute competitions. The deceleration caused by the opening of the parachute is extremely sharp, but the system of restraint by belts is so well designed that not even the slightest injuries are caused.

In conclusion, it is impossible not to agree with the MacKay report when it states that the time is not yet ripe for laying down final regulations and that the problem must be tackled through transitional protective regulation pending a better understanding of biomechanics. We have probably reached a point where we must adopt solutions dictated by good sense and a few undisputed figures rather than by very inadequate controversial information obtained from biochemical studies. Perhaps the reason is that too much is being asked of biomechanics, and in particular the solution to an impossible problem : that of being able to find precise answers to a problem whose components consist of a number of variables, none being more variable or more inconstant than the behaviour of the human machine itself.

GENERAL DISCUSSION

COMMENTS MADE BY MR. HOFFERBERTH

I want to compliment Dr. Mackay on his paper. He has really gone direct to the heart of the various issues that he raises - that is not an easy task. It is here, however, at the crux of the issues, that I would like to address a few brief comments. I hope that my comments will be taken as they are intended - to be constructed to the cause of international understanding of harmonisation of standards. I believe that the best way to overcome disagreement is to state it clearly and hope that a mutual understanding will follow.

Dr. Mackay states that it would be foolhardy for us in Europe to attempt to go immediately for a total performance standard at this time with the elimination of all regulations which specify the various sub-systems. I agree with that proposition. What I do not agree with is that we must wait until we can do the job totally before we start to do the job at all. We have in our now obsolete programme plan from the United States, and on numerous occasions since that time, endorsed the policy that, ultimately, system performance standards would prevail, but in the interim the combination would exist. We recognise that the Part 5/72 dummy does not reflect the ultimate in crash victim simulation, and that the injury criteria applied to that dummy in crash situations is less than perfect. However, we are inclined to use the dummy in system performance requirements and standards when we believe that society will benefit from that action and retain such low standards as we consider necessary in serving the public interest in view of the less and optimal characteristics of the system performance standards.

Dr. Mackay states that existing regulations reflect current levels of design and, as a consequence, have earlier effective dates applied to them. He further states that further regulations must allow longer lead times if they are to reflect the most up-to-date knowledge. Lead times need to be determined on the basis of the cost of accelerating the introduction of a technological change relative to the social cost of taking a longer time. There is, after all, some urgency with the task at hand. It has already been suggested by several of the comments Dr. Mackay presents, a version of the cost-benefit analysis as opposed to cost-effectiveness analysis primarily on the grounds of the debatability of the benefit assessements. He states that cost-effective analyses are preferable for establishing priorities for accurate protection activities and I agree completely. However, such a concept is of little help when one considers the absolute value of a given safety measure relative to other considerations such as energy conservation, pollution control and, of course, ultimately expenditures by the consuming public. Cost-effectiveness can tell us what to work on next, but it cannot tell us when to stop, and that is one of the essential regulatory décision making elements.

I would like to endorse Dr. Mackay's comments on the need to conduct somprehensive field accident programmes, both in the USA and Europe. However, I think it is appropriate to go beyond Dr. Mackay's comments to indicate that the concept of what is required in a field accident in investigation is very much in need of up-dating, with the possible exception of some recent work done by Dr. Tarrière and others in France, Dr. Seiffert and Prof. Fiala in Germany and in some parts of our programme in the USA.

It is essential and mostly absent from field accident investigations to date, our objective relevant measures of crash severity. The deformation of a given vehicle without consideration of other factors is not adequate.

What is an adequate description of crash severity appears to vary from different restraint systems and different crash situations. In side impacts the velocity changed or the closing velocity given the masses of the sliding vehicles, may be adequate. In frontal collisions it is suggested theoretically, with some experimental verification, that for unrestrained occupants and unbelted occupants, velocity change is also adequate. For lap and shoulder belted occupants, velocity change affected the stopping distance with the implied limitation on maximum allowable acceleration as defined in my paper entitled : "The study of structural and restraint requirements for automobile crash survival". In pre-impact braking, a consideration of the sensitivity of belt restraint system effectiveness to pre-tensioning, may suffice. With air cushions, velocity change and effective stopping distance would appear to be adequate. In any event the continuation of what generally has passed as field accident investigation will not suffice in the future. I refer you to my paper at the recent NHTSA Conference on field accident investigation for further information and invite any questions beyond that.

Dr. Mackay properly and correctly states that tolerance of impact data come largely from three sources :

- accident reconstructions;
- volunteer tests, and
- other studies.

Further elaboration is worthwhile. The usefulness of accident reconstruction as a possible source of hyman tolerance data, further reinforces my previous comments on the need to accurately determine objective and relevant measures of crash severity in field accident investigations. Unless one has measured the relevant parameters for a given crash situation for the restraint system in use in the crash, one cannot hope to learn anything about human tolerances. Dr. Mackay states, volunteer tests do, for the most part, involve young, healthy, male, military volunteers. However, it is interesting to note that within this population, acceleration levels in excess of those currently specified, with the thorax and passive restraint requirements in Standard 208, are exceedingly crucial restraint systems, whereas levels far below that cannot be achieved with the present day belt systems. The results of cadavre tests conducted both within the USA and Europe, much of which was reported in a recent Stapp meeting, are subject to analyses that show relatively good correlations which suggest when a lap and shoulder belt system is in use, human tolerance varies primarily as a function of the age of the crash victim and the tension in the upper torso restraint. With a 3,000 lb total force load of the upper torso belt corresponding approximately to accident injury severity level 3 for a 40 year old subject, these results are preliminary, but they also show reasonable correlation with the voluntary tolerance limits exhibited by the young, healthy, male, military volunteers used in the live experimental projects.

With regard to better restraint systems, Dr. Mackay states that considering the acceptability question, it would seem appropriate that main efforts should be connected with improving comfort and convenience and acceptance of the belts, with the obvious immediate developments including : an adjustable upper mounting point; a rear mounting point moving with the seat; one handed operation of the entire system. I leave it to my colleagues in the automobile industry to comment on the feasibility and the cost-benefit aspects of these proposals.

Dr. Mackay further suggests that a feature performance standard should allow both belts and other alternative systems which meet specified requirements. Based on the preponderance of current bio-mechanical data, it appears likely that at some point in the future the criteria will differ for different restraint systems, at least until sufficient data are gathered to allow a more fundamental specification of injury criteria, if possible.

With regard to Dr. Mackay's discussion of the comparison of different strategies for occupant restraint systems, I do not propose to debate the many points raised in that paper. It suffices to say that I agree with Dr. Mackay's comment that there are obviously gross assumptions made in conducting this predictive analysis and that I do not agree with many of his assumptions. It appeared to me that the analysis of benefits and cost conducted by the NHTSA has been discounted and, needless to say, I consider that not to be appropriate, at least from the point of view of regulations in the USA.

In summary, Dr. Mackay concludes that present dummy technology and our existing knowledge of injury criteria is insufficient to allow performance standards for active protection to be drafted at present. I would not disagree with his comment that a total performance standard may be 10 years, or even more, away. I disagree heartily that the initial steps cannot be taken in the very near future.

Thank you very much.

Question by Mr. Muller

Switzerland has made it compulsory to wear safety belts as from 1 January 1976.

The question is :

1. whether it is necessary or desirable also to make it compulsory to equip vehicles with head restraints;

2. whether it is reasonable, despite the obligation to wear a seat belt, to require windscreens to be made of laminated glass ?

Question by Mr. Matthes

In the section on commercial vehicles and public transport, Dr. Mackay said that accidents in which a small car under-runs the rear of a lorry had been found to be a frequent cause of car occupant fatalities.

Is there data available on the frequency of this type of accident ?

Question by Mr. Teesdale

Would Dr. Mackay like to comment on the French proposal for the creation of a family of dummies having specialized tasks which are simple and give reproducible results, etc., rather than continuing endeavours to establish a single universal dummy that would necessarily be very complex and unsuitable for extreme dimensions (very large men or very small women) ?

Questions by Mr. LEFRANC

1. On page 34 of Mr. Mackay's paper there is a table on the cost-benefit ratio.

   On what bases is this table calculated (cost of equipment, socio-economic costs of the victims) ?

2. On page 43-44 Dr. Mackay speaks of a pause; should it not also be used for the wider dissemination of existing means : seat belts as compulsory equipment in light goods vehicles on the lines of recent proposals by the French authorities to the Commission.

3. Progress towards a method of improving road safety based on performance standards or overall tests is bound to take at least several years.

   Are we to understand that during this period nothing will be done to diminish the severity of side impacts ?

Reply by Mr. CHAPOUX

There is perhaps some further information to be obtained before giving a reply to this question. We have to know how people die on side impact; whether it is by brain concussion or penetrating injury. The measures to be taken are different in each case. Even if measures are taken to avoid serious penetrating injuries today, it cannot be ruled out that the problem will merely be shifted and subsequently people will die from brain concussion. We consider this an extremely difficult problem to solve and pending more precise data we have made various proposals. The results of experiments based on these proposals, that is regulations or draft directives such as the Interior Fittings Directive, help to solve these problems since all components coming into contact with the head (if death is caused by brain concussion) must have good energy-absorbing qualities.

Consequently we must not try to solve all the problems too hastily as there is then a risk of coming to a dead end and, having taken a step forward, being forced to move back again. I believe a decision should be taken rapidly on the proposals for the side impact test that we have put forward. This does not mean that we should do just anything so as to be able to say that we have done something. It must, of course, be useful. We do not yet have any proof that what we can do will be effective.

Mr. MACKAY'S answer

I think my difficulty now is that besides the questions which there are, the members of the panel also ask me a number of questions. Perhaps , therefore, if you would agree, I would like to say what I have concluded so far, in general terms, from the discussion and then go on to some specific points which might be useful.

It seems to me that there are four general conclusions so far. The first is an obvious and a simple one which relates to the tremendous importance of the use of seat belts, and it should be very clear that, at the technical level, it is impossible to provide any good protection in the future without supporting legislation on the compulsory use of seat belts.

Secondly, it seems to me that most people are in agreement that the next important priority is to produce a limited performance standard for specifying the seat belt, and technically this is quite possible now. The existing draft directive is most adequate and could in the very short term, therefore, be improved by putting it in the form of some performance standard.

Decisions will have to be made on the type of dummy that is to be used. The present proposed TNO dummy is inadequate but should one go for the American dummies called the 5/72 dummy for example, or some other, perhaps simpler or more repeatable dummy ?

Decisions will also be needed on the type of test, whether one could go directly to a total test in the car, and if it is a test in the car, what sort of test ? Is it a barrier test at 30° for example, or should one stay with a sled test but use a pulse for the sled test which is representative of some sort of barrier test maybe an angled one or possibly a symmetrical one ? The test will also specify chest, femur and abdominal injury criteria and it seems to me, as a general agreement, that this could be done very quickly. This will require the ad hoc group on restraint systems to look at the problem again and produce a new directive.

Beyond those two obvious first priorities, it seems to me you then get into the medium term where there are a whole number of problems and there is no clear view as to their priority, these are the problems of lateral impacts, collisions between cars of different masses, the question of light goods vehicles, be included in the restraint system specification, child restraints, the underrun problem. In the medium term too there is in the biomechanical area the problem of dummies. In relation to Mr. Teesdale's question, it does seem to me that dummy development has to go in two different directions. So for pure research purposes one needs a sophisticated dummy which you can use to evaluate response to different sorts of loading patterns. But for type-approval purposes, one probably needs a very much simpler device, perhaps two different devices : one for the frontal situation and another for the lateral situation. This seems to me an important area where research is needed, particularly for side impacts, to produce an acceptable device.

Coming back to a more general point which a number of people have made, I did not intend to say that there should be a pause in legislative action for ten years, while scientists deliberate on the perfect answer. All I was suggesting in putting forward a time period of ten years, was that it seems to me the knowledge that one needs for a total performance standard is going to take us ten years.

But in the interim, as I have already said, there are very high priorities where a limited performance standard, first of all for the frontal situation with seat belt can be developed, the lateral impact case, etc. I certainly did not mean to imply that there should be a moratorium on regulations. All I mean is that the regulations as they develop in the medium term must recognize that they are based on inadequate knowledge and should, therefore, be able to be adjusted as new information becomes available.

Mr. Lefranc enquires about the details of the cost-benefit analysis. I would refer him to my original studies and he could read the full paper, because it is a long and quite complicated procedure.

With regard to the frequency of underrun accidents which one person enquired about, there is data available on car occupant fatalities which shows the UK situation. Something around 15% of car occupant fatalities occur in the car versus the rear of some form of heavy vehicle. This perhaps varies considerably within the Community and it is based on small scale sample studies so it is not necessarily a very firm figure.

Mr. Müller states the fact that in Switzerland seat belts are required and as a consequence asks if head restraints are necessary. This is not connected in any way and one should consider the case for head restraints, I think, in terms of the whole field of priorities involved; the head restraints do not, in fact, rank very highly. I think the panels have indicated this, that they are not one of the major immediate demands that we should meet, that is not to say that we should discount them but there are perhaps higher priorities.

He also, and I remember other people too, asked about laminated glass in the situation where seat belts are worn and Dr. Seiffert commented that in his laboratory experience with his vehicles, the dummies did not contact the windscreen at all. He must have well-behaved dummies who have no slack in their belts, but in the real world people perhaps show a greater range of the way in which they wear belts. Altough undoubtedly the importance of the windscreen is diminished with high uses of seat belts, it does not seem to disappear entirely and one of the longer term effects is that prior to performance, standards are required, perhaps in future, for cars which may have different compartment shapes, the windscreen may well be involved and, therefore a head contact is still a consequence.

The other point which Dr. Seiffert was making, concerned the unrestrained occupant and he suggested an 80% use of belts was, in fact, a very good, high level of performance. I would certainly agree with that, but this does mean, for example, that 20% of the front seat occupants are going to be unrestrained, and when we are considering the priorities in the medium term for such items as head restraints, side impact protection etc., you may well find that the unrestrained occupant is perhaps still of more importance than the rear impact conditions, and again one should perhaps not discount the unrestrained occupant completely.

I have a general comment which comes out of what the biomechanic specialists among the members of the panel were saying. I make the point which has been made by several people that the population at risk varies tremendously. I have a note that says that age and sex make all the difference, and it is a fundamental difficulty to try and evaluate what proportion of the population at risk are going to be protected by a particular performance standard, and this is no easy problem to answer and again in the medium term, it requires looking at.

I think, Mr. Chairman, in the interests of time, that is perhaps all I should say, although undoubtedly I have missed some points. If you are happy with that, I would limit my comments there.

Question of Mr. BEKE

In the conclusions of the paper on page 27 it is written that the laminated windscreen is generally accepted as technically superior to other conventional windscreens (proven in extensive laboratory work and field accident studies). It has also been found that it reduces the frequency of laceration which can be balanced off against its higher cost. If the windscreen situation is regularly reviewed to allow an up-dating of performance standards and regulations as a result of new types being developed, knowing also that some European manufacturers have been using laminated windscreens for a long time and others decided to move towards the general use of laminated windscreens shortly, we wonder why no official decision has been taken in the Common Market to generalize the use of laminated windscreen on new vehicles.

Answer of Mr. SCHLÖSSER

The answer is quite simple. The Commission has elaborated a proposal which has gone to Parliament and the Economic and Social Committee, and which is now before the Council for decision. When the Council will decide is unknown but this is all I can say on the present situation.

Question of Mr. BRENKEN

The rapporteur, Mr. Mackay, has formulated some very important recommendation concerning future action in the legislative field. First of all : pause in legislative action; next goal : total performance standards within ten years; in the meantime : critical review of standards, research on test conditions, biochemical data and dummies. BPICA supports these conclusions. What is the opinion of the Commission and of the Governments of the Member States ?

Answer of Mr. SCHLÖSSER

It is not possible for me, as you will understand, to give you the opinion of the Member States. As far as the Commission is concerned, you will realise that we could not in the midst of a symposium already draw very definitive conclusions as to what the outcome of the discussions and deliberations are. We have the tendency to listen with interest, critical interest, to any proposal, to any suggestion being made, but the exploitation of the results of the symposium will certainly take some time and certainly not be made during this week.

Question by Mr. MARTINO

I have heard consumer representatives say several times this morning that the level of existing knowledge is adequate for the preparation of preliminary proposals regarding vehicle strength performance to provide better protection for occupants. There has even been mention of integrated tests. This is all very well and is very interesting but as a representative of consumers, that is to say users of véhicles, I would like to know how the manufacturers group, and in particular the CCMC of which we have heard so much and which claims that its task is to approach the countries and in particular the Commission to obtain a better scientific basis to the regulations, intends to make the results available to those who prepare these regulations. I stress the words "make available" all the results of the research, even those which might not be quite in line with certain existing design , rather than carefully prepared summaries which are perhaps very interesting but do not give those responsible for issuing regulations a knowledge of all the objective data.

Reply by Mr. SCHLOESSER and conclusions

I would reply briefly that in the course of our cooperation with the CCMC and other groups supplying data, we have not had the impression that they refuse to let us have the data we want. I should also like to point out that in the internal Community procedures consumers are represented at all levels of the preparatory work on our directives and it seems to me that here Mr. Martino is asking a theoretical question.

Ladies and gentlemen, I think that we have now reached the end of our session. I should like myself to express a few comments that have emerged from our discussions this morning.

I believe that there is a general tendency to move towards the performance standard that would make it possible to assess the effectiveness of the methods used on the basis of criteria regarding the tolerance of the hyman body and by means of standard impact tests. Obviously the time has not yet come for the preparation of performance standards in Europe, partly because scientific and biomechanical knowledge is not yet at a stage where experts can be expected to agree on human tolerance criteria and partly because the status of accident analyses and statistical analyses is not yet adequate for the definition of a standardized impact test method to verify that tolerance limits are observed by a given protection system. It is obvious that if a performance standard system is adopted test methods will become all the more important, expecially harmonized test methods in those countries which are expected to apply these performance standards.

I believe that the next ten years must be considered as a transitional period during which existing design standards must be evaluated. There is first of all leeway to be made up in some fields; further directives still have to be adopted to complete the first generation and at the same time improvements could also be made to existing standards (we heard suggestions on these lines this morning). I do not rule out the possibility of making an attempt at this stage, where conditions are ripe, to move towards performance standards in specific cases instead of design rules. Community action should first be concentrated on reducing the number of serious or fatal accidents suffered by vehicle occupants. A suitable method of establishing an order of priority for the measures to be undertaken would be to use cost-effectiveness comparisons to seek the most economic technical means of attaining this aim. A preliminary condition for this must be the adoption and implementation as soon as possible of the two proposals for directives on safety belts and anchorage points for, as Dr. Mackay has just said, no one has challenged the usefulness of safety belts. The next stage should be to improve the comfort and above all acceptability of safety belts for although the figure of 80% may appear high, it nevertheless leaves 20% who for reasons that are not yet known do not wish to wear or do not wear their safety belts.

In this context, an increase in acceptability is obviously an aspect that cannot be ignored. The work should be based as far as possible on suitable criteria enabling these improvements to be carried out, by the specification of geometrical positions for the loads transmitted to the user in the event of accident. This would already be a preliminary step in the direction of performance standards. Later moves towards the performance standard could take the form of requirements that could be satisfied both by safety belts and by more advanced restraint systems that would in^rease the effectiveness of occupant protection.

However, despite these improvements and the obligation to wear safety belts in most of our Member States, as we have heard several times, the percentage use of belts will remain sufficiently low for a transitional period for unprotected occupants to have a substantial influence on accident statistics. For this reason, it will be essential to improve the requirements in existing directives concerning the parts of the vehicle with which unprotected occupants may come into contact in the event of accident. For example, the steering wheel, on which Professor Goegler expressed his doubts so eloquently just now, windscreens and interior fittings in general. Obviously, as the improvements I have just mentioned as subjects for action are introduced into existing regulations during the transitional period, it will become necessary to have suitable impact tests, criteria for injury and human tolerance and dummies representing the human response. I do not think it necessary for me to go into further detail on the problems concerning the "dummy phenomenon" which was extensively discussed this morning. A combined research and development effort by the persons concerned is undoubtedly essential at Community level to throw light on various subjects so that regulations can be drafted in the next five, six or seven years.

It is first necessary to carry out collision tests, in particular with frontal impact which statistics show to be the most frequent, so as to permit verification on the test bench of the performance of restraint systems mounted in certain type of vehicle, using the curve of its actual deceleration in such an accident. At the same time it is necessary to define injury and tolerance criteria, in particular for the four parts of the human body mentioned this morning (the head, thorax, abdomen and femur), and a test dummy representative of human reactions to the various accident stresses and capable of supplying reproducible results at reasonable cost.

In so far as future regulations will reflect the most recent scientific data, the present design of vehicles will probably prove to be far from optimum.

Consequently, provision must be made for sufficiently long lead times between the publication of these regulations and their implementation to allow industry to find design solutions suited to their traditional production range and above all to allow industry to adapt to new constraints regarded as absolutely essential by the public authorities. These are the first conclusions that I have derived from your discussions. I must say that this has been of benefit to me personally and gives us much food for thought in the weeks to come.

I should like to thank Dr. Mackay for his excellent preparatory work and for the fascinating discussion he stimulated both amongst the members of the panel and amongst the audience. I also wish to thank the members of the panel who took the trouble to study this paper carefully and give us the benefit of their views on the subject.

CONCLUSIONS OF SESSION 3

by

Dr. G.M. Mackay

The contributions from the members of the panel following my report, lead to a most useful discussion, from which the following points can be extracted, on which there appeared to be a reasonable concensus of opinion :

1. It is vital for the successful protection of car occupants that the highest possible use of seat belts is achieved. This requires those member countries of the EEC which do not have laws for the compulsory use of belts, to make every effort to introduce such laws as soon as possible. It is impossible at the technical level to provide simultaneously adequate safety design for both the restrained and the unrestrained occupants. The use of seat belts is paramount.

2. It is desirable in the long term that any regulations controlling occupant protection should be written in the form of performance standards. The standards should be specified in terms of acceptable injury tolerance levels measured in realistic standard tests. We should thus change from specifying design rules for separate components of the car (the seat belt, the steering assembly and the windscreen) and aim towards "comprehensive performance standards" in which injury criteria for given input test conditions are examined on dummies or similar test devices.

3. At the present time in Europe it is premature to attempt to establish comprehensive performance standards for occupant protection. Scientific and biomechanical knowledge is at the moment inadequate for the establishment of generally applicable injury criteria and the means used to measure them. Also the state of accident analysis does not yet allow a good definition of the appropriate types of crash tests which should be used, and the impact speeds of those tests.

4. The next ten years should be considered as a transition period during which current standards should evolve towards performance standards when possible as new knowledge is acquired from accident research and from biomechanical experiments.

5. Initially Community action should concentrate on reducing the number of fatal and serious vehicle occupant casualties. Cost effective comparisons should be used in establishing the order of priorities for the several measures to be taken, so that the most economic technical solutions are produced to achieve the target reductions in deaths and injuries. However, the limitations of strict cost benefit analyses of deaths and injuries should be kept in mind, because of the inherent inadequacy of cost benefit techniques in this field. This should be remembered particularly when child casualties are considered.

6. In the short term the first priority in legislation should be that a draft directive on seat belts is adopted and implemented as soon as possible. Thereafter the directive should be improved in the light of

new data which are becoming available; at the same time, one should aim at making seat belts more confortable and acceptable in everyday use.

7. Next, progress should be made quickly towards a performance standard for the restraint system, tested as part of the total car structure. This will allow the development of more advanced restraint systems and more efficient optimisation of the seat belt, the vehicle geometry and the vehicle front structure.

8. In spite of anticipated high usage rates of seat belts and better crash performance of the systems, in the transition period, unrestrained occupants will still be present frequently enough to be of some consequence in establishing the priorities of occupant protection. It follows that existing directives which specify the steering assembly, the windscreen and the interior fittings for example, should, whilst evolving towards a comprehensive performance standard, still recognise the problem of the unrestrained occupant.

9. Whilst the improvements mentioned above are introduced into existing regulations over the transition period, it is necessary to agree on the appropriate conditions for crash tests, the criteria for injury and the test devices to be used. A concerted effort in research and development at Community level is needed to specify :

   a) The nature and severity of the crash tests to be used, and in the case of sled tests the shape of the deceleration pulse most appropriate to the real accident situation, for each type of car;

   b) The nature of the injury criteria, and the appropriate tolerance levels for the head, the thorax, the abdomen and the femur;

   c) The development of suitable test devices - dummies which reflect adequately the required human response to collision forces in the directions of loading considered to be important, and at the same time provide reasonably reproducable performance.

10. Future regulations should reflect the most up-to-date scientific knowledge. In consequence, it is inevitable that existing vehicle design will be shown to be less than optimal. Therefore lead times for the introduction of new requirements must be sufficient for industry to adjust to the necessary consequences. This problem may well become more acute because of energy and material conservation considerations discussed in the other sessions of this Symposium.

11. The research and development effort mentioned above should go hand in hand with discussions and exchanges of information on as wide an international scale as possible. In particular it is important to explore the problems which are common to and those which separate the United States and the European Community. Existing trends suggest that in ten years time, the differences between accident characteristics and vehicle design on the two continents may well diminish greatly.

12. Finally, the great importance of monitoring the effectiveness of Directives was emphasized. It is essential that sufficient research is conducted to establish the actual performance of such Directives in the

real world, and that procedures should exist so that deficiencies which are detected can be corrected.

FOURTH SESSION

ACCIDENT PREVENTION

ACCIDENT PREVENTION BY SUITABLE VEHICLE DESIGN

Active safety, braking, road holding, tyres,

Lighting systems, field of vision, etc.

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REPORT OF Mr. MITSCHKE

PREVENTION OF ACCIDENTS BY MEANS OF SUITABLE VEHICLE DESIGN

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From 9 to 12 December 1975 the Commission of the European Communities is holding a "European Symposium on Trends in Regulations concerning Motor Vehicle Design" in Brussels. "Session 4" is concerned with the subject given in the heading, in other words with active safety, brakes, handling, tyres, field of vision, etc.

I. INTRODUCTION

To begin with the complexity of the subject must be pointed out.

It is the Commission's task to draw up common legal provisions for the countries of the European Economic Community. Amongst other things these should serve to eliminate barriers to trade. The article of trade in question here is the motor vehicle.

The subject of this paper is active safety. Its task is to reduce the number of accidents.

A connection must now be sought between reducing the number of accidents and improving the "article of trade", i.e., the motor vehicle. If, as is often the case, improving the car is equated with reducing the number of technical defects then such a connection barely exists: according to the statistics only 2-3% of all accidents are due to technical defects. Rather, the chief cause of accidents is the driver or traffic conditions, followed by road conditions and the weather.

This surely already demonstrates very clearly that it is not worth promulgating laws on motor vehicles with the aim of reducing the number of technical defects even further since, even if these measures were to be fully effective, the number of accidents would hardly decrease.

We should, rather, try to reduce the main causes, that is, train man, the driver (the pedestrian and cyclist, too), and improve the roads, road management, regulate traffic conditions and mitigate the influence of the weather on traffic. However, this is not the duty of the motor-vehicle engineer or at least not his alone - teachers, psychologists, road builders and traffic engineers should all be involved. On the basis of statistical data, the work of the motor-vehicle-engineer in the field of active safety must concentrate on adapting the motor-vehicle to the man, the traffic and the weather in such a way as to reduce the number of accidents. Similarly it is the duty of lawmakers to draw up regulations which do justice to this adaptation of the car to man, the traffic and the weather. To restate the matter, the main object of a regulation cannot be to reduce the number of technical defects.

Hence in what follows the question to be answered is:

> What regulations for motor vehicles have been, or have yet to be, drawn up in order to help reduce the number of accidents?

Figure 1 shows the factors influencing active safety, namely the vehicle, driver and environment (road, traffic, weather). In addition, as in Reference /3/, active safety has been divided into four groups - driving safety, perceptional safety, safe conditions and operating safety.

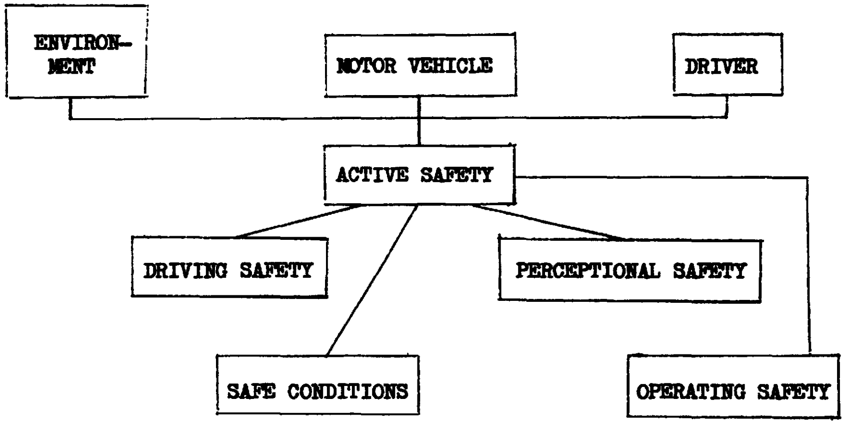

Figure 1: Factors influencing active safety; its components

Driving safety means the road behaviour of the motor vehicle, particularly, in this case, its adaptation to the driver and traffic. The effect of any measures to ensure safe conditions should be to maintain a properly qualified driver in a suitable physical and psychological condition. Perceptional safety includes seeing and being seen and, where acoustic signals are concerned, hearing and being heard. Operating safety requires devices which are easy to reach and use as well as operating and warning signals to indicate the malfunctioning of an important element of the vehicle.

Having made these general introductory remarks, we now come to the individual points which the Commission of the European Communities has specially requested should be examined and which are therefore of interest to it.

II. SALIENT FEATURES OF EXISTING PROVISIONS AND DRAFT PROVISIONS IN THE MEMBER STATES OF THE COMMUNITY

At the outset of the EEC's labours an EEC Type-Approval Certificate was instituted (Directive 70/156/EEC). It may be assumed that all the points included in it are part of the national laws. Under the Certificate system specific component groups of any motor vehicle must be tested. Of the 12 items listed there the following are important in connection with active safety:

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5. Axles
6. Suspension (tyres, springing parts of the suspension)
7. Steering
8. Brakes (many sub-sections)
9. Bodywork (field of vision, rear-view mirrors, controls)
10. Lighting and light signalling devices
11. Connections between drawing vehicles and trailers or semi-trailers
12. Miscellaneous (audible warning devices)

Of these groups the ones underlined have been published in the Official Journal of the European Communities (see Reference 4).

The rules on brakes (Directives 71/320, 74/132 and 75/524/EEC) which are the most extensive body of law so far, consist of provisions governing construction and operation.

The aim is to achieve safety in the use, and reliability in the effect of brakes by means of extensive provisions governing construction. Terms such as "resistance to ageing and corrosion" are used. The most important characteristic of a braking system is partial redundancy. Taking the example of a dual-circuit brake system this means that when one circuit fails, a fraction of the vehicle's normal deceleration can still be achieved.

Provisions governing operation (which are just as extensive as those on construction) are either identified as such or appear in the form of test requirements. As regards safety during braking, these provisions boil down to the following order of priorities,

1) directional stability when running straight;
2) short stopping distance;
3) steerability whilst braking.

The first of these requires accentuating; it relates to a characteristic of a motor vehicle which is a decisive factor in driver/vehicle interaction and can therefore help to reduce the accident figures.

Another important point in the rules on braking systems arises in the section dealing with road trains and articulated lorries. It is characteristic of the EEC rules that they take to cognizance of road trains. It is based on the assumption that any type-approved trailer behind any type-approved drawing vehicle must produce adequate retardation of the whole outfit. In order to achieve this, a specified retardation is assigned to the drawing and drawn vehicles. This is done through the medium of the pressure at the brake line coupling in a dual-circuit braking system. This dictates the distribution of braking force between the drawing vehicle and trailer. The differential retardation, that is, the longitudinal force (on the coupling) between the two vehicles is therefore limited.

The much shorter directive on <u>steering equipment</u> (70/311/EEC) also includes provisions governing construction and operation. Minimum user comfort is quantified by limiting the operating force required.

The driver is not apprised of failure of power-assisted steering; it takes him by surprise and is indicated by higher steering forces, although an upper limit for them is specified. The directive on <u>audible warning devices</u> (70/388/EEC) requires endurance tests as well as checks on effectiveness and operation.

For <u>rear-view mirrors</u>, the Directive (71/127/EEC) essentially prescribes the field of vision of importance to the driver.

To summarize, the following points from EC Directives enacted so far should be noted:

Perceptional safety is the matter at stake only in connection with audible warning devices and rear-view mirrors, safety in respect of conditions, only through the laying-down of maximum forces required for the steering and braking systems, and safety in driving (as defined, i.e., that the vehicle is not to be regarded in isolation) only in connection with the braking system. On the basis of what was said in section 1 this is all very correct. On the other hand, the lack of indication of failure of a power-assistance system (i.e. the driver receives no advance warning of the sudden increase in operating force) seems less than sensible. So does the requirement for an endurance test.

It is possible to generalize the rules governing the braking systems of road trains and articulated lorries: there should be a requirement that discreet vehicles which can be coupled to form road trains but are separately type-approved should be matched. (A fresh example is provided by the handling of the car and trailer caravan combination common on the roads nowadays.)

III. THE SITUATION IN THE EEC COMPARED WITH THE MAJOR NON-MEMBER COUNTRIES

These non-member countries can be divided into (a) European countries and (b) the USA, Canada and Australia.

The European countries work together in the UN Economic Commission for Europe (ECE). In addition to the EEC countries, ECE members include the countries of Northern Europe, Spain and the Eastern Bloc. As a general rule the EEC and the ECE handle similar topics and come to similar conclusions. Consequently, this section should be devoted chiefly to the US standards (MVSS) and the Australian provisions (ADR).

In both the USA and Australia the required stopping distances (to MVSS 105 and ADR 31) are shorter than in the EEC. The only rules regarding directional stability are that the vehicle must keep within a lane of specified width during braking and the wheels must not lock. It is obvious that the USA sets great store by testing brake components. A typical example is the testing of brake hoses (MVSS 106) for resistance to stretch and bursting strength, tensile and fatigue strength, the effect of absorption, temperature and much more besides.

One could also include the testing of brake linings to SAE J 661a which is mandatory in some States of the USA but it would be wrong to do so as this primarily concerns spare parts, the subsequent embodiment of a vehicle component. This test is intended to ensure that worn linings are replaced by new and suitable ones which meet minimum requirements.

In the USA the rules concerning steering equipment are chiefly concerned with aspects of passive safety. In Australia (Draft Regulation 113 or 114), where they drive on the left, only right-hand drive vehicles are allowed by law, which can be ascribed to active safety.

There are several US standards concerning tyres (MVSS 109, 110, 117 and 119). For example tests are carried out to assess resistance to side forces and to see whether a tyre bursts under radial load. In addition to a high-speed test tyres have to undergo an endurance test lasting several hours (up to 24). This is not included in the test requirements being prepared by the EEC and the ECE. In the USA safety criteria (MVSS 117) are also laid down for retreads.

The USA also has very detailed rules (MVSS 108) concerning lights. We shall discuss the differences between these provisions and those of the ECE in the panel discussion.

Like the EEC provisions, MVSS 111 concerning rear-view mirrors gives a precise description of the field of vision to the rear. The field of vision towards the front, which is even more important as far as safety is concerned, is dealt with in the US standards (MVSS 104 and 103) which prescribe the field of vision to be kept clear by the windscreen wipers and (in winter) the windscreen defrosting system.

Unlike the EEC provisions MVSS 101 lays down requirements concerning the controls. They must be easy to locate and handle at all times so as to distract safety-belted drivers as little as possible from their other tasks. On the other hand, standard control positions are not required, though they would appear to be a good idea and facilitate drivers' adaptation to another vehicle (first and second cars, private and company cars). A small step in this direction has been made by introducing a standard gear shift lay-out (MVSS 102).

In this section mention should also be made of the experimental safety vehicles (ESV). In addition to the above-mentioned rules provisions have also been introduced concerning the handling of motor vehicles, e.g. driving in a circle, turning into the circle, self-centring of the steering equipment, sensitivity to irregularities in the surface, roll limit.

Conclusion

The US provisions have been regarded as the most important for the purpose of making a comparison with EEC provisions. The US standards are more numerous than the EEC Directives, extending to tyres, the field of vision through the windscreen, lights and controls.

As little is being done in the USA regarding driving safety, many provisions have been laid down concerning the approval of motor vehicle components. Although not embodied in standards, some good thinking has been done in the USA about the handling of motor vehicles and the testing of the major spare parts.

IV. WHAT THE COMMUNITY IS DOING: INFLUENCE ON TRAFFIC SAFETY

If what the Community is doing has had a good influence the number of accidents should have dropped in absolute or at least relative terms. It would have had either no influence at all or a bad influence if total accidents had not fallen or had even risen. It is impossible to establish such a correlation at the moment firstly because the directives adopted so far have not been in operation long enough and are too few, secondly because the meagre accident statistics at our disposal do not explain the causes of accidents satisfactorily.

Accordingly, all that we can do at the moment is attempt to find out whether or not the causes shown to be important by the information available have been tackled in the directives.

It is clear from various sets of accident statistics that the causes of accidents are in order of decreasing importance:
(a) drivers, (b) weather and road conditions, (c) technical defects in vehicles
Although the figures differ from one set of statistics to another the driver is named as the cause in well over 50% of all cases. Some offences, such as being drunk in charge of a vehicle, have nothing to do with inadequate active vehicle safety. However, it is the possible cause of other driving offences such as coming off the road.

In Table 1 Vallin /2/ gives examples of where there is a connection between the driver, the vehicle and the rules and regulations and cases where there is no such connection. In only 37.8% of the 486 serious accidents analysed were the brakes applied beforehand, which means that it is only in such cases that an effective law concerning brakes, possibly supplemented by provisions concerning automatic anti-locking devices, can bring down the number of accidents. There is an EEC law on braking. The only way to ameliorate "skidding, brakes not applied" is improved vehicle handling or for the vehicle to be better adopted to the driver in this area. There is no EEC law on the subject. In 34.4% of cases of "no skidding, brakes not applied" it is probable that the vehicle is not at fault, but rather the driver has been inattentive.

	What happened before the accident	Brakes applied, skidding	Brakes applied, no skidding	Skidding, brakes not applied	No skidding, brakes not applied
Information given by Vallin [2]	% of serious accidents	14,3	23,5	27,8	34,4
Could have been avoided by	Better braking (devices incorporation of automatic anti-locking devices)	x	(x)		
	Better vehicle handling or better vehicle/driver matching			x	
	More attentive driving, not by a more efficient vehicle				x

Table 1 Analysis of 486 serious accidents indicating how they might have been avoided.

Analysis of 63,084 reports on accidents involving serious injuries in the records of the German HUK insurance association [1] shows that vehicle defects played a role in only 2.9% of all cases. Although this category does not appear important it has been broken down in Table 2 to establish a link with the EEC provisions.

Cause	Number	Main consequence	EEC provision
Tyres	670	Coming off the road	no
Load	348	Various	no
Brakes	271	Collision	yes
Lights			draft
Headlights	61	Passive accident	
Rear lights	117	Passive accident	
Indicator lights	44	Branching off, turning	
Braking lights	14	-	
Steering	44	Coming off the road	yes
Coupling	19	-	no
Misted or frosted windscreen	63	Coming off the road	no
Windscreen wipers	8	-	no
Other causes	92	-	-

Table 2 In a total of 63,084 accidents involving serious injuries these were the causes attributable to technical defects in the vehicle.

It can be seen from this that only a few of the causes are covered by directives. But even when there are provisions, concerning steering equipment for example, they are not capable of reducing the number of cases of "coming off the road", and some of the "brakes" cases are attributable to worn braking devices. Changes in vehicle design or improved rules and regulations concerning the type approval of vehicles would do nothing to change the situation. Improved maintenance is the answer.

Apart from accident statistics, information on the major technical defects in vehicles can be obtained from court reports and assessments. The following defects are often reported:

Tyres (worn smooth; under inflation; mixing of tyres (summer/winter, radial-ply/cross-ply), exceeding the maximum safe speed)

Weight (overloading, exceeding the permissible towed load).

Trailer coupling (not closed, not secured).

Braking devices (worn linings; chafed, bent or swollen hoses; leaky brake pipes; laden/unladen sensor valve on the trailer out of adjustment;
corroded and leaky brake cylinder).

Lights (headlights) dirty or out of adjustment; bulb wrongly fitted.

Basically, most of these are maintenance and operating defects and in many cases more than one is present at the same time.

Let us examine the consequences of mixing tyres in greater detail. Tyre characteristics play a mojor role in determining how a vehiele behaves. If the front tyres are of a different type from the rear tyres - having consequently a great difference in side force/drift behaviour - the vehicle's cornering characteristics might be adversely affected. Consequently, it should be concluded that rules concerning tyres must be examined from the angle of the vehicle as a whole and not in isolation.

Conclusion

As it is not (yet) possible to assessthe influence that the work of the Community has had on traffic safety, thought has been given, on the basis of accident statistics and reports and assessments, to whether there is a relationship between the causes of accidents and EEC legislation.

The causes are mainly the result of human failings, either on the part of the driver (while driving) or of the driver or owner of the vehicle in the form of inadequate maintenance. Little if any account has been taken in the existing EEC rules (except those on braking devices) for the need for vehicles to be adapted to drivers.

V. CURRENT RESEARCH AND DEVELOPMENTS IN TECHNIQUES

The conclusion drawn from the hierarchy of accident causes given in the previous section is that it is not enough to improve the vehicle: it, the driver and the traffic and weather conditions must be simultaneously considered.

Consequently, research work is being carried out all over the world into the driver/vehicle control loop depicted in Figure 2.

The vehicle and the driver are each represented by a bleek. From the vehicle information impinges on the driver, e.g., visual information (vehicle does not go where the driver intends it to) or lateral accelerations or forces are transmitted to the arms via the steering wheel. There is also external information: the route of the road, vehicles and pedestrians on the road. The driver influences the vehicle via the steering wheel, accelerator and brake pedal.

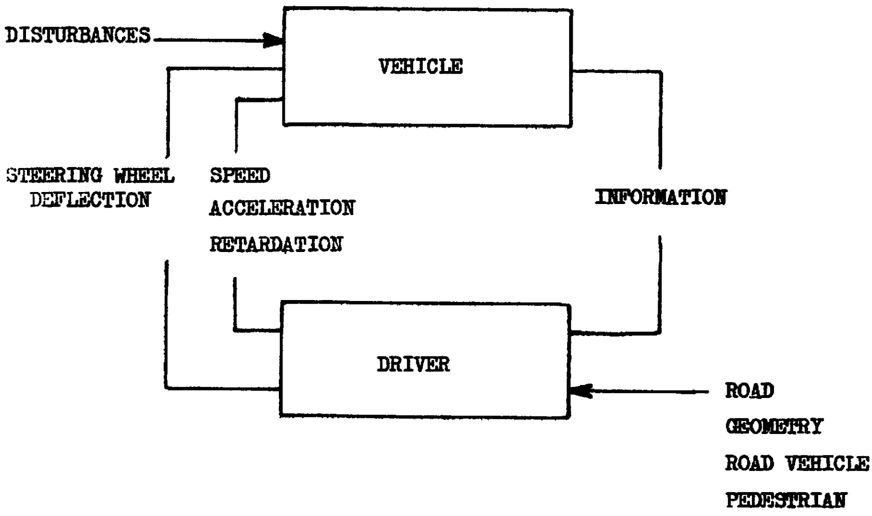

Figure 2: Driver-vehicle control loop

Disturbances such as cross winds, road irregularities, or irregularities in the vehicle itself can also affect the vehicle. This total system - called a control loop - must be harmonized so that - in simple terms - as little as possible can go wrong.

In order to do this, the two blocks - vehicle and driver - must be simulated on the computer; this can only be done if they can be expressed in mathematical terms.

Firstly, an attempt is made to establish the characteristics of Man so that the vehicle can later be attuned to him. However, since it is not yet possible to record human qualities, only the road behaviour of the vehicle must be investigated. Current R&D work therefore has the following aims:

a) to endow the vehicle with great accuracy of control in all driving conditions combined with the greatest possible ease of operation;

b) to make the vehicle as resistant as possible to disturbances.

In order to achieve these aims, vehicle behaviour in various combinations of driving conditions and disturbances is investigated.

Examples of this are:

Driving conditions:	straight-running, cornering, driving at a constant speed, acceleration or braking;
Disturbances:	extraneous: cross wind, road irregularities, reduced coefficient of adhesion on wet or icy roads;
	internal: breakdown or malfunction of individual vehicle components or systems (brake failure, non-uniformity of tyres, play in steering).

Current R&D work in this field is concentrated on the following three sectors:

1. Development of mathematical models which can describe vehicle behaviour in all the driving conditions and with all the disturbances mentioned above.
2. Development of uniform testing methods to measure important characteristic quantities and functions of the vehicle under road (or track) test conditions.
3. Research into human control behaviour when driving the vehicle with a view to adapting vehicle dynamics to human characteristics and abilities.

The present status of R&D work in these three sectors is described briefly below.

1: Mathematical vehicle models are required primarily for basic research into the effect of vehicle design on road behaviour. They also provide the basis for developing the testing methods referred to in 2. and represent an important element in the driving simulators increasingly used in recent years.

The models of straight running now available can describe sufficiently accurately the effect of steering commands (control) and cross wind (disturbance) on even road surfaces and at a constant speed.

Mathematic models of extreme driving conditions exist, e.g. combined steering and braking (braking when cornering), but they are not yet sufficiently developed. There are also no mathematical models for a theoretical investigation into the

effect of road-surface irregularities on vehicle behaviour; and the feedback effect of road-surface irregularities, via the dynamic wheel load and stress on the road, on the state of the latter.

Effect and feedback effect depend primarily upon the dimensions, weights and speeds in the EEC type-approval certificate.

Research into dynamic tyre behaviour and corresponding road stress, in particular, is needed to complete the theory, with the effect of changing circumferential, lateral and vertical forces investigated in both cases.

2. The present development status of uniform testing methods for vehicle dynamics is fully up to the level of theoretical knowledge.

   Uniform testing methods are currently being prepared on an international level for driving conditions, the theory of which has been adequately researched. These include the vehicle tests now being developed by the ISO (turning test, transient response test).

   It is much more difficult to develop other important test methods for critical driving situations, such as braking when cornering, since the requisite theoretical basis is not complete.

3. Man and vehicle form a closed control loop which is subject to external disturbances. The control loop works well if the driver and vehicle are attuned. Before they can be matched, generally applicable information about the control behaviour of a car driver is required. This can only be acquired by means of relatively lengthy measurements during test drives or on the driving simulator. However, the theoretical basis necessary for the interpretation of the results is not yet complete.

Work in this field is now in progress at various establishments.

The probability of failure has received closer attention since space flight began. It can also be applied to the active safety of vehicles, becoming a study of the probability of accidents. It should be remembered that in the driver/vehicle control loop shown in Figure 2 the driver is the main cause of accidents, i.e., he frequently fails.

This can be seen in a comparison: if an important component, say, in a rocket for the Moon mission, failed as frequently, the flight would not take place or an additional unit would be fitted, for safety reasons, to take over if the original unit failed. This produces a so-called redundant system.

These principles can be applied to road safety. A redundant system, installed in parallel with the unreliable driver, can do the work if the human "fails" or prevent an accident occurring. The total system - again in block-diagram form - can be seen in Figure 3.

Such a system exists: the automatic anti-locking device. If the driver presses too hard on his brake pedal the wheels stop turning (i.e., they lock) and the vehicle slides, with impeded control.

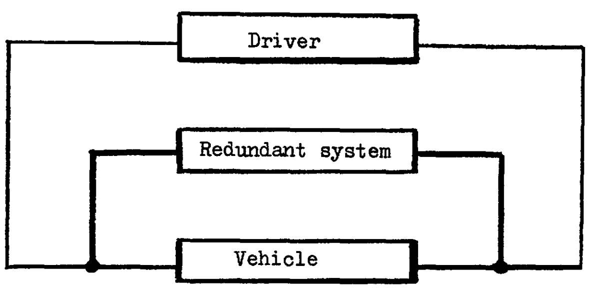

Figure 3 Driver/vehicle/redundant system control loop.

An additional system would prevent the effects of the driver's mistake. In a vehicle fitted with an automatic anti-locking device the wheels do not lock, however hard the driver presses the brake pedal.

In conclusion, it can be said that R&D to enhance active safety needed in the fields of the driver/vehicle control loop, the description of vehicle behaviour, the development of test methods and accident probability is far from complete.

6. New legislative requirements

That accidents caused solely by technical defects in the vehicle are relatively rare compared to the total number runs like a red thread, especially through the last few sections. Most accidents are due to driver error.

Any future legislative requirements must take this fact into account. Consequently, any important new legislation must not relate to the vehicle alone but to the vehicle in combination with its driver.

A good example to begin with concerns the vehicle deceleration rates and wheel-locking sequences laid down in the EC Directive on braking systems, in conditions of reduced coefficients of adhesion. When the brakes are operated, directional stability is required at the expense of a shorter stopping distance, and this in turn at the expense of steerability. These priorities take into account the driver's poor control characteristics.

Similar action should also be taken in other fields. It is proposed that requirements relating to vehicle behaviour should be set. They should concern selected, clearly defined driving conditions and should be applicable both to discreet vehicles and combinations of vehicles (road trains, articulated lorries and passenger cars with caravans).

In addition, requirements should be set with regard to changes in the behaviour of a vehicle during its lifetime. This would be intended to prevent balance of vehicle behaviour from being upset when the tyres are changed, e.g., through ill-chosen or arranged tyres. The same applies to the effect on braking behaviour of the replacement of worn brake linings. Other examples could certainly be found. Attention must be drawn to the fact that test requirements should take into account driving not only on dry roads but also on wet and icy roads, that the driver should be given prior warning of any failures, and that the installation of redundant systems is the best means whereby the driver can be eliminated as the principal cause of accidents.

Directives on lights and the field of vision (in the widest sense of the term) should be issued in order to increase perceptional safety.

7. Means of meeting the requirements

Some of the requirements set out in section 6 are new, e.g.

Adaptation of the vehicle to the driver;
Definition and examination of the road behaviour of the vehicle;
Driver redundancy.

Any they could be filled by action in the following sequence :

Definition and conceptual design stage;
Research work; and, concurrently :
Compilation of more accurate accident statistics;
Formulation of rules on vehicle testing;
Drawing-up of Directives.

8. Summary and conclusions

An attempt is made in this paper to suggest legal provisions relating to active safety of vehicles which can reduce the number of accidents. Active safety was first broken down into driving safety, perceptional safety, safe conditions and operating safety; it was pointed out that most accidents are caused by the driver; technical faults in the vehicle are the least common cause. It would therefore be pointless to improve active safety as meaning mainly the reduction of technical faults. A more effective solution would be to adapt the vehicle to (Fallible) man, and to traffic and weather conditions.

If the rules in force in the EC, ECE and USA are compared with this requirement, it is found that they often deal with technical details. This is wrong. A change of ideas is required here. The control loop (driver - vehicle - environment) must be viewed as a whole, and should this not yet be possible because research findings are still lacking, the vehicle should at least be viewed as a unit.

The EC Directive on braking devices can be regarded as a good start in this connection. As regards driving safety, it is proposed that requirements relating to road behaviour should also be set.

The rules should not be applicable only to brand new vehicles; checks are also important, and it must be remembered that in certain circumstances the driving characteristics of a vehicle may be adversely affected on replacement of important components.

As far as perceptional safety is concerned, directives on lights and field of vision, in the widest sense, are to be adopted soon. Requirements for increasing the safety of in-vehicle conditions and operating safety are few.

Better accident statistics are required before the effect on the enhancement of road safety of the EC's work can be gauged.

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DISCUSSION BY THE PANEL

Intervention by Mr Pocci

First I shall say a few words about the historical background, then I shall make some comments on the main paper and I shall finish with some ideas on active safety so as to give the widest possible picture of the problems concerning active or primary safety.

I shall start by commenting on what has been said about the Directive on braking, which I always regard as "Geneva Regulation 13" as I am one of those who took an active part in the drafting of this document over several years. It is necessary to find a compromise among the various braking requirements : the brake must be efficient when cold, be capable of working efficiently when hot, must not act too suddenly in emergencies, etc.

The difficulty was not so much to prepare design specifications as to define performances in such a way as to prevent the construction of poor brakes.

As for the driver, I share the rapporteur's views. He must be informed. For example, most drivers do not realize that after a few miles on the motorway in damp conditions the first touch on the brakes has no effect. If you drive on country roads with drum brakes, once again the first touch on the brake is ineffective because of the dust that accumulates in the drum. The more powerful the brake, the more difficult it is to obtain good braking - good braking being braking that acts at the right moment.

Another exemple : a good driver with a driving licence buys a very well made car. When he finds himself in a situation where emergency braking is needed - for the first time - because of a tree, a motorcyclist or some other obstacle, what does he do ? He stands on the brake and starts to skid out of control left and right. To prevent this, we need something that is just starting to be done in some countries - instruction in gradual braking. The driver is put on a track with obstacles that are not dangerous, such as cardboard or rubber boxes, and learns how to brake in emergencies, both on a dry road and on an icy or wet road. Thus the first time he has to carry out a difficult manoeuvre he will do it safely and not under panic conditions.

This is one of the aspects of familiarizing the driver with his vehicle. I disagree with the rapporteur's statement, as the end of his paper, that the specifications are rather too concerned with technical details. I believe that if safety is to be improved there must be a lot of details. For example, my experience of flying during the War showed me that all aircraft accidents were caused by a mass of small things that did not work. An aircraft never crashed because a structural part gave way, an engine never failed because of a connecting rod. The accidents were caused by malfunctioning of an item of equipment, an accessory. The same applies to motor vehicles.

I remember in the past, for I also played a small part in the historical scene, that at the FISITA Congress in Paris in 1958 I read a paper defending equipment and accessories and I showed that real progress consisted in improving all these little details.

Now for the historical background. We are in Brussels. All this technical vehicle legislation at international level started here in the early 'fifties.

It started in a rather odd way. If someone bought a headlight and then decided to fit it with a vehicle, everyone would think he was mad. But there were madmen who started with headlights and from there progressed to complete vehicles. All these procedural questions concerning international standards started with the study on the European dipped lights which are now fitted to our cars. Later they were extended to other things, to brakes and other equipment. Consequently Brussels has played a historical part in automobile history, as far regulations are concerned.

There are many regulations concerning active safety, i.e. those safety aspects that aim to prevent accidents. For example, there are a number of regulations on headlights which are being, will be or have been incorporated to a greater or lesser extent in the directives : the European asymmetrical beam headlight, the sealed-beam headlamp, i.e. without a bulb, the American-designed sealed reflector and headlamp having the European asymmetrical beam with cut-off, headlights with halogen bulbs, or with iodine bulbs, which have also been constructed as sealedbeam headlights. There is now the European beam : it is a good beam that satisfies everyone and, all things considered, will probably delay the advent of polarized light as research at the Road Research Laboratory over several years has shown that, even if the difficulties and disadvantages of polarized light can be overcome, it still has to be proved that it is really better than a good conventional headlight with the same physiological visibility distances.

Still in the historical context, but turning to Geneva, there are regulations concerning all light-signalling devices, there are regulations on anti-theft devices, all designed to prevent unauthorized use of the vehicle, i.e. impulse theft or joyriding, a potential source of danger; there are regulations on the audible warning devices which are useful in some cases and regulations on the layout of pedals. All these details together make for safety.

For driver visibility in clear weather, there is the problem of windscreen visibility angles, and in difficult atmospheric conditions windscreen wiper, washer, de-icing and demisting systems.

Still on the subject of active safety, there are draft regulations on the compatibility of tractors and trailers which the rapporteur has already mentioned. There is a draft on the mechanical strenght of coupling; you probably know that many accidents are caused by the uncoupling of trailers. And I could go on. But let us stick to the most important matters.

Although I am an official and considered as a tyrannical Chairman of WP 29, I am a friend of the motor vehicle. And I shall say something that is perhaps rather shocking, or at least unorthodox. The progress of the motor vehicle owes much to motor sport; the true competition was the pre-war version on open roads. At that time research was needed to obtain cars with good roadholding that forgave driver errors.

In my own country, Italy, during the war we had fairly reliable vehicles as all the manufacturers had committed themselves to competition. This resulted in good braking and good road-holding.

What is there today that militates against active safety? The general speed limits which will one day lead to the construction of vehicles whose safety characteristics will no longer be commensurate with the vehicle's performances, but only with the legal permitted performances, i.e. the speed limits. There are also people called traffic engineers who are cluttering the roads with traffic signs. At a given moment, instead of knowing where your steering wheel and controls are, you have to look simultaneously at ten signs and other traffic signals. If one comes across a road where there are not yet any signs because it has just been resurfaced, for example, one is more relaxed at the wheel.

Lighting : Mr Boschetti will speak about this, but I should just like to say something about lights : the problem of lights that are visible night and day, brake lights. They must be visible from afar against the sun and yet must not dazzle at close quarters - they therefore have two conflicting tasks. Research in progress (and to be undertaken in the future) is already indicating solutions based on an intelligent combination of photometric distribution of the light and the mounting of the lamps - based for example on the effect of the brightness of these lights under the quantity of light and luminous flux reflected by them, etc. In the ESV programme, for example, the Italian administration, which is responsible for brake lights, has already certain achievements which will be presented by Mr Taylor when the ESVC resumes its studies based on a brake light system in which the intensity and number of light sources change as a function of deceleration and the distance from the obstacle. All this work on lighting also started in Brussels and we should not forget the GTB (Brussels working Party) whose representatives are here today, and the work of the International Commission on Illumination. Another subject on which much work was done to reach agreement was the colour of lights. For shipping, aircraft and railways, the colour of lights is something sacred, not to be questioned. In the motor vehicle, however, any colour could be used for any signal. The work we did over many years successfully solved these problems despite the ill will of some, thanks to the good will of others. The results formed the basis for the 1968 Vienna Convention.

There remains the question of the utilization and inspection criteria for vehicles. I do not want to encroach on Mr Cornelis' field, but I should like to stress that inspection must ensure that the initial safety conditions are maintained. There is something else as well : design safety from the repair angle : this has nothing to do with type approval, with the standards we are drafting, but it is an aspect that must not be neglected. Suppose that to repair a brake it is necessary to leave the car in a garage for ten days, pay ten hours of labour at current prices and replace parts that are difficult to obtain. The driver will then prefer to leave his brakes in poor condition. And windscreen wipers? There is the recommendation in the 1949 Geneva Convention that an electric windscreen wiper should be equipped with an auxiliary manual control. This has disappeared, but if you are on a journey and your windscreen wiper fails, and if to have it repaired you have to spend days and days at a garage, you will decide to carry on without it and sooner or later an accident will occur. For example, to change a vane in a water pump, a small part costing 10 Belgian francs, the whole pump has to be dismantled and the assembly replaced, which costs Bfrs 2 000. The user will carry on with his faulty equipment. Why? Because the car has become such a habit in our everyday life that it is difficult to do without it.

Amongst the regulations in force, at least in the Geneva organization, there is one on tyres. It is fairly strict, based on American standards, and should increase the chances of having good quality equipment.

Probably the outcome will be spoiled by the speed limits as it will be difficult to find on cars equipped with tyres suitable for more than 130 or 140 k.p.h. There is also the problem of roadholding on wet roads, which has become acute because of the width of the tyres. Wide tyres have excellent roadholding characteristics on dry roads but then are very poor on wet roads, to say nothing of icy or snowcovered roads. It is realized that a device such as studs could save lives, but at present efforts are being made to prohibit them as they damage road surfaces. So you see the car has enemies not only in the Ministries of Finance, but also in other bodies which are supposed to be concerned with safety.

Roadholding : a car is considered good when it can take a bend without rolling. A car should be able to say to the driver : "Look out, you are in a dangerous situation". I can tell you of my personal experience. I have often used American jeeps and I have never gone off the road, but I have gone off the road in racing cars, although they are considered good cars with good roadholding.

In conclusion, I shall say that all aspects of the vehicle must be considered and not merely those which appear to be technically very advanced.

Intervention by Mr Boschetti

PROBLEMS RELATING TO LIGHTING, VISIBILITY, SIGNALLING AND CONTROLS

I shall begin by agreeing with both Mr Mitschke and Mr Pocci and will speak as a manufacturer.

In the fields of lighting, visibility, signalling and controls, it is the manufacturers' concern to continuously improve motor vehicles. However, when it comes to improving active safety through lighting, visibility, signalling and the use of controls, the driver becomes involved.

Mr Pocci has just told us that we will continue to make improvements under the benevolent supervision of the authorities responsible for regulations - very often with closely worked out and justified details.

I am therefore of the same mind as Prof. MITSCHKE, who revealed this essential role.

I would also like to say a word on active safety in general before talking about lighting. Technical progress serves to improve both safety and the services rendered by the motor car, these being the basic object of motor transport.

Whether the problem to be solved has to do with lighting, visibility, road holding, braking or speed, the driver must at all times be able to perceive the traffic, the road and the trajectory of neighbouring vehicles while mastering the behaviour of his own car as regards acceleration, direction and signalling.

If the driver, in any driving configuration, takes advantage of the technical advances achieved in design in order to increase his safety margin, there will be a real progress in the field of safety.

If, on the contrary, the whole of technical progress is exclusively directed towards comfort or improving performance, progress in safety shall no longer exist. It may even be negative.

It would be of very little use to improve urban and highway lighting, signalling under foggy conditions, braking on icy road surfaces and general road characteristics if constant risk driving should bring drivers close to the danger limits in the same way.

With a view to increasing this margin, we must continue to improve vehicles, but these must no longer be driven to their maximum limits and to the limits of the traffic, as in the past.

In vehicle use, this constitutes a fundamental threshold, which must be crossed by drivers in any driving situation, at their usual speeds and not only, as one always tends to think, at the maximum statutory speeds.

On these grounds, we believe that after the very substantial reduction in the number of people killed or injured achieved as a result of stringent regulations our greatest chance of making further progress in active safety lies in fair-play driving and "under-utilization" of vehicle performance.

The second point more particularly concerns lighting and signalling.

Formerly, some cars were inadequately lit. Nowadays the problem is reversed and aggravated by the greater number of vehicles.

You all - not, of course, the manufacturers, but all of the other persons concerned - should be informed that lighting in excess on roads and in towns creates no only confusion, but also unpleasant dazzle, which is particularly dangerous in rainy weather.

As regards construction, the design engineers face an increasing number of problems in designing front and rear ends which at least blend harmoniously with each other and which provide a fair compromise between factors such as:

- Dimensions and number of lamps, dimensions and statutory location of bumpers and registration plates with the dimensions necessary for proper lighting of the latter cross-section to be provided at the front for the cooling air intake, low opening requirement for rear boot, and space to be provided for nationality plates. On some models, and in particular those which meet the specifications most scrupulously, there is twice as much space for the nationality plates.

Once again, a threshold has been crossed as a result of regulations.

In the future, it is our wish that not a single additional lamp be proposed without attempts being made to remove another.

The problem must be dealt with as a whole and in this, the car manufacturers who are responsible for designing the whole car would like to have a bigger say in the technical meetings held between the Authorities and the Industry.

This point was clearly stressed by the CCMC in their second Memorandum to the Community.

The third point will be a request.

We request the Community to issue Directive 2024 on lighting as quickly as possible.

The above-mentioned Directive should make the lighting and signalling of devices fitted to cars more homogeneous throughout Europe.

It should also make it possible to avoid creating models which differ from country to country through the use of equipment, wiring looms or holes in bodywork.

The impossibility of taking advantage of standardized design and of a reduction in cost due to larger scale mass production for a given item of equipment constitutes a great waste for the Community and for the users in every nation.

We need this Directive and the application decision for each country so as to know how to make our cars.

We know that the only reasonable way is to accept the Directive just as it is, in view of the status of the procedure, if one does not want its adoption to be postponed further.

However, we shall always regret that the manufacturers' request that some problems be Put aside (perhaps 5 % of the overall requirements) was not retained.

The following problems might have been incorporated in the Directive in one year's time after a more thorough technical examination :

- Dipped beam setting, the relatively close tolerances for which apply to beam cut off, which itself is very imprecise and very difficult to define.

- Rear fog lamps, whose definition, utilization and efficiency still require a large amount of research work.

  There are still too many questions connected with fog density, day or night use and the method of actuating these lamps.

  It cannot even be clearly decided on a technical basis whether they should be prohibited as dangerous or made compulsory as a result of their contribution to safety!

  A lamp, which is to be ineffective by day in thick fog can well be dazzling at night in a light fog.

- The problem of the lateral visibility of lamps or side marker lamps, which requires more thorough examination.

As far as we know, not all Countries are ready to make all these specifications compulsory owing to their national viewpoint on the cost-efficiency ratio of questionable devices.

It would therefore be theoretically possible not to install such equipment on vehicles intended for some countries, but it removes most of the appeal of the Directive.

Models which are intended to be EEC approved and henceforth to be standardized as much as possible, shall be equipped according to the "comprehensive" solution specified in the Directive.

There will then be either non-standard models or "comprehensive" models, which are needlessly costly for these Countries.

Regarding this matter, our position is quite clear; a distinction must be made between the short and the long term.

In the short term, we must know of future regulations several years ahead, i.e., as early as 1976 for 1980, and we hope that these quick-application regulations will not be questionable comprehensive solutions.

In the medium and long term, we are ready to develop research and discussions in order to improve the knowledge which will guide the Authorities in preparing supplements to Directives.

I shall no go on to talk about medium and long term research : Mr Sallinger will say a few words about that.

In the medium and long term, there is still much to be done on equipment of this type. Let us mention some examples :

- Reference will probably be made again to headlamp colour standardization, to the quality of the cut off between main and dipped beams, to the colour of front flasher lamps.

- In dense modern traffic, roads busy with long queues of vehicles, and overcrowded cities, may throw the use of conventional lights (headlamps, marker lamps, low beams) in doubt.

  One must be very cautious before contemplating new lights (running lights, third beam, etc.) with prolonged testing and technical discussion between Authorities, car and equipment manufacturers.

- In view of the late hour I shall no discuss visibility, rear-view mirrors or the cleaning of windscreens since that would lengthen the meeting.

  As concerns visibility from the driver's seat, one must not forget to give first priority to forward visibility. To this end, visibility angles toward the rear should not be too ambitious.

  The interior rear-view mirror should not mask too wide an area of the windshield.

  Furthermore, the radius of curvature of mirrors must also be reasonable.

  Too small a radius distorts the distances and the differences between the radii of inner and outer mirrors confuse some drivers.

In modern traffic, particularly on multilane roads, where speed differentials are lower than before, correct judgement of the distance from vehicles approaching from the rear may be even more important than the width of the field of vision.

- I would like to point out that some thick-framed spectacles create a blind spot larger than that of the windshields pillars, which are criticized so much :

  I was informed recently that the solution was to move the head more often when glasses are worn. This solution, which is essential for many drivers, is also an efficient way of increasing the field of vision of mirrors.

- Concerning the cleaning of headlamps by means of wiper blades or through a spray, I think that a regulation would be regrettable for the present time since it might hinder technical progress.

  For that kind of problem, public information and advertising should be enough to support progress for the time being.

- Reference should also be made to the problem of controls.

  All manufacturers are currently making substantial efforts with a view to grouping dashboard controls closer to the steering-wheel so that they can be reached easily with the most restraining of belts.

  As for me, I object to any regulation in this field for the present time, since this is a period of evolution and creativity.

  Any attempt to impose regulations would halt progress without fail.

  In order to give satisfaction to some users, who change their cars very often, particularly in the case of rented cars, it is only to be wished that examinations currently being conducted by the ISO will continue without undue haste so as to prepare for the efficient distribution of the various functions on either side of the steering wheel.

- The controls also include automatic systems and aids to driving,namely:

  - Ice detection device
  - Distance radar
  - Speed regulators
  - Overspeed warning systems.

  All driving aids contribute to safety insofar as they improve driver information or lessen fatigue or irritation.

  One must be more cautious as concerns feed-back or automatic systems affecting vehicle development.

  The fundamental responsability for driving rests with the driver and this must remain so. He is the only person, as already mentioned, who controls the car's equilibrium within the traffic at any given moment.

Cars are not guided by rails, and have nothing to do with railways. Nor are the aircraft, which automatic systems can guide only provided they fly alone without neighbours nor obstacles.

The driver bears the responsability. He is master of his steering, which has not yet been automated. He must also be in control of his accelerator at all times, at the usual traffic speeds.

There has also been some talk of speed regulation through design, and of automatic regulation.

Attention must be drawn to the fact that adjustment and manufacturing tolerances would lead to cars being set at various constants though differing speeds.

On the other hand, one may well question the desirability of introducing, at maximum speeds, automatic feed-back systems that would partly relieve the driver from his responsibility at the very moment when he should be still more watchful and take this responsibility entirely upon himself.

The service rendered by the motor car derives from flexibility and variation. Safety derives from a moving,continuous balance and an infinite sequence of such balances.

As for me, I am sure that the simplistic theory of uniform driving speed must be rejected.

Indeed, speed for its own sake has become "out of fashion". This must also become true of wide speed variations. However, automatic or statutory speed uniformity should not be retained when looking for the balance which leads to safety since, owing to its excessiveness, it is outside the car/driver/traffic relationship.

Controls and automatic systems are designed to facilitate man's task by helping him, physically or intellectually, to set his speed more easily.

They must not encroach upon his decision-making powers, which could cause a dangerous transfer of responsabilities.

°°°

I have attempted to point out the difficulties raised by apparently simple questions.

We are confident that the Community will find out a fair compromise between freedom and constraint, simplicity and confusion, progress in safety and at least maintaining the service rendered.

Intervention by Mr Van Winsen

I would like to quote two sentences in the letter of invitation to this symposium on motor vehicles :

1. Further regulations will no doubt be needed (especially in the field of safety).

2. The symposium will provide bases for a programme of new vehicle regulations.

Since no inherent value can be assigned to the term "regulation", we must first of all ask : "What use can further regulations be to us?"

The field of accident prevention, which is receiving special attention in this seminar seems extremely unapproachable from this angle.

The problems will perhaps emerge most clearly if we compare the factors involved in regulations. Roughly speaking we can quote four types of situation which regulations can deal with.

1. Situations whereby agreements can be reached, e.g., on dimensions, weight classifications.

2. Characteristics whereby quite clearly : "more" should be equated with "better" or "less" should also be equated with "better".

   E.g., in the first instance the lower limit to the horsepower per tonne ratio of commercial vehicles or, secondly the maximum permissible braking distance.

3. Characteristics whereby there is, to some extent, a natural optimum between "large" and "small" or between "much" and "little".

   E.g., range of dipped beam.

4. Qualities representing a compromise between several individual characteristics for which there can consequently be no indisputable optimum. The individual characteristics must be arranged according to priority.

   E.g., distribution of braking forces.

In general it can be said that the degree of difficulty in quantifying the phenomena under discussion (and the drawing-up of regulations requires the use of quantities) increases sharply in this sequence and it becomes increasingly more difficult to achieve a correct solution by means of technical experience or political negotiations.

In some of the details of existing EEC regulations and in particular the complex section or Type 4 we have already outstripped our knowledge and are on the way to doing so further. Let me quote the directive on braking systems as an example : This has already received a certain amount of praise from Mr Mitschke.

The requirements,contained in the EEC directive, are that no wheel may lock during the braking-distance test takes us inadvertently from the simple problem of "less" i.e., a shorter (braking distance) is "better", into the extremely complex problem of maintaining the direction of travel. The following aspects of this can be criticised :

First of all, the outcome of the test is by no means the shortest braking distance of the vehicle. Secondly, this test is not exactly reproducible since a certain locking limit margin must always be maintained. Thirdly, the test reflects practical conditions only poorly or else not at all.

The abovementioned orders of priorities, which we consider to be correct, namely : "directional stability - short braking distance - steerability" is indeed dealt with superficially in the EEC directive but it is then unfortunately again submerged. Naturally the requirement that the front wheels of passenger cars lock before the rear wheels makes it appear as if the first priority is directional stability. At the same time, however, the requirement concerning adhesion utilization in cases where the engine braking torque acts on the rear axle promotes vehicle instability. If you pardon me for being so blunt the ban on locking during the test and the adhesion utilization consequent to this are nothing more than an insufficiently thought out requirement for a certain degree of steerability whereby no account is taken of what degree of directional stability is needed in order to actually achieve safety in respect of steerability. We are of the opinion that a correction is possible and we are prepared to help to compile an improved version.

A further example is provided by the regulations planned by the EEC on voluntarily installed anti-locking systems.

No anti-locking system is yet on the market which would meet the necessary requirements as regards efficiency and reliability, at least in passenger cars.Nevertheless, stringent regulations are already being drawn up, which clearly run-counter to technical progress. Higher deceleration performance is required in the regulations planned than for a normal brake, without its being borne in mind that the adhesion coefficient reserve needed for the most <u>important</u> objective is thereby reduced.

In developing an anti-locking system, depending on the system installed, priority is given to stability in the case of single-axle regulation and to the maintenance of steerability - on bends also - in the case of all-wheel regulation. In the case at issue the dilemma raised by the inability of the overall system performance to be quantified again emerges. It will be a good idea to first of all hand over the matching of such new systems to the old-hands in the vehicle development departments of the industry without hemming them in with regulations before they have got on with the job.

I would like to go on to the regulations on vehicle handling which have been discussed and recommended.

A demand was also made here that its adaptation to human capabilities be better regulated by means of regulations. It is true that adaptation is necessary.

Nowadays this is taken care of by subjective assessment by experienced test engineers during extensive, varied test runs. They themselves operate the control circuit and at the same time assess its quality.

In contrast to the plethora of variants and the detailed assessment of the individual variants dealt with here we barely cover 5% by analytical measuring methods. We do not know here with what validity we should include such recorded data in the overall compromise which constites handling quality.

We know very little about man as a controller who sets his vehicle's trajectory. We only know that he possesses a highly changeable and adaptable - and even an over intrusive - set of control characteristics. We know absolutely nothing about man's control behaviour in dangerous situations where he is confronted with a potentially fatal accident. Here also adapting things to man would seem to be the most necessary course. We do not have a single statistical figure to hand on how much steering takes place during accident sequences and how much steering and braking, for example, are superimposed.

Attempting to describe the control behaviour of man in exceptional situations seems to me to be very much an unphill task. On the other hand the third component in the control circuit, namely the control variable, has obviously been neglected. Although we are not directly concerned with this today this part of the overall complex should not pass without mention. (Control variable = here all conditions applying to the situation).

Nowadays we possess relatively extensive knowledge of the information density which can be offered to the controller i.e., driver, for conscious processing and coordination. In all too many cases however, this is always simply ignored in the controlling of traffic flows and in the measures aimed at driver guidance. This offers wide scope for traffic planners and psychologists to adapt the situation to the driver.

In conclusion I would like to summarize as follows :

1. If in future sensible development is to take place it might be useful to adopt the following motto :

   as few regulations as possible,

   as many regulations as necessary.

2. Regulations should not outstrip the state of the art, so that technical development is not deflected in the wrong direction.

3. There should only be regulations on effects and not on design so that the state of the art is not frozen and development is not hindered.

4. Even where there are no regulations the industry should be trusted more to try to do what is reasonable, just as it has done for the eight decades since the birth of the motor car.

5. I would ask for understanding for the development engineer who has lost valuable new development capacity because he must already thread his way through a maze of regulations and attendant administrative procedures.

Intervention by Mr Salinger

A recent study, done by my company, showed that the youngest age group of drivers, i.e. those below 25 years of age, were involved 6 times as often in single vehicle accidents than the average Volvo driver. The age group distribution of Volvo drivers is the same as the national Swedish. Since single vehicle accidents account for a 37% of all Volvo accidents, the young driver involvement in this type of accident poses a real problem.

Whatever parameters we may use to set priorities obviously it pays off to save the young. Better driver education, learners' plates and such are obvious solutions which I will not deal with today.

Since we know that young people proportionally drive more at night, I intend to speak of the matter of lighting.

Firstly, I will discuss the dipped headlight or the low beam. Prof. Rumer at the University of Upsala has compared the detection distances in a meeting situation between different head-lamp systems. He has shown that the distances are vastly superior to those offered by European headlights.

His experiments were done with a headlights according to SAE 7 579 a. The newest type, according to SAE 7 579 b. is superior both in low beam and high beam intensity. Personally, I prefer the American headlight to the European. I know that others do not agree with me in this respect.

Consequently, I merely propose that the matter of headlight systems is to be included in the future studies in the Community.

Secondly, I will speak at some lenght of another matter.

During the early sixties the idea came up to use running lights, i.e. lights which are automatically switched on when the vehicle is started. Major experiments, above all in the UK, the USA and Finland showed that a considerable reduction in traffic accidents could be achieved by using running lights. The experience gained by the Greyhound Bus Company often is quoted in this connection. Since November 1972 dipped headlights are required when driving during the winter period in Finland.

In Sweden, we were impressed by the research results with respect to accident reduction through running lights. However, in our minds there remained a few problems to be solved. In our experience dipped headlights would not be ideal as running lights. They would be well suited for this purpose in daytime. In nighttime, however, in illuminated streets, dipped headlights cause glare, above all when the road surface is wet.

It should also be mentioned that average headlight bulb life only is 200 hours. The now common iodine bulbs are also quite expensive. Consequently, we did not expect our customers to welcome a running light of this type.

One solution, used by SAAB, is a dipped headlight with reduced voltage. This increases bulb life considerably without decreasing light intensity appreciably. A compromise is found where in daylight the light is still clearly visible whilst glare is reduced in nighttime urban driving.

The Volvo Running Light is a separate one. When the ignition is switched on the running light comes on automatically. We use a bulb with two filaments. The running light uses a 20 W filament. When the light switch is set at the parking position a 5 W filament is selected. Together with the headlights, only the parking light filament is used.

In the absence of regulation for running lights we have decided to keep the maximum intensity of the running light below what has been prescribed for dipped headlights.

Since legislation on lighting equipment in most countries only recognises specified lighting sources, we have had some difficulties to introduce the Running Light outside of Sweden. Now the authorities in Denmark and the UK have accepted it too.

We have observed that the introduction of running lights has made the general use of daytime lights more common in Sweden. We feel that this will contribute to improve road safety.

I propose that the matter of running lights is studied within the Common Market. I believe that a general introduction of running light would yield appreciable accident reductions.

Intervention by Mr Cornelis

I would like to pay a sincere tribute to the rapporteur - Professor Mitschke - and to the other members of the panel for their work; however, I feel that they did not cover the proposed subject of their study fully.

The problem of how to improve active vehicle safety was in fact only considered from the point of view of product design. It is clear that in order to promote accident prevention as well as possible by means of more appropriate design specifications, the latter must take into account what happens to the vehicle on the road. The question is, how to find the best design of the product in order to maintain its level of active safety throughout its life.

Tht life of a car is not comparable to that of a refrigerator, for example. Among the products that we use it is the one that is subjected to the most rigorous conditions and which is most maltreated. Unfortunately, it is also the most lethal product we use.

It is therefore essential to maintain the active safety level over a long period. I cannot agree with Professor Mitschke when he refers to official statistics in order to demonstrate that technical improvements have a minimal effect on accidents.

We all know, indeed, what should be thought of official statistics as far as the so-called causes of accidents as treated therein are concerned. They are valueless and should be forgotten.

I should like to remind you briefly of investigations carried out in this sphere by multidisciplinary teams in the United States on behalf of the Department of Transportation, in France, in Denmark and also by Doctor Mackay of the University of Birmingham which show that a far higher percentage of accidents are due to technical reasons. Moreover, certain reports stress the fact that the hypothetical nature of this type of investigation necessarily leads to excessively low estimates of these percentages.

Also, although I would certainly agree that the road user is indubitably the most at fault as far as accidents are concerned, it would be highly erroneous to minimize the blame which can be apportioned to the vehicle.

How, therefore, does vehicle performance change, as far as safety is concerned, over a period of time ? For several years detailed information has been provided on this subject by organizations responsible for vehicle. roadworthiness testing, namely in "Weak Points Of Cars" (Sweden), which is of course, a very explicit title, and the "Technical Inspection Authority" (TUV) Auto Report (West Germany).

Now that such testing organizations have been formed into an International Committee for several years, it is clear that collaboration between this international Committee (CITA) and the manufacturers is bound to be beneficial as far as accident prevention is concerned. The quantity and quality of the information that can be provided are bound to effect the product favourably in the sphere of reliability and particularly where maintaining the level of active safety is at stake. Moreover, the designing of vehicles so that they can more easily be repaired following collision, many of which are inevitable and becoming more and more numerous, presents an important potential sphere of research which such information would help to direct more suitably.It is a question of restoring the vehicle perfectly to its former safety level in a way that is economically acceptable.

Vehicle designers should pay more attention to the need to facilitate the monitoring of the equipment affecting safety. The condition of much of this equipment cannot be determined properly except by dismantling it, which is always expensive, or by using apparatus that is not always available. In fact, certain tests are not able to be carried out even by the routine roadworthiness testing authorities. Ideally, this information should even be directly available to the user by means of diagnostic systems incorporated in the vehicle.

Here we come to one of the most important factors involved in motor vehicle construction, namely, corrosion.

Let us first of all stress the fact that with motor vehicles, corrosion occurs all over the world and is not limited to the countries in which de-icing products are used in winter. Damage is caused even more rapidly in certain tropical areas (e.g. the Ivory Coast, a country associated with the European Community) than in northern countries.

Corrosion reduces the life of vehicles, makes them depreciate more quickly and also, unfortunately, affects their safety. The damage it causes can affect the dynamic stability of vehicle control components where they are attached to the body and also that of other equipment affecting safety and can substantially reduce the overall integrity of the vehicle and make the consequences of accidents more serious. They can also break the seal between the passenger compartment and corrosive effluents such as carbon monoxide etc.

The undesirable effects of corrosion are made even more dangerous by the fact that they normally manifest themselves in a most insidious way. This is particularly true as regards channel section in integral body shells, where the corrosion process can start from the inside.

Unfortunately a large number of defects discovered in roadworthiness testing stations are those due to corrosion and which reduce safety. Documents showing specific cases of this have been published by the "Svensk Bilprövning" (Swedish Vehicle Inspection Authority) and the "Bavarian Technical Inspection Authority " (TÜV Bayern).

Also, a report prepared in October 1969 by an OECD road transport research group contained a comprehensive analysis of the problem of "corrosion of motor vehicles and the effects of chemical solvents".

I will refrain from speaking further on the phenomenon of corrosion as such and will return to purely practical matters.

The extent of damage caused by corrosion detected in testing stations presents very great problems. In practice it is normal for defects to be discovered when it is no longer economic to repair them, particularly with respect to the first routine test (after four years in Belgium). As it is not possible simply to abandon the vehicle, it is repaired for better or for worse, but often without its original safety qualities being restored. This is all the more regrettable by virtue of the fact that it is just those users who are least favoured economically i.e., those who are not able to change their car every year or every two years who are victims of this situation.

For a long time now this problem has been worrying vehicle testing organizations. Many of them have tried to develop a "code of practice for the assessment of corrosion and for the repairs methods used". The Union of Belgian Vehicle Testing Authorities (Le Groupement belge des Organismes de Contrôle Automobile) recently produced a similar document by arrangement with the Belgian Ministry of Transport.

This code should enable inspectors to evaluate more objectively and more uniformly the degree of damage caused by corrosion. It also contains precise requirements as regards elimination of the defects found in order that the vehicles' original characteristics, particularly as far as safety is concerned, be restored to it as far as possible.

In this sphere, progress has still to be made as far as design is concerned, in order to prevent corrosion, particularly in those parts where it can adversely affect safety. Vehicle designers should cater for the cheap replacement of those parts which are still subject to corrosion.

We have noted with great satisfaction the very lively interest with which this code of practice has been received by the organizations involved. A number of manufacturers have also asked us for copies.

It is not possible to analyse the conception of this "corrosion" code and the philosophy behind this symposium. However, we would be very interested to hear the opinions of manufacturers, and particularly of those who are on the Committee of Common Market Motor Vehicle Manufacturers, on this document, and, above all, their remarks and suggestions, which are likely to be of great value and relevance. For this purpose we are leaving a copy of this document with the Secretariat for the benefit of the Committee of Common Market Motor Vehicle Manufacturers.

Intervention by Mr Moore

My remarks will be quite brief dealing mostly with the tyre. If we consider tyres, it is true that already they have reached a level which I would consider as close to optimum in performance This has been through intense competition among the world's great manufacturers over the years. And the result is, performance which differs little from manufacturer to manufacturer. It can be seen that in this climate it is less important to prescribe strict EEC regulations, relating to performance and testing than perhaps in the USA. Although tyres should still be clearly classifield and identified by the manufacturers relating to the limits of their operation performance such as load and speed. Now to illustrate for example no other factors are significantly more variable as regards the road traction of vehicle in motion. Changes in surface texture, road surface, produce about twice the range of friction coefficient as temperature variation, (that is variation from winter to summer) light braking locked wheel skidding, etc.

The range of frictional coefficient due to temperature variation in turn is about twice that due to variation in rubber properties. If we now take rubber properties the choice available is limited by the conflicting requirement of maximum wet grip and minimum abrasion losses which are necessary for long life and if we add to this the effect of the composition of rubber properties in the tyre, which are restricted by the now widely accepted radial carcase construction, the overall result is a very small variation in tyre performance from one tyre manufacturer to the next.

From the point of view of regulation we might set up a goal, the equalisation of stopping distances under wet and dry conditions. This is not the case at present. We can go a long way towards doing this by changing the surface texture, but this is outside the scope of the vehicle, so given the tyre as it is, close to optimum performance, and given the fact that changes, however slight, will have a small effect, we can do very little to improve the friction coefficient and hence the safety aspects of tyres.

A brief word about anti-locking devices in regard to safety and perhaps future legislation (these have already been referred to by Prof. Mitschke and others). It has been correctly stated that this is one area where vehicle performance can compensate to a large degree for driver error in braking, and noticeably in regard to slippery surface conditions. These devices, anti-locking devices, have now reached the stage where a computer regulates brake pressure and intensity and cyclic frequency in such a manner as to match exactly the friction performance of the road. It is therefore true to say that where as driver's error or misjudgement may be the primary cause of accidents, the vehicle can compensate by sophisticated design features. We cannot exactly separate the individual influences of driver, road characteristics and vehicle defects, although we agree that generally driver error is the main culprit.

As mentioned by the speaker,Prof. Mitschke, vehicles require regular inspection for the detection of defects and then maintenance and repair to minimize their influence in accidents. They also require, in addition, individual care and attention by their owners. This care varies significantly from country to country, depending on the temperament and the nationality of the owners. In countries where little attention is paid to ordinary care of road vehicles, it is suspected that the contribution to accidents from vehicle defects will be higher than the small percentage mentioned by the speaker.

Our final word relates to basic differences between active and passive safety in vehicles : active safety is primarly devoted to accident avoidance and passive safety to minimizing the effects of accidents once they occur. It is generally agreed that considerably more can be done in terms of vehicle design to achieve passive rather than active safety : for example, cars can be designed for high speed survivability for frontal impact, even though at the expense of high injuries at lower speed impact etc. For the case of accident avoidance, however, with which this session is concerned, the driver error will remain the primary cause of accidents, but we emphasize that we can minimize such possibilities of error by improved sophisticated devices.

Thank you very much !

Intervention by Mr Nelson

In general we must indeed agree with Professor Mitschke when he says that it is desirable that driver and vehicle should be regarded as being a composite system in, so to speak,a hostile environment. It sounds wonderful to Danish ears when Professor Mitschke holds out the prospect that, speaking purely scientifically and always considering the motor vehicle as a unit, it will gradually be possible to lay down the specifications for the various vehicle handling characteristics such as braking, braking whilst cornering and manoeuvring violently. On the other hand there is a subject that has always been difficult to grasp and Mr Pocci touched on it : I mean that a very clear insight into how a motor vehicle should be built in purely practical terms in order to be endowed with good handling characteristics used always to be acquired in the past through the development of advanced cars, of Italian origin for example, which were used for racing. Meanwhile we hope that the research which Professor Mitschke holds in prospect will continue and that, as a result, we shall in future also be able to obtain cars providing better handling characteristics, irrespective of price.

I should now like to turn to some more general remarks on active safety which I also feel merits a certain interest. I shall begin with what is known as "comfort". By this is meant that the driver does not become fatigued and thereby loses the necessary alertness while driving. Here I am naturally thinking first of all of those drivers who use a vehicle almost daily - not just purely professional drivers such as lorry drivers and taxi drivers - but also, for example, commercial travellers driving from one place to another and who preferably ought not to become unnecessarily fatigued in the process; in that connection I could well imagine for example seeking measures aimed at reducing high interior noise levels and vibrations. We all know those resonance nodes which occur at the speeds normally chosen - even in modern motor vehicles - when it becomes more tiring than necessary just to sit and drive the vehicle. With special reference to professional drivers, and I am thinking here of lorry and coach drivers, it could well be desirable that there be a requirement that their seats should always be specially insulated against noise and vibration. Still on driver comfort : it would be conceivable for there to be specific regulations on reasonable ventilation and reasonable heating in the driving cabin - or alternatively for reasonable cooling in the warmer countries - always with a view to combatting unnecessary fatigue. Another example is the virtually compulsory introduction of automatic transmissions. I am well aware that these are already in extensive use in practice and, for example, in the case of taxi drivers, it is undoubtedly a great relief for them if they are always provided with a taxi equipped with an automatic transmission. Finally as a purely general problem affecting the above-mentioned handling characteristics I should like to mention here that it would certainly be desirable to be able to produce a motor vehicle which is built in such a way that correcting manoeuvres do not have to be taken constantly with the steering wheel where there is a side wind, a cambered carriageway or an uneven surface - not during extreme manoeuvring but simply during ordinary straightforward driving.

I must agree with Mr Pocci on effective vision, He said that many small detailed provisions gradually produce a unit, meaning that, in addition to passive safety, active safety is receiving attention. This is indeed already well in progress within Mr Pocci's Working Party. Work on forward vision is nearly complete ; proposals for regulations are being prepared on windscreen wipers and washers - and on the removal of mist and ice from all windscreens. We would like this to apply likewise to side and rearward vision. In that connection I could mention that the manufacturers note with pleasure that fewer of those smart coupé models and other smart models have been produced where clearly not the slightest consideration is given to the fact that anything straight behind or at an angle behind can really be seen best only by turning the head and not merely by being lulled into a false sense of security by what is seen in the driving mirrors. While on the subject of rearward vision, I would like to say that it can be desirable to have special backlight wiping or heating and ventilating arrangements, or perhaps into the bargain backlight wipers and washers in the case of certain estate car models, for example.

I mentioned earlier Mr Pocci's views on the manv details that constitue, in aggregate, a useful whole for a car as regards safety, and I agree that that also applies to lamps, reflectors, light-signalling devices and horns. We are indeed well on the way and I can in fact mention that there is an improved proposal regarding reflectors in progress in Geneva which incorporates the "IA" or "IIIA" reflectors which are appreciablv better than their predecessors and, as has happened hitherto here in Brussels, we assume that, as soon as the proposal is presented in its final form, the Commission will adopt it. This has certainly been the case with all the other lighting regulations from Geneva, so I really harbour no anxiety that we are graduallv building up a well stocked arsenal of lighting regulations and again I agree with Mr Pocci that such an arsenal of lighting regulations or directives, as they are called here, will together with the driver constitute a unit, because it simply enables him to see and, as Professor Mitschke emplasizes, to be seen and it must be ideal to have a body of lighting and reflector regulations which is gradually approaching the objective. Under supplementing regulations or directives we now have yellow sidelights on the way. We have the British proposal for large striped reflecting panels which serve as special markings across the rear of long and wide vehicles. We can count on having rear foglamps, included in vehicle construction specifications from Geneva and also revolving flashers, but this really applies to emergency service vehicles. It mav be said that the development to follow is that motor vehicles can be seen as units, whose manoeuvres can be observed and which can be used by drivers.

I do not wish to go closer into the subject of handling characteristics as it has just been said that driving along in a side wind should not be too tiring and, as regards antilockbraking systems, I weary of hearing from Mr Van Winsen that there are long-term prospects for mass-produced, antilockbraking systems on private cars where reliability is satisfactory.

Therefore I should like, even though Mr Cornelis has already touched upon it, to turn to the question of maintenance and mention the problem of recommendations which also includes the motor vehicle instructions called for by Professor Mitschke. Firstly it must be said that the manufacturers have an important task as regards issuing really effective owners' handbooks and also workshop handbooks where, for example,as stated by Professor Mitschke, it is pointed out that it is highly undesirable to mix radial tyres and crossply tyres incorrectly when tyres are replaced. The manufacturers can also show support for the consumer in another way by, for example, making his product serviceable and maintainable so that it is relatively simple to carry out not only the most minor check, which the ordinary owner can carry out, but also the inspections which workshops must perform at 10,000, 20,000 and 30,000 km. By this I mean that it serves active safety extraordinarily well if the manufacturer tries in advance to make the vehicle easily maintainable. It has been seen that the Commission has paid hardly any attention to maintenance, with the exception of the one subject which falls within the purview of the transport directorate, i.e., routine inspection, which is being worked upon now. I should like to say that it would be desirable for the Commission to take an interest in the many recommendations which the UN (Geneva) has managed to agree upon with trouble and difficulty over the years which apply to such things as the braking requirements for secondhand solo road vehicles or road-trains, whether such are 100 % new, secondhand or mixed. Geneva has also published recommendation on, inter alei, tyre retreads. These are regarded as being a kind of wearcoatings or composite tyre cover. Furthermore, I can state that Geneva, long ago prepared a proposal for a regulation on road-trains "compatibility", i.e., matching the powered vehicle to the trailer or semi-trailer towed. Unfortunately this proposal has been shelved.

So I shall now once more turn my attention to the manufacturer and say that it is certainly the experience of all people in the vehicle inspectorate and surveillance service who are concerned with maintenance problems that the manufacturers could make a really large contribution to the on-the-road active safety vehicles if they would tighten up their production and conformity control at the outset and if, moreover, they would inform their importers and dealers that a more intensive pre-delivery check would be desirable. As a special item within this check I should like to mention that if an anti-corrosion treatment is carried out as a part of the preparatory check, there is a risk of a situation arising in which the motor vehicle being delivered has its brake linings filled with anti-corrosion chemical, because there has been insufficient time to cover these brakes and also other parts of the vehicle with the necessary plastic bags or other articles. It is a very dangerous thing to deliver new motor vehicles which have been prepared for service in accordance with all the normal rules but where they have clearly been prepared so thoroughly that the effectiveness of other handling properties has been reduced appreciably and are most unlikely to be detected by the ordinary user.

Having expressed several hopes I should like to say in conclusion that I would not wish to go into the priorities to be assigned to these hopes since we have annual meetings both here in the Commission and at the UN (Geneva) where we discuss our programmes, whether new topics ought to be included, whether others ought to be amended and whether the order of priority ought to be altered, etc.

GENERAL DISCUSSION

Intervention by Mr. CESTARO

We would like to stress the importance of the windscreen as regards both the active and passive aspects of passenger safety. As far as field of vision is concerned, there can be no doubt as to the superiority of the laminated windscreen since, in the event of an impact sufficiently serious to cause starring, the windscreen does not shatter into small fragments, does not become opaque, continues to provide very good visibility and sometimes the driver does not even need to stop, thus retaining full freedom of manoeuvre. Furthermore, the laminated windscreen is the only windscreen currently capable of reducing significantly the probable risks of injury in the event of an accident. Laminated glass, as distinct from the other type, absorbs a proportion of the impact energy. This proportion is considerable and adequate. In Italy the moral obligation to guarantee the safety of the individual in the event of an accident is acknowledged by the highway code, which makes laminated windscreens compulsory. The proposal for an EEC Directive on the adoption of the laminated windscreen was approved by the European Parliament on 4 June 1973 and by the Economic and Social Committe on 26 July 1973.

It is regrettable that the adoption of this proposed Directive has been delayed, since this exposes the occupants of motor vehicles to greater risks. We would be interested to hear the opinion of the members of the panel on this point.

Answer by Mr. VERDIANI

All I can say is that, in the absence of agreement among the Member States on the solution to be adopted, the proposal for a Directive is still before the Council awaiting a decision.

Intervention by Mr. HALLEUX

Why is it that, in his introductory speech, the Rapporteur passed over in silence the numerous recent statistics showing that poor vehicle maintenance is a direct, or aggravating, factor not in 2-3% but in 17-25% of accidents ? Why did he not take account of the "time" parameter, in other words, why are steps not taken to ensure that the original integrated vehicle/driver control system is updated by the introduction of EEC provisions for vehicles in service ?

Answer by Mr. MITSCHKE

The theme, after all, of this symposium is "future regulations". In other words, we cannot take as a basis the situation prevailing at the moment in a number of countries, but must instead create a framework for the future.

If we accept European Community predictions that an entire body of legislation will soon be available and if perhaps the additional point is made that the system of monitoring called for during the panel discussions will subject motor vehicles to closer scrutiny, then I am certain that the percentages involved will be very low (2-3% or 4-5%) and most emphatically not of the order of 17-25%.

Answer by Mr. CORNELIS

In reply to Professor Mitschke, I would just like to say that my remarks were based on totally different figures from those put forward by Professor Mitschke.

Accordingly, I agree with Mr. Halleux.

As far as the second part of the question is concerned, International Committee recommendations have already been made regarding vehicles in service. Thus, in my view, the first step has been taken.

Intervention by Mr. JACOBSON

We have heard a great deal about corrosion. How do the panelists define it and when does it begin to have a significant weakening effect on the vehicle structure and the braking system ? We have carried out extensive and numerous tests and survey investigations on thousands of vehicles in daily use and find that it does not occur in under 3-4 years. In most cases only after about 6-8 years.

Answer by Mr. CORNELIS

Statistics compiled by West German test centres clearly show the escalation in damage caused by corrosion. On the basis of the available figures it can be seen that, specifically in the case of vehicles less than two years old, corrosion has the lowest rating of all the 24 component assemblies of motor vehicles. According to the West German figures, corrosion occupies 11th position in the case of vehicles in the 2-4 year old category and 9th position in the case of vehicles in the 4-6 year old category. I must stress at this point that this represents the average position, i.e. , in the case of certain models corrosion is among the most frequent defects. I would add that not only do the findings of the Belgian inspection centres tie up with those of the West German centres, but in fact they are even more pessimistic.

Intervention by Mr. WIEGNER

Mr. Van Winsen has already referred to the lack of adequate statistical data on driver reaction in critical situations. It is possible to o btain such information whith the help of drive recorders or "pre-crash recorders". Does the Commission envisage the possibility of conducting and/or financing on a European level, a large-scale experiment with drive recorders (involving several thousand vehicles) ?

Answer by Mr. VAN WINSEN

We are of course aware that the CCMC (Association of Motor Vehicle Manufacturers in the European Community) has come up with proposals on these so-called pre-crash recorders, i.e., it has drawn up a list of specifications on everything which would need to be installed in order to obtain information on events during the 30 seconds immediately preceding the accident.

This question, and I believe it is justified, will now be referred to the Commission. Should the Commission envisage conducting and financing a large-scale experiment, then the whole venture will start costing money. For my part, in fact, I would now like to pass on this question to the gentlemen representing the Commission at this round of talks.

Answer by Mr. DOUSSET

I would like to say that to my knowledge the Commission has no plans in this connection at present. As you know, a seminar on accident statistics is being held and it cannot be ruled out that this meeting will produce certain guidelines and information which the Commission will need to take into consideration. In the course of several remarks, starting with those made by the Rapporteur, I was struck by the problem of statistics and the overriding need to devise a better system of data and statistical analyses. This, I believe, will provide an effective basis for decisive progress.

Intervention by Mr. GERRYN

I note that the urgent problem of tyres which cause so many deaths on West German roads has not been the subject of adequate discussion by the panel. What is the Commission's attitude to this ? Is there an implied desire to maintain the status quo or, on the other hand, are steps currently being taken to draw up proposals without informing the circles concerned ?

Answer by Mr. VERDIANI

Very briefly I can say that the problem of tyres is one of our priorities and I believe it will remain so even after the symposium assuming, that is, that it has not taken on an even greater note of urgency.

Intervention by Mr. OPPENHEIMER

Prof. Mitschke has described the advantages of automatic anti-locking braking systems : but the latest EEC Directive of braking (75/524) effectively prohibits such systems.

Could the Commission please indicate when this situation will be remedied, so that manufacturers may feel encouraged to adopt such advanced safety systems ? (especially for trucks and trailers) ?

Answer by Mr. VERDIANI

In my view, Directive 75/524 does not prohibit such devices, but merely stipulates that anti-locking devices must comply with the specifications laid down. Nowhere is it stated that these devices must not be installed. (Such a statement, moreover, would be unforgivable in a Directive.) I do not think that Mr. Pocci will contradict me when I say that, as far as the Geneva Regulations are concerned, it is quite a different matter. At all events, studies are currently being carried out.

Intervention by Mr. KLAMMER

One of your basic statements to the effect that only relatively minor causes of accidents can be attributed to technical defects is surely only valid if currently accepted requirements are rigourosly imposed in respect of all important vehicle components and specifications ?

If this is the case, then the competent Community authorities would be in a position to make a significant short-term contribution only if you took action as soon as possible to introduce, in harmonized form, the relevant proposed Directives.

Answer by Mr. MITSCHKE

My figure of 3% which has obviously animated the discussion somewhat, was based on the assumption that a minimal body of legislation and system of monitoring already existed. Provided this were the case, the figure which I quoted would probably be a fair reflection of these defects.

Answer by Mr. DOUSSET

I cannot subscribe to the views expressed in the seccnd part of Mr. Klammer's comments. Above all else, the Community must accomplish the objective which it set itself, i.e., to finalize the EEC type-approval procedure.

Comments from the Chairman

I believe that our meeting is drawing to a close. We were naturally not here to make discoveries in the fields of interest to us, since we have already done a lot of work on them. I was struck by the number of times people have said they have almost achieved perfection and that they could not really see what more they could do. On the other hand it seems to me that some very useful, very important points have been made and Professor Mitschke has just summarized these. Perhaps I could simply stress some points which have struck me. Firstly I was struck by the fact that everybody has underscored the notion of vehicle driver interaction, perhaps because it has hitherto been put forward too unilaterally i.e., with too much emphasis on equipment and technicalities and perhaps too little on man himself. Man is the unknown quantity, as someone just said. The search for technical perfection must, of course, continue but with man in mind.

It struck me that we have been exceeding the bounds of perfectionism where, as pointed out, there has in some cases been a superabundance of requirements, which could lead to confusion. We ought, perhaps, to make things simpler, more practical and efficient.

Another point stressed was that vehicles should be considered not only at the time of their production, but also throughout their life, so that they must be more easily checked and more economical to repair. This is not so much a matter of technical perfection but of better matching of vehicles to their actual, existing, human conditions of use. We feel that we must pay more attention to safety aspects than in the past, and have already made a start on this, in particular on the roadworthiness testing of vehicles, on driving licences and on other measures affecting driver behaviour. These are the lines along which we are thinking.

Something else which struck me forcibly and which I greatly believe in is that genuinely serious statistics enabling the true causes of accidents to be analysed and classified are currently unavailable. I don't know whether some of you will attend tomorrow's session, but I personally attach a great deal of importance to what could be said then, since I believe that improved data and tools for statistical analysis will be highly desirable and useful as regards safety and vehicle design. As you have seen, some of the matters raised just now will be included among those data and tools for statistical analysis. These are the impressions which I personally have gained and which I offer to the organizers of this symposium.

Closing statement by Mr. MITSCHKE

Several decades ago a number of countries began to draw up provisions governing the operation and construction of individual vehicle components. Vehicles development and, certainly, these provisions themselves have brought about a reduction in the number of technical defects, particularly in individual states which carried out technical inspections.

Over the past two decades as the number of motor vehicles and consequently the number of accidents increased, it has become clear that we cannot continue in this manner. Up to now, we have concentrated only on passive safety, i.e., no change has been brought about in the number of accidents - only in their effects.

The object of the fourth Session is to determine how the number of accidents can be reduced (the title even mentions the word "avoid", i.e., reduce to zero) by applying measures to vehicles.

This Symposium has concentrated mainly on future legal provisions. Opinion is divided as to what is meant by future or long term. It is nevertheless a fact that during the meeting and in other discussions it was pointed out that the features initially to be dealt with are those listed in the EEC type approval certificate : tyres, lighting, forward vision. Although windscreens are also mentioned, it was requested that the discussion be postponed until the effects of the increased use of seatbelts are known.

When the items which have been listed in the EEC type approval certificates since 1970 have been dealt with I am certain, and statistics confirm this, that the number of accidents which can then be attributed to technical defects will be very small. I calculated a figure of 2.3%. It would therefore be incorrect to concentrate on technical defects in motor vehicles. It would be far more important to concentrate on the main causes of accidents : the driver's traffic conditions, the weather and the roads. Motor vehicle designers must adapt their products to human imperfections, traffic and the weather.

Consequently, it is the task of the legislators to prepare rules which bring about this necessary adaptation of vehicles.

For this purpose, it is necessary to know how man, i.e. the driver or - in terms of control technique - the control element, functions. The accumulation of this knowledge will take some time.

Consider therefore first of all the motor vehicle in its entirety. With reference to the EEC Directive on braking, I have shown that it would have been more correct not to have given first priority to long braking distances but rather to the maintenance of directional stability during braking, which is a necessary prerequisite for the overall stability of driver and vehicle.

This still leave us with handling characteristics i.e. first of all the definition of handling characteristics and then the drawing-up of test specifications (ISO). This applies not only to solo vehicles but also to vehicle combinations. The next item in the overall consideration consists of motor vehicle plus driver?

During my speech at this session, I also mentioned the concept of redundancy, i.e., the possibility of making uncertain systems certain by means of parallel linking. The uncertain component is the driver; a unit linked in parallel with him in the case of braking could be the ALS (Anti-locking system). Perhaps there also other possibilities.

During the panel discussion it was pointed out that these considerations should apply not only during the design place i.e., while the vehicle is still within the factors, but also during its operation.

Since we are also dealing here with human imperfections, motor vehicles must be easy to test and to inspect.

To reduce the number of accidents :

1. Continue working on the EEC type approval certificate i.e, on :

   (a) Tyres;
   (b) Lighting;
   (c) Forward vision;

2. View the motor vehicle as a unit as regards :

   (a) Handling characteristics of solo vehicles and vehicle combinations;
   (b) Drawing up test specifications;

3. View motor vehicle and driver as a unit;

4. This applies not only to the formulation of the concept but also to operation

5. Statistics :

   (a) Number;
   (b) Control.

FIFTH SESSION

AIR POLLUTION

AIR POLLUTION
FUTURE REQUIREMENTS, POTENTIAL
TECHNICAL TRENDS IN VEHICLE DESIGN

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REPORT of Mr. SIBENALER

INTRODUCTION

This report has been written at the request of the EEC's Directorate-General for the Internal Market. The scope of the subject matter covered by the heading "Pollutant Emissions from Motor-Vehicles" is of course vast, and the aim of this symposium is to look ahead to future motor-vehicle design and Community requirements. It is therefore necessary to make a choice i.e. to limit oneself to the essentials as viewed by the participants in the meetings to be held in Brussels in December 1975. The memorandum appended is the result of this choice : it only deals with motor vehicles which are driven by internal combustion engines (MV/ICE) using liquid fuels. Of all sources of motive power these pollute the most, but is is nonetheless certain that they will continue to be the most popular type for a very long time yet (certainly for ten years and perhaps fifteen, or even longer).

The subjects covered are presented in the form of technical reports in the annexes listed below :

Annex A1 : List of abbreviations used in the report (the reader is asked to study these carefully before passing on to the subsequent annexes)

Annex A2 : Foundations of a future policy on emission standards for motor vehicles driven by IC engines

Annex A3 : Fundamental and associated parameters for internal combustion engines and their effects on pollutant emissions

Annex A4 : Current situation with regard to testing techniques in the EEC - restrictions imposed by standards - Discussion

Annex A5 : Situation with regard to the principal test techniques other than those set out in EEC Directives

Annex A6 : Particular Lead emissions

Annex A7 : Tasks of the motor-vehicle engineer - development and research

Annex A8 : Planning of restrictions imposed by standards for motor vehicles driven by internal combustion engines.

The page numbers contain first of all the number of the annex, followed by the number of the page within the annex.

Owing to the limited amount of time and space available it has not been possible to list the large number of recent papers and memoranda consulted. My apologies to their authors. I would also like to thank everyone who has assisted me in my task.

*
* *

KEY TO ABBREVIATIONS USED IN THE REPORT

SI	: spark ignition
CI	: compression ignition
CO	: carbon monoxide
CVS	: constant volume sampling
CVS-C	: constant volume sampling-cold
CVS-CH	: constant volume sampling-cold and hot
FAR	: fuel/air ratio $d = De/Da$
MFA	: mass flow of air
MFP	: mass flow of petrol
(FAR)s	: fuel/air ratio (stochiometric)
EPA	: environmental protection agency
Evp	: evaporation
EG	: exhaust gas
PNA	: polynuclear aromatics
HC	: hydrocarbons
HC-Evp	: evaporation hydrocarbons
HC-EG	: hydrocarbons in exhaust gases
λ	: coefficient of excess air $\lambda = 1/r$
AFM	: air/fuel mixtures
ICE	: internal combustion engine
ICE/CI	: compression-ignition internal combustion engine
ICE/SI	: spark-ignition internal combustion engine
ICE/4st	: 4-stroke internal combustion engine
ICE/2st	: 2-stroke internal combustion engine

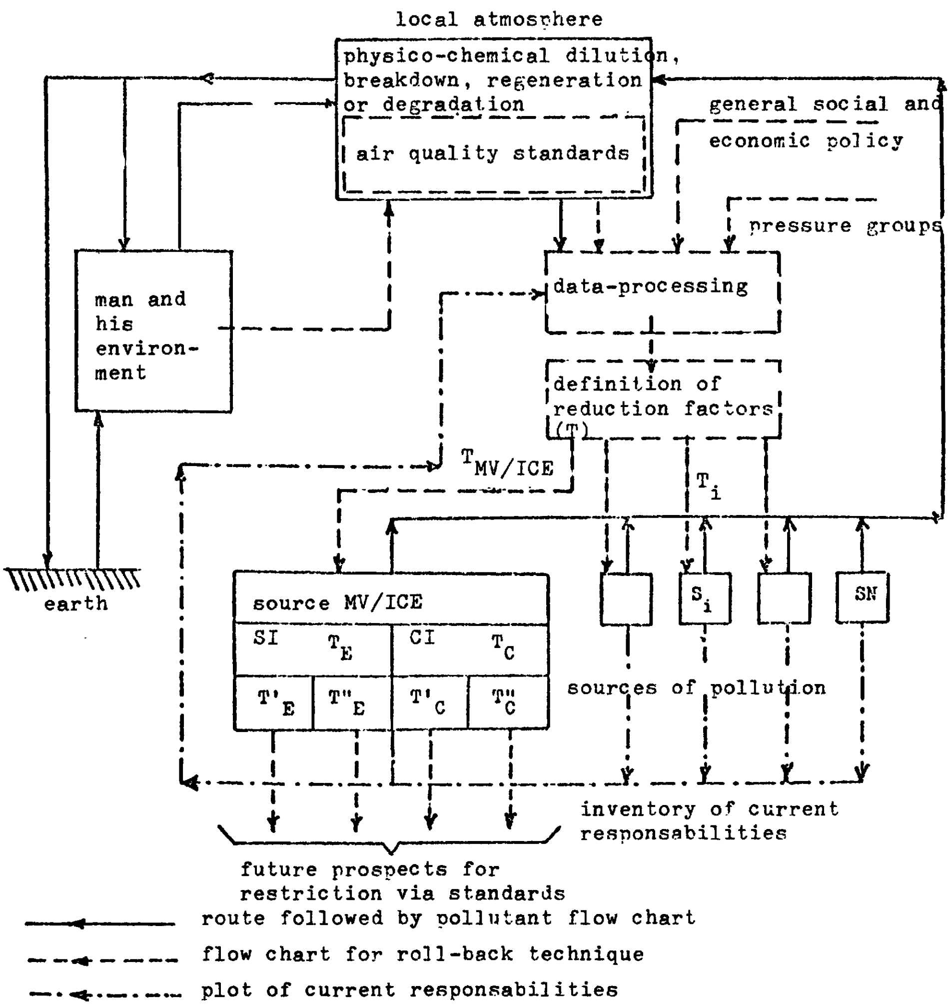
NOX	: nitrogen oxides	
r	: richness of fuel/air mixture	r = FAR/(FAR)s
SOX	: sulphur oxides	
MV	: motor vehicle	
MV/ICE	: motor vehicle driven by an internal combustion engine	
MV/ICE/CI	: motor vehicle driven by a compression-ignition internal combustion engine	
MV/ICE/SI	: motor vehicle driven by a spark-ignition internal combustion engine	

In addition use is sometimes made of characteristic symbols for atoms and molecules.

FOUNDATIONS FOR A FUTURE POLICY ON EMISSION STANDARDS FOR MV/ICE

1. GENERAL DATA - DIFFICULTIES IN DEFINING RESPONSABILITIES AND REQUIREMENTS VIS-A-VIS THE VARIOUS SOURCES OF POLLUTION

1.1. The route followed by pollutants from their source to man and his environment runs directly counter to the various stages of the roll-back technique which, alone, can provide the basis for a stringent policy of restriction via standards.



1.2. In its practical application the roll-back technique makes use of a number of parameters which have been the subject of frequent discussion, if not argument. These are:

- inventory of current responsabilities of the sources, including the natural environment (these responsabilities depend, by and large, on geographical and temporal factors);
- physico-chemical changes in the pollutants following their discharge into the atmosphere;
- effects on man and his environment, taking into account the pollutant content of the local air;
- air quality standards and the various health-hazard levels;
- interference of a non-technical nature at the data-processing centre;
- reduction factors to be imposed in respect of the verious sources, taking into account not only the varying degrees of responsability of the latter but also the technological and economic difficulties which the application of restrictions via standards would create for each source;
- these factors, moreover, have to be increased as a function of date of origin, so as to offset
  (a) delays in the implementation of new techniques and
  (b) the growth in the number and volume of a type of source.

1.3. Very special attention must be paid to all the above-mentioned parameters in any discussions on air quality standards and the repercussions which these would have on the restrictions to be imposed on sources of pollution.

2. AIR QUALITY STANDARDS

2.1. National air quality standards - USA

pollutant	primary standards (health)	secondary standards (welfare)
CO max. 8 hours (*) max. 1 hour (*)	10 mg/m^3 40 mg/m^3	10 mg/m^3 40 mg/m^3
HC max. 3 hours (*) (6 - 9 a.m.)	160 ug/m^3	160 ug/m^3
NO_2 annual mean	100 ug/m^3	100 ug/m^3
Solid aerosols - annual geometrical mean - max. 24 hours (*)	 75 ug/m^3 260 ug/m^3	 60 ug/m^3 150 ug/m^3
Photochemical oxidants max. 1 hour (*)	160 ug/m^3	160 ug/m^3
SO_2 annual mean max. 24 hours (*) max. 3 hours (*)	80 ug/m^3 365 ug/m^3 ---	60 ug/m^3 260 ug/m^3 1300 ug/m^3
Pb mean: 3 months or over	2 $\mu g/m^3$	
(*) not to be exceeded more than once a year		

2.2. <u>There is no such thing as an air quality standard peculiar to the European Communities or to Europe in general.</u>

2.3. National air quality standards

Country	Pollutant	Maximum concentration		Duration of sampling	% of time within limits	Frequency
		mg/m^3	ppm			
France	NO_2	0,47	0,25	1 hr	99%	max.
	CO	46	40	1 hr	99%-1year	
Italy	NO_2	0,20	0,1	24 hrs	50%	1/8 hrs
		0,56	0,3	30 min	94%-8hrs	
	HC	135	40	24 hrs	50%	1/8 hrs
		275	80	30 min	94%-8hrs	
	CO	23	20	8 hrs	50%	1/8 hrs
		57	50	30 min	94%-8hrs	
West Germany	NO_2	1	0,5	30 min		long-term exposure
		2	1	30	94%-24hrs	not more than 3/24 hrs
USSR	NO_2	0,085	0,045	24 hrs	100%	not to be exceeded
		0,085	0,045	20 min		
	CO	1	0,9			
		3	2,7			
Japan	CO		10	24 hrs		
			20	8 hrs		

2.4. Recommendations of the World Health Organization (WHO)

Pollutant	Limits
SO_2	60 µg/m^3 (annual mean)/98% at 200 µg/m^3
particles	40 µg/m^3 (annual mean)/98% at 120 µg/m^3
CO	10 mg/m^3 8 hrs max - 40 mg/m^3 1 hr max
oxidants (O3)	60 µg/m^3 8 hrs max - 120 µg/m^3 1 hr max

2.5. Note : These somewhat conflicting opinions are an intellectual irritant, since there is no fundamental physical difference between Americans, on the one hand, and Europeans or Japanese, on the other.

3. PROGRAMME OF ACTION ON THE ENVIRONMENT BY THE EUROPEAN COMMUNITIES - PROJECTS AIMED AT REDUCING AIR POLLUTION - IRT BULLETIN 185/1973

The aim of these projects is to create a common basis for evaluating . limits at Community level, i.e.,

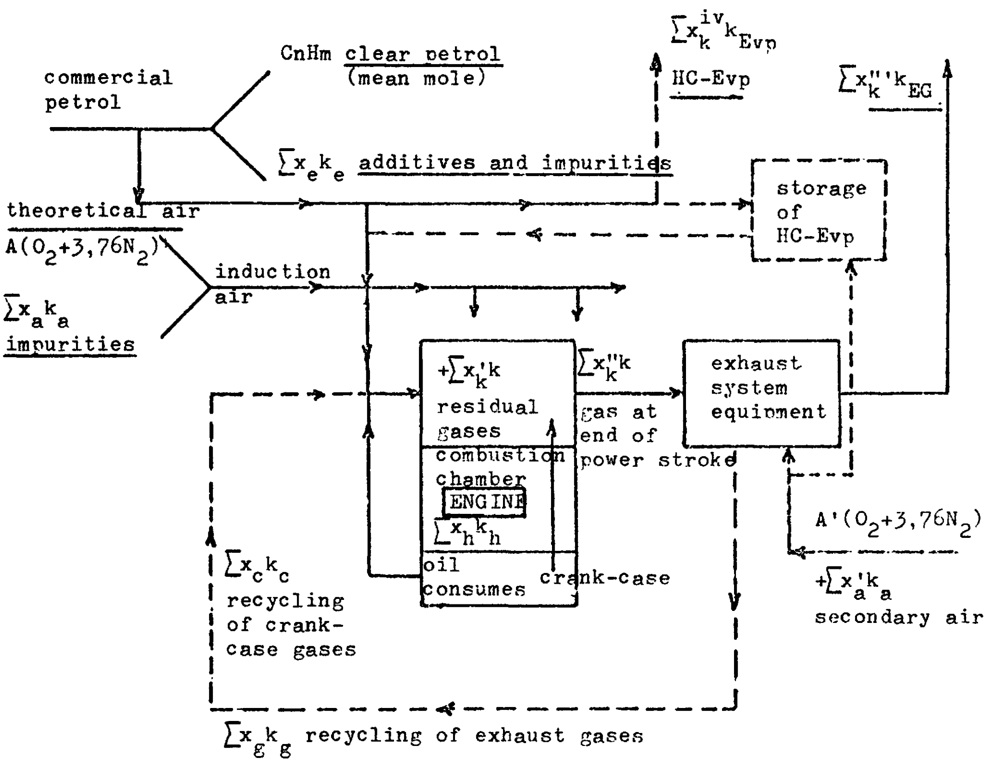
- to establish an objective basis for evaluating health risks,
- to lay down common health standards,
- to draw the appropriate conclusions and act accordingly.

NB : In other words, the Commission of the European Communities is strictly complying with the requirements of the roll-back technique (a difficult and long-term task).

FUNDAMENTAL, INTERRELATED PARAMETERS FOR INTERNAL COMBUSTION ENGINES AND THEIR EFFECTS ON POLLUTANT EMISSIONS

1. POLLUTANT EMISSIONS FROM ICE/SI

1.1. Complex path of fluid flows through an ICE/SI referred to the mean mole of clear petrol



——— always

– – – – if necessary

k_i : product determined (examples: CO, H_2O, O_2, C_6H_6, ...)

x_i : moles of k_i per mean mole of petrol

$A=(n+m/4)/r$ $\quad$ $r=FAR/(FAR)s$: richness of air/fuel mixture

$FAR=MFP/MFA$: proportion D: mass flow { e: for petro[l] / a: for air }

d_S : fuel/air ratio (stochiometric)

1.2. Fundamental, interrelated parameters that have a significant effect on emission from spark-ignition internal combustion engines

1.2.1. Fundamental parameter "air/fuel mixture (AFM)"

- Commercial petrol
  - composition of clear petrol
    - paraffinic HC
      - normal
      - isoparaffins
    - olefinic HC
    - aromatic HC
  - additives to clear petrol
    - TEL and (or) TML
    - ethylene dichloride and (or) dibromide
    - detergent-dispersants (DD)
    - etc...
  - impurities in clear petrol containing additives
    - sulphurous substances
    - gums, etc...
  - physico-chemical characteristics of clear petrol
    - volatility
    - density
    - C/H ratio
    - anti-detonation properties
    - viscosity, etc...

- Physical preparation of the AFM and its even distribution among the cylindres

- vaporization and homogenization or vaporization and stratification of the induction charge - optimum metering - quantitative and qualitative even distribution among the cylinders	in all operationg modes - stable economical and power operating conditions - acceleration and pick-up - deceleration - cold start-up and warming-up

by means of

- conventional carburations with a carburettor

- continuous petrol injection with mechanical metering operation and control
- cyclic petrol injection with control and operation by electronic computer
- etc...

while avoiding HC emissions by evaporation as far as possible

- Recycling of crank-case and exhaust gases (the latter of necessity)
- Introduction of oil particles into the air/fuel mixture

1.2.2. Fundamental parameter "spark-ignition engine"

- Complex process of initiation of combustion and propagation of flame front
  - combustion rate combining speed and area of flame front
  - optimum ignition advance and its variation as a function of speed and load :
    - ignition system involving a battery and a high-voltage spark
    - inductive ignition with electronic triggering of spark
    - capacitive-discharge electronic ignition
  - combustion chamber shape
    - general shape
    - swirl
    - compression ratio
    - quenching areas
    - total cylinder capacity and number of cylinders
    - S/V ratio
    - location of the spark plug
- Improper combustion
  - detonation
  - running-on
  - cyclic dispersion
  - pre-ignition
  - misfiring
- Induction system
  - geometry of air and petrol supply pipes
  - valve dimensions, lift, timing, overlap on opening

- Lubricating oil
  - composition
  - viscosity
  - additives
  - degradation and contamination
- Condition of engine (deposits and degree of wear)

1.2.3. Fundamental parameter "exhaust system"

- Length and geometry of the piping
- Position, volume and design of the silencer
- If applicable
  - heat insulation
  - lead trap (Pb)
  - recycling of exhaust gases (EG)
  - thermal or catalytic oxidation of the CO and HC
  - catalytic reduction of NOX
  - catalytic oxidation and reduction of the EG

1.2.4. Fundamental parameter "motor vehicle"

- Type of transmission and its kinematic and dynamic characteristics
- Distance covered
- Shape and weight
- Maintenance
- Driving habits

1.3. Qualitative effects of the parameters on emissions from vehicles driven by spark-ignition internal combustion engines

1.3.1. Emissions of substances which can be predicted on the basis of the energy-conversion process occurring in spark-ignition engines

H_2O - O_2 - H_2 / CO_2 / CO - NOX

1.3.2. Substances detected at the exhaust outlet

Those listed above, to which the following must be added

- unburnt HC
    - total HC
    - paraffinic HC (slightly reactive)
    - olefinic HC and Evp exhaust-gas (highly reactive)
    - aromatic HC (highly reactive)
    - polynuclear aromatics (PNA, some of which are carcinogenic)
- products due to incomplete oxidation of HC
    - aldehydes (total-formaldehydes - aromatic aldehydes)
    - ketones, phenols
- particulate emissions
    - total particulate
    - compounds of Pb, Ba, Ca, Z, P, etc...
- sulphur oxides
    - SOX
    - and, in some cases, sulphates

1.3.3. When in the atmosphere in the presence of O_3, and under solar irradiation and special climatic conditions, some of these substances (reactive HC, NOX and others) sometimes give rise to photo-chemical fog (smog).

1.3.4. The generally accepted order of priorities as regards emissions from MV/ICE/SI in urban traffic, is as follows:

Priority 1 CO, HC-total, HC-Evp

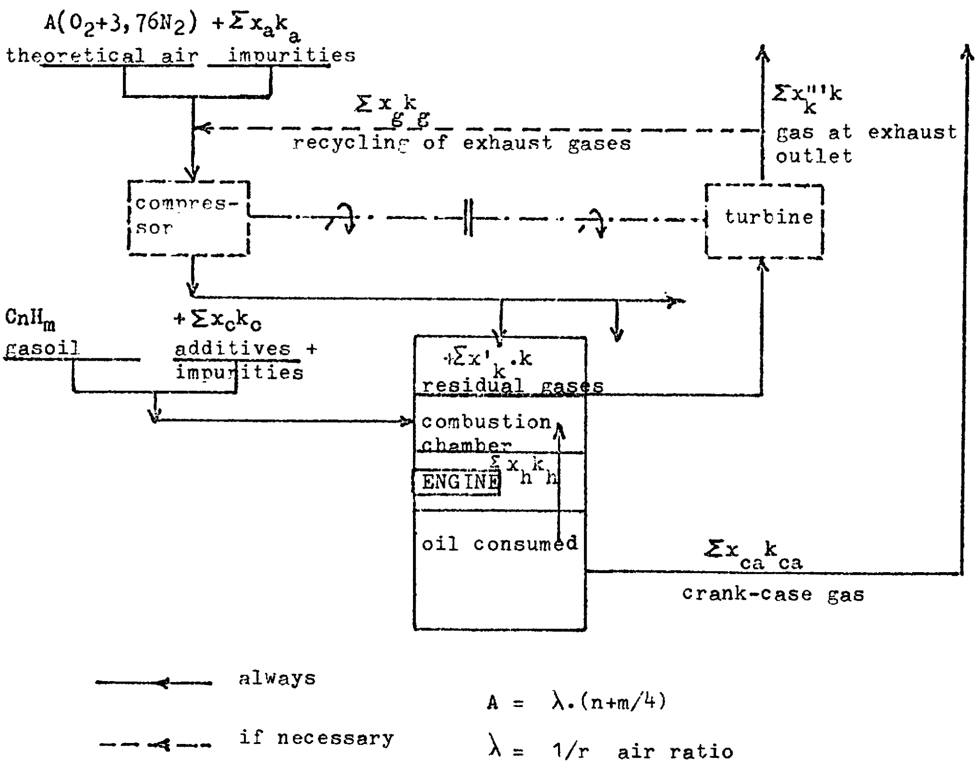
Priority 2 NOX, Pb particles

Priority 3 reactive and carcinogenic HC

Priority 4 SOX and total-particles

2. POLLUTANT EMISSIONS FROM COMPRESSION-IGNITION ENGINES

2.1. Path of fluid flow referred to mean mole of fuel



$A = \lambda.(n+m/4)$

$\lambda = 1/r$ air ratio

$r = FAR/(FAR)s$ and $FAR = MFP/MFA$

2.2. Significant fundamental interrelated parameters

2.2.1. Parameter "air supply"

- Gas recycling (possibly of crank-case and exhaust gases)
- Even mass distribution of air among the cylinders
- Pressure and temperature of induction air
- Supercharging

2.2.2. Fundamental parameter "fuel"

- Composition
  - HC families and molecular weight
  - additives to clear gasoil (ignition improvers, detergent-dispersants, anti-smoke additives, etc...)
  - impurities in gasoil (composed mainly of S)
- Physico-chemical characteristics
  - volatility
  - chemical reactivity
  - density
  - viscosity
  - carbon residues and ash

2.2.3. Fundamental parameter "compression-ignition engine"

- Combustion chamber
  - shape (direct injection, precombustion chamber or hybrid)
  - swirl
  - compression ratio
- Optimum pre-injection and its possible variation as a function of speed and load
- Injection system
  - location in chamber
  - direction and shape of jet
  - penetration of jet
  - dynamic phenomena between pump and injector

- electro-magnetically controlled and electronically metered injection
- injection pressure
- degree of atomization
- control of injection rate

2.2.4. Fundamental parameter "exhaust system"

- Length and geometry of piping
- Position, volume and design of silencer
- Pre-dilution of exhaust gases in exhaust system
- Possible recycling of exhaust gases
- Reduction of NOX (difficult)

2.2.5. Fundamental parameter "motor vehicle"

- Type of transmission and kinematic and dynamic characteristics
- Distance covered
- Maintenance, particularly of the injection system
- Driving habits

2.3. Qualitative effects of the parameters on emissions from vehicles driven by compression-ignition engines

2.3.1. Substances which can be predicted on the basis of the energy conversion processes

$$H_2O \; - \; O_2 \; / \; CO_2 \; / \; CO \; - \; NOX$$

2.3.2. Substances detected at the exhaust outlet

Those listed above, to which the following must be added:

- unburnt HC (as for ICE/SI except for the HC-Evp)
- products of incomplete oxidation of HC (as for ICE/SI)
- bad odours
- smoke - blue-white
  - grey-black
- emissions of particles of Ba, Ca, Z, P, etc...
- SOX

2.3.3. As in the case of ICE/SI, in the atmosphere, under solar irradiation and special climatic conditions, some of these substances sometimes give rise to photo-chemical fog.

2.3.4. As regards the MV/ICE/CI, the generally accepted order of priorities is as follows:

<u>Priority 1</u> grey-black smoke

<u>Priority 2</u> NOX

<u>Priority 3</u> bad odours

<u>Priority 4</u> CO HC HAP

<u>Priority 5</u> SOX and particulate emissions other than smoke

CURRENT SITUATION WITH REGARD TO TESTING TECHNIQUES IN THE EEC - RESTRICTIONS IMPOSED BY STANDARDS - DISCUSSION

1. EEC DIRECTIVE 70/220 AND CO AND HC EMISSIONS FROM MOTOR VEHICLES DRIVEN BY SPARK-IGNITION ENGINES

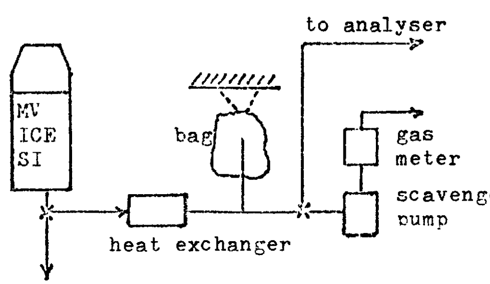
1.1. 70/220/EEC - Tests types I - II - III

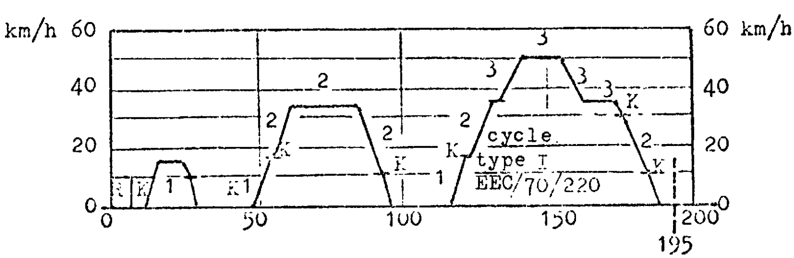
1.1.1. Type 1 sequence and collection of gases

4 cycles for type I : 4052 m in 780 sec.

$$e_i = T_i \cdot V \cdot p_i$$

e_i = pollutant emission (i) in g/test
T_i = volume content of (i)
V = volume of gas emitted per test
p_i = specific mass of (i)





1.1.2. Test type II (hot and no-load idling)

$T_{CO} = T' \frac{15}{COT'_{CO}+T'_{CO_2}}$ in %   T' measured in % volume

1.1.3. Test type III (verifying the efficiency of crank-case gas recycling)

mode km/h	induction-depression mm Hg	gear ratio	time	volume lit/EG	consump-tion	HC ppm/10^6
idling	-	-	x'	V'	c'	T'
50±2	(400±8) or the value at 50 km/h on a level road in third gear	highest allowing smooth running	x"	V"	c"	T"
50±2	(250±8) or 0.625 times the previous value		x"'	V"'	c"'	T"'

$e' = 3.84.T'.V'/x'$

$e'' = 3.84.T''.V''/x''$

$e''' = 3.84.T'''.V'''/x'''$

$cu' = c'/x'$

$cu'' = c''/x''$

$cu''' = c'''/x'''$

$P = 0.25\ e' + 0.25\ e'' + 0.50\ e'''$

$c = 0.25\ cu' + 0.25\ cu'' + 0.50\ cu'''$

P : weighted emission per unit of time

c : weighted consumption by mass per unit of time

NB: Variation for type test III :

check for depression in the crankcase in these three modes.

1.2. EEC/70/220 - Type approval - Restrictions - Applications

1.2.1. Test_type I

Pr : reference weight in kg
LCO : CO limit in g/test max.
LHC : HC limit in g/test max.

PR	750	750-858	850-1020	1020-1250	1250-1470	1470-1700	1700-1930	...
LCO	80	87	94	107	122	135	149	...
LHC	6.8	7.1	7.4	8.0	8.6	9.2	9.7	...

NB : if the test result (g/test) is recorded for each V

- 1 test only where VCO $<$ 0.7.LCO and VHC $<$ 0.8.LHC
- 2 tests where:
  0.7.LCO $<$ $VCO_1 \leq$ 0.85.LCO and $VHC_1 \leq$ 0.85 LHC or when
  $VCO_1 \leq$ 0.85.LCO and 0.7.LHC $<$ $VHC_1 \leq$ 0.85 LHC
  but where { $VCO_1+VCO_2 <$ 1.70.LCO $VHC_1+VHC_2 <$ 1.70.LHC
  { $VOC_2 <$ LCO $VHC_2 <$ LHC
- 3 tests in other cases provided that
  VCO $<$ 1.1.LCO or VHC $<$ 1.1.LHC

1.2.2. Test_type II the vehicle complies if $T_{CO} \leq$ 4.5 %

1.2.3. Test_type III the vehicle complies if P $\leq$ 0.15.c/100

1.3. EEC/70/220 - Verifying conformity of production models

1.3.1. Test_type I

- Limits: those for type approval multiplied by 1.20 in the case of LCOs and by 1.30 in respect of the LHCs

NB : where the vehicle selected from the production batch does not conform to the rules laid down in the note to 1.2.1. above (still taking account of these new limits), the arithmetical mean in respect of the VCO and the VHC shall be calculated from the 3 type I tests for this vehicle as follows:

$$x_o = (V_1+V_2+V_3)/3$$

The manufacturer still has the possibility of taking a sample of (n-1) MV from the same batch; in this case each one undergoes a single type I test; the following calculation is then made in respect of each pollutant (CO and HC):

$$\underline{x} = \frac{\sum_1^{n-1} x_i + x_o}{n}$$

x_i : emission from MV (i) of the batch (n-1)

The production batch is said to conform if $\underline{x} + k.S \leq L$

S : standard deviation of sample n

k : statistical factor, decreasing function of n

L : maximum limit for conformity of production models

1.3.2. Test types I and II : as for type-approval

2. EEC DIRECTIVE 70/220 AND TESTS AFTER A CERTAIN DISTANCE HAS BEEN COVERED

There are no plans for such tests. I believe that this is a shortcoming of the Directive.

3. EEC DIRECTIVE 70/220 AND NOX EMISSIONS

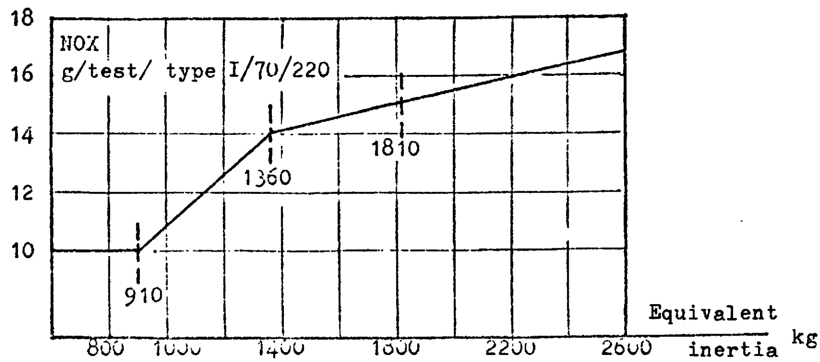
3.1. Restrictions imposed by present standards : none

3.2. Present position

3.2.1. Generally speaking, it is thought that NOX should only be measured in an "urban"-type test; the type sequence and technique used in 70/220 can be applied satisfactorily; the EEC plans to amend EEC Directive 70/220 in order to take account of the NOX.

3.2.2. The proposals put by the GRPA to WP-29 (Geneva) are summarized below:

- vehicle type-approval



Remarks: - these limits should be translated into figures via ranges of reference weights as for CO and the HCs using identical approval regulations.

- some countries have requested that there either be a temporary raising of these limits or that there should be limits which are specific to certain types of MV/ICE/SI.

- checking the conformity of production models

the approval limits multiplied by a coefficient k could be 1.2 ; some countries, however, think this figure is too low.

4. EEC DIRECTIVE 70/220 AND POLLUTANT EMISSIONS OTHER THAN CO, HC AND NOX

4.1. Reference to Annex A3, page A3/09 section 2.3.4. - Order of Priority shows that Pb particulate emission follows immediately after the emission of CO, HC-total and HC-Evp; and so it is questionable whether EEC Directive 70/220 is properly suited to the measurement of this very special type of emission, i.e. whether one can simply and rapidly determine the mass ratio of the emitted lead to the consumed lead during the 70/220/Type I sequence; this problem has to be discussed if a way is to be found of reducing lead particulate emission, other than by reducing the lead content of petrol.

The experience of a number of laboratories shows that, during a 70/220/Type I journey by motor vehicles in the reference weight ranges which are the most representative of all European vehicles on the road, the ratio (without a lead trap) of Pb emitted to Pb consumed does not exceed 20% with petrols containing 0.6g - Pb/lit. Under these circumstances, a 1360 cm^3 vehicle weighing 985 kg and consuming 355 g of petrol per test (approximately 500 cm^3/ test) where the volume of gas emitted is 4000 lit/test, the amount of lead emitted does not exceed:

$$0.6x0.5x0.2 = 0.06 \text{ gr/test or } 600\,\mu g/\text{test or } 600/4 = 150\,\mu g/m^3.$$

If it is accepted that a Pb trap can reduce this content by approximately 75% (which does not seem unusual) the amount of lead emitted drops to 600x0.25 = 150 μg/test. Of these 150 μg/test, more than 90% (i.e., 135 μg) are retained and peptized in the condensed combustion water and therefore before they reach the bag; this represents concentrations of approximately 75 ppm by weight in the condensate.

On this basis it should be possible, if more attention is paid to the washing of the gases with the combustion water, to extend the technique laid down in 70/220/Type I (without altering the time factor).

4.2. It may be possible to extend techniques 70/220/types I, II and III to at least some of the other pollutants referred to in Annex A3, page A3/04 ; to the best of my knowledge this avenue has not yet been explored.

5. EEC DIRECTIVE 70/220 AND POLLUTANT EMISSIONS FROM MOTOR VEHICLES DRIVEN BY COMPRESSION-IGNITION ENGINES

5.1. MV/ICE/CI are part of the same urban traffic as those motor vehicles covered by the 70/220 technique and one might ask why these vehicles are not subject to the same approval. On the one hand such vehicles still represent only a small minority of all urban traffic (in the case of Brussels traffic, for example, the figure is 1.5%); on the other hand EEC Directive 70/220 only verifies CO and HC emissions and it is not therefore necessary to subject vehicles driven by compression-ignition engines to it; the question might come up again of the Directive is extended to include NOX, as will be seen from the results given below:

Vehicle	A	B	
engine	SI	CI	
cylinder capacity (cm^3)	2 565	2 164	
reference weight (kg)	1 390	1 510	A and B same vehicle
equivalent inertia (kg)	1 360	1 590	
transmission	manual	manual	
consumption (g/test)	533	385	
NOX-70/220 : type 1	16.6	19.87	
NOX : GRPA limits	14.1	14.5	

6. EEC DIRECTIVE 70/220 AND MISCELLANEOUS OBSERVATIONS

The technique set out in EEC/70/220 (like any other method of measurement) is not perfect and prompts discussions on the following topics for example:

- representativeness of the type-I urban cycle
- the washing-out of a number of pollutants by the condensed combustion water before they reach the bag (which in the rapporteurs opinion is not always a bad thing)
- the bag material and the amount of dead volume between the bag and the vehicle
- calculation of the corrected volume
- general accuracy of the measurements including their reproducibility
- the difficulty in adapting the method to certain pollutants
- adjusting the dynamometer brake to the road resistance curve
- the principle itself and the procedure for repeating the tests in the light of the discrepancy between the value(s) obtained and the requirements of standards in connection with both approval and verifying the conformity of production models
- etc...

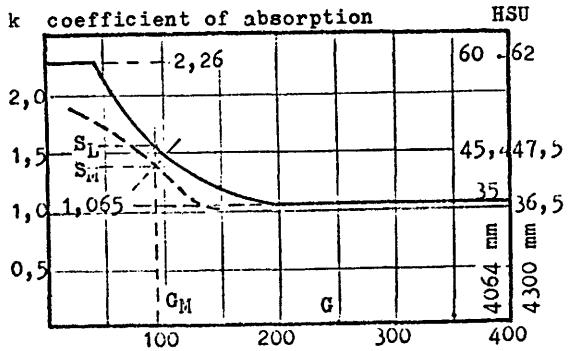
Generally speaking, however, and in the opinion of those using the 70/220 technique, this method is very valid and is simple, rapid and relatively economical to implement; moreover, it can always be perfected and there are working parties devoted to this. In this connection, mention should be made of a study entitled "Comparison of British and European Emission Laboratories/Department of the Environment/Vehicle Engineering Division" in which English, German, French, Dutch and Belgian laboratories have taken part; the aim of the study was to collaberate each separate institution by using the same vehicle.

EEC technique 70/220/Types I and II/ MV/ICE/SI / Automatic transmission EI 1130 kg					
laboratory one per country	date of tests	CO g/test requirement 70/220 107	HC g/test requirement 70/220 8.0	NOX g/test requirement 70/220 12 (put forward by GRPA)	Idling CO % 4.5 max.
A	9-10/4/74	49.7	4.28	12.16	2.18
B	22-24/4/74	57.8	4.64	11.33	2.65
C	25-30/4/74	54.8	6.23	10.70	1.91
D	1- 3/5/74	52.6	5.24	12.02	1.59
E	6- 8/5/74	45.6	5.11	10.47	1.46
A'=A	19-21/5/74	56.2	4.59	10.69	2.42
average	$\underline{x}$	52.8	5.02	11.23	2.04
maximum	x_1	57.8	6.23	12.16	2.65
minimum	x_2	45.6	4.28	10.47	1.46
x_1-x_2		12.2	1.95	1.69	1.19
100. /2$\underline{x}$	%	11.5 %	19.5 %	7.5 %	29.2 %
100. /standard value		11.4 %	24.4 %	14.1 %	26.4 %

7. <u>EEC DIRECTIVE 72/306 CONCERNING EXHAUST EMISSIONS FROM MOTOR VEHICLES DRIVEN BY COMPRESSION-IGNITION ENGINES</u>

7.1. <u>Type Approval</u>

7.1.1. Steady-state test



- on engine bench or on vehicle
- measurements under steady-state conditions and full throttle at 6 speeds evenly divided between the maximum power speed and the highest of the two following speeds : 0.45 x maximum power speed or 1000 rev/min
- ICE/CI/4st —— G = (zVc)n/120

  ICE/CI/2st —— G = (zVc)n/60

  (z.Vc) : cylinder capacity in litres

  n : in rev/min

  HSU : Hartridge smoke unit
- for supercharged compression-ignition engines the values for G remain unchanged and for each speed adopted the exhaust smoke intensity is measured with supercharging and also without supercharging if it can be disengaged in operation
- restrictions imposed by standards : at each speed the exhaust smoke intensity measured at each point G must lie below the curve shown above.

7.1.2. Free acceleration test

- on engine bench or on vehicle (in neutral)
- the lowest of the following values is calculated and adopted:

$$X'_L = (S_L/S_M).X_M \qquad \text{or} \qquad X''_L = X_M + 0.5$$

  X_M : exhaust smoke measured during free acceleration

  S_M : value of the coefficient of absorption nearest to the curve for restrictions imposed by standards measured during the steady-state test

  S_L : value of the coefficient of absorption of the curve for $G=G_M$
- for a supercharged engine with switch-in supercharging, the test is carried out with or without supercharging; the highest of the X_L values is adopted
- restrictions imposed by standards
    - for a naturally-aspirated engine or one with a switch-in supercharger, there is no restriction; the value for X_L is merely noted
    - for turbocharged engine : $X_M \leq S_L + 0.5$

7.2. Conformity of production models

7.2.1. The first step is always a test under free acceleration conditions, where the restriction imposed by standards is :
(X_M) production model $\leq$ (X_L) type approved + 0.5

7.2.2. Where the above restriction is not met, a steady-state test is carried out and in this case the restriction is the same as for type-approval.

7.3. Technique EEC/72/306 and observations

7.3.1. As in the case of technique 70/220, this technique has been discussed and sometimes challenged for similar reasons, namely:

- technological details
- accuracy of measurements and reproducibility
- no strict application of the check to production models
- absence of restrictions imposed by standards after a certain distance has been travelled
- questioning the concept behind the calculation for X_L and its comparison with X_M for production models
- etc...

7.3.2. What is contested most of all is the test under free acceleration conditions; it is criticised for its lack of correlation with the full-load curve test and this has led to considerable pressure to abolish it altogether:

- The rapporteur agrees that there is no correlation between the 2 tests; he said over and over again that no such correlation could exist and that too much time and money has been wasted in order to confirm or deny such a correlation. What is more, if such a correlation were to exist one of the 2 tests would be superfluous and it would be the longest and the most costly which would have to go, i.e., the full-load curve test.

- It should be borne in mind, however, that the aim of a screening test such as the test under free acceleration conditions, is the control of production models, i.e., verifying the practical equivalence (within certain tolerances) between production engines and the "model". If, in production control, such a screening test yields results which are markedly different from those obtained using the same test for type-approval purposes, the production batch will automatically be suspect, and not only as regards exhaust emissions. It must be clearly demonstrated, as with any other screening test, that this free acceleration test is sufficiently sensitive and meaningful to be able to detect any lack of conformity.

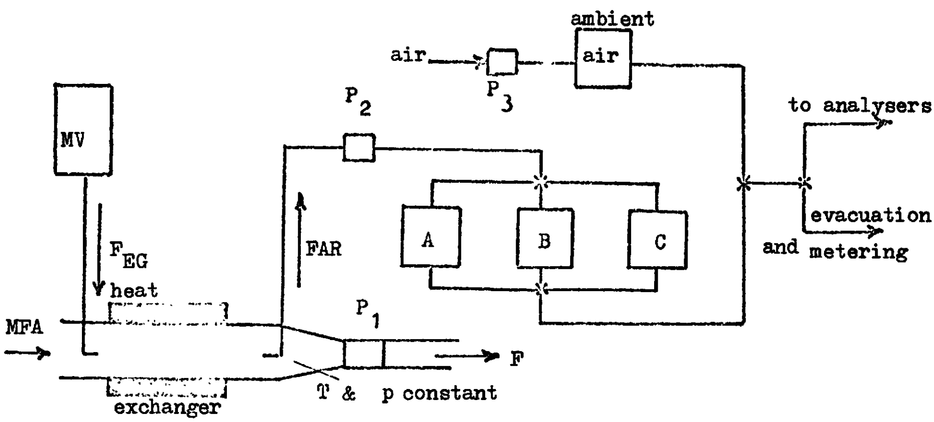
- It is quite clear that it must be possible to detect features which do not conform other than by means of a free acceleration test and to do this by viewing other criteria which have nothing to do with the measurement of exhaust smoke. Such a test must however be simple, quick and cheap.

SITUATION WITH REGARD TO THE PRINCIPAL TEST TECHNIQUES
OTHER THAN THOSE SET OUT IN EEC DIRECTIVES

1. Test techniques and restrictions imposed by standards in the USA

1.1. Gaseous emission from light vehicles weighing less than 6 000 pounds (lbs

1.1.1. Constant volume sampling (CVS)



P : positive displacement pump
A-B-C inflatable bags for parts A-B-C of the type sequence
MFA : mass flow of air
F_{EG} : mass flow of exhaust gas
FAR : mass flow of sample
F $=(MFA + F_{EG}) - FAR$
M : mass of pollutant emitted by the MV while filling a bag
Ms : mass of pollutant collected in the bag at the same time
Vol : corrected volume of gas in a bag
T : volume of pollutant in a bag
ρ : specific mass of the pollutant

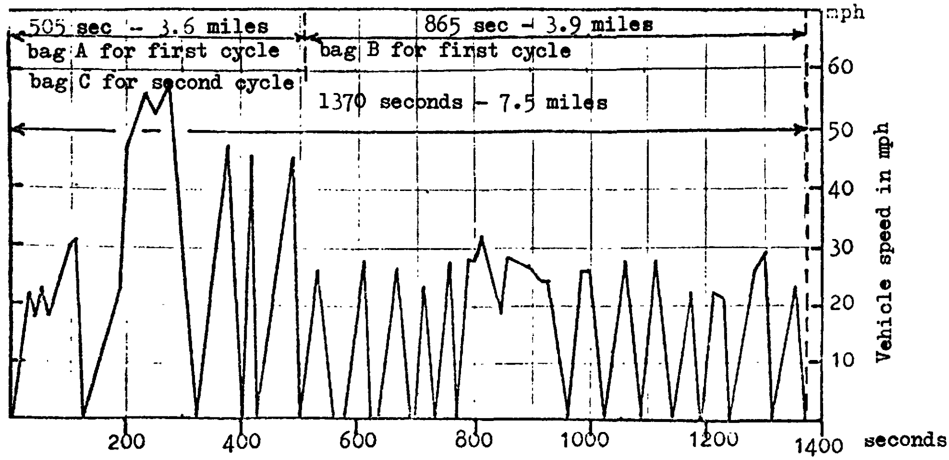
it can be shown that : $M = Ms.(1+F/FAR)$

where $Ms = Vol.T.\rho$

1.1.2. Constant volume - CH sampling sequence

C : Cold - 1st cycle - bag A then bag B

H : Hot - 2nd cycle - only the first 505 seconds - bag C



1.1.3. Calculation of the corrected emission (e_c in g/mile) of a pollutant in accordance with the CVS-CH technique

- Calculation of (e) for one pollutant and one motor vehicle

  $e = Mc/7.5$ where $Mc = 0.43.M_A + M_B + 0.57.M_C$

- calculation of e_c for one pollutant and 3 vehicles

$$e_c = e_o.f_c$$

e_o : mean arithmetical emission value for 2 vehicles

$e_o = (e_1 + e_2)/2$ in g/mile at 4 000 miles

f_c : endurance correction factor

$$f_c = \frac{\text{e at 50000 miles for a third vehicle}}{\text{e at 5000 miles for a third vehicle}}$$

1.1.4. Restriction imposed by standards on vehicles of a given "type"

- current interim Federal standards

year	HC	CO	NOX	in g/mile max.
75/76	1.5	15.0	3.1	
1977	1.5	15.0	2.0	

- the 1977 standards have, however, been called into question and it is very difficult to predict what the standards will be after 1976. For information purposes, the following recommendations might be noted:
  - EPA recommendation to Congress

Year	HC	CO	NOX	in g/mile max.
78/79	1.5	15.0	2.0	
80/81	0.9	9.0	2.0	
1982	0.41	3.4	2.0	

  - recommendation from the President to Congress

77/81	1.5	15.0	3.1	Present status quo

  NB: The President has the right to veto any Congress dicision.

  - situation in California

77/76	0.9	9.0	2.0
1977	0.41	9.0	1.5

  The Californian standards after 1977 will most likely depend on Congress decisions and the freedom of action granted to this State under the laws.

  - Remarks
    - MV/ICE/CI, the overall weight of which is less than 6000 lbs normally undergo the same tests and are subject to the same restrictions, however, since some heavy hydrocarbons are likely to deposit out in the bags, a special sampling circuit diverts a constant fraction of the diluted exhaust gases to a hot-flame ionization detector (HFID). The hydrocarbon content is therefore integrated as a function of time and, in this way, the average content corresponding to this particular flow (which is always constant) can be calculated.

    - MV/ICE/SI weighing less than 6000 lbs and light utility vehicles are subject to less stringent restrictions; thus, for 1977 : HC-2, CO-20, NOX-3.1 g/mile max.

1.1.5. The requirements regarding the conformity of production examples are the same as those for the "type"; the tolerance covers the percentage of vehicles which are authorized to exceed these constraints.

1.2. Smoke emissions from MV/ICE/CI weighing less than 6000 lbs.

As far as the rapporteur is aware no checks are made on these emissions; the EPA believes that, with the present number of such vehicles on the road, this check is not necessary.

1.3. Gaseous emissions from MV/ICE/SI weighing more than 6000 lbs

1.3.1. 9-mode cycle at steady speeds

No.	Mode	Induction depression in Hg	Time Sec.	Statistical weighting a_i	speed rpm
1	idle	-	70	0.232	normal idle speed
2	load	16	23	0.077	2000
3	load	10	44	0.147	2000
4	load	16	23	0.077	2000
5	load	19	17	0.057	2000
6	load	16	23	0.077	2000
7	load	3	34	0.113	2000
8	load	16	23	0.077	2000
9	accelerated idle	-	43	0.143	2000

1.3.2. Calculation of a pollutant emission

$e_c = e_m + K$

$e_m = (e_c + e_{125})/2$

$K = e'_{1000} - e'_{125}$

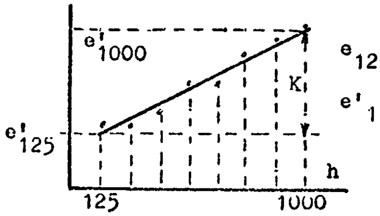
$e_o = (\Sigma_9 e_i a_i)/(\Sigma_9 W_i t_i a_i)$ emission at hour 0 in g/hp h

e_i : emission during mode (i), in gr

a_i : statistical weighing of mode (i)

W_i : power during mode (i), in hp

t_i : duration of mode (i), in h



e_{125} as for e_o but at hour 125

e'_{1000} and e'_{125} recorded at 1000 and 125 hours on the most probable line of e versus time at 125 h intervals during the degradation test

1.3.3. Restrictions imposed by standards on engines of a given "type"

- Federal restrictions on engines in 1974 and afterwards

$e_{CO} \leq 40$ g/hp h $\qquad e_{CH} + e_{NOX} \leq 16$ g/hp h

1.3.4. Restrictions imposed by standards on the conformity of production examples

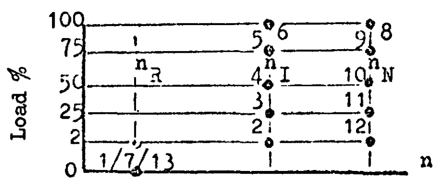
- restrictions on the "type"; the tolerance relates to the percentage of vehicles which are authorized to exceed these limits.

1.3.5. Special case of California

- 75/76 $e_{CO} \leqslant 30$ g/hp h $e_{HC} + e_{NOX} \leqslant 10$ g/hp h
- 1977 $e_{CO} \leqslant 25$ g/hp h $e_{HC} + e_{NOX} \leqslant 5$ g/hp h

1.4. Gaseous emissions from MV/ICE/CI weighing more than 6000 lbs

1.4.1. Standard sequence in 13-mode cycle at steady speeds



- technique similar to that described in 1.3.1. above
- figures 1 - 13 are the numbers of the modes in order of succession
- n_N : rated engine speed
- n_I : intermediate speed - either max. torque speed or 0.6 n_N
- the statistical weights are as follows:

  $a_1 = a_7 = a_{13} = 0.3/3$ all other $a_i = 0.8/10$

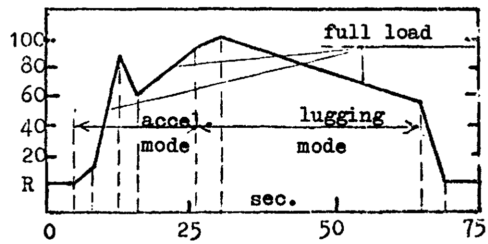
1.4.2. Calculation of a pollutant emission : as in 1.3.2. above

1.4.3. Restrictions imposed by standards: as in 1.3.3., 1.3.4., 1.3.5.

1.5. Smoke emission from MV/ICE/CI weighing more than 6000 lbs

1.5.1. Standard test sequence = 3 times the above standard cycle

% of rated speed



the smoke is continuously measured with an opacimeter; a selection is made of:

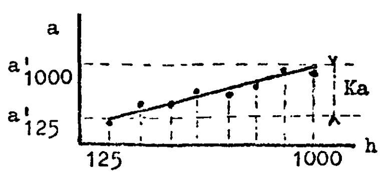
- 3 x 15 measurements during the "acceleration mode"
- 3 x 5 measurements during the "lugging mode"

(a) denotes the mean of the first 45 measurements, (b) the mean of the remaining 15, and (c) the mean of the highest of the 3 times 3 values from each cycle.

1.5.2. Calculation of smoke emission

a_c, b_c, c_c corrected values of a, b, c $\boxed{a_c = a_m + Ka}$ with $a_m = (a_o + a_{125})/2$

the indices correspond to the hourly accumulation



$K_a = a'_{1000} - a'_{125}$: degradation factor

$b_c = b_m + Kb$ as for a_c

$c_c = c_m + Kc$ as for a_c

1.5.3. Restrictions imposed by standards in respect of MV of a given "model"

1974 and thereafter $a_c \leqslant 20$ $b_c \leqslant 15$ $c_c \leqslant 50$ % of opacimeter

possible in 1982 and thereafter $a_c \leqslant 5$ $b_c \leqslant 3$ $c_c \leqslant 10$ of opacimeter

1.5.4. Restrictions imposed by standards on conformity production, see 1.3.4.

1.6. Evaporation emissions from MV/ICE/SF

The former test sequence in 3 phases remains unchanged, as does the restriction imposed by standards which corresponds to the weighted mean of the 3 phases:
HC - Evp $\leqslant$ 2 g/test.

2. SITUATION AS REGARDS TESTING TECHNIQUES AND THE RESTRICTIONS IMPOSED BY STANDARDS IN SWEDEN

2.1. Gaseous emissions from MV/ICE/SF of more than 30 h.p. and weighing less than 2500 kg

1975 EEC technique/70/220, but the restrictions of standard cycle I are:

HC – 2.2   CO – 45.0   NOX – none   g/km max.

1976 and afterwards USA technique/CVS/C of 1370 sec and the restrictions :

HC – 2.1   CO – 24.2   NOX – 1.9   g/km max.

2.2. Smoke emission from MV/ICE/CI

EEC technique/72/306 – Fmax is recorded on the full-load curve

– MV designed to carry less than 30 passengers or another equivalent:

2.5 Bosch or 30 HSU max.

– MV designed to carry more than 30 passengers or the equivalent:

3.3 Bosch or 45 HSU max.

3. SITUATION AS REGARDS TESTING TECHNIQUES IN JAPAN AND RESTRICTIONS IMPOSED BY STANDARDS

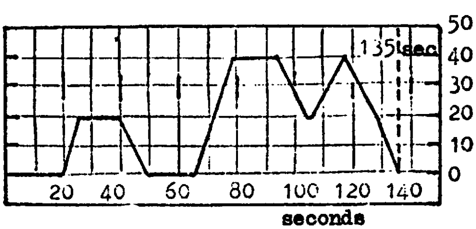
3.1. Gaseous emissions from MV/ICE/SI

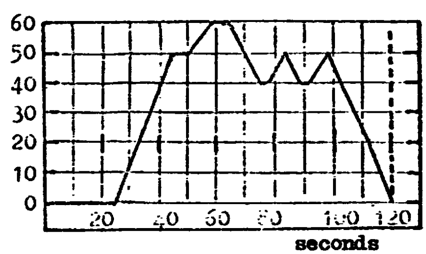
3.1.1. Technique for collecting gases   USA/CVS

3.1.2. Standard sequence

10-mode down-town cycle (hot engine and 1 cycle)

11-mode suburban cycle (cold engine and 4 cycles)





3.1.3. Restrictions imposed by standards on the MV of a given "model"

MV	technique	restrictions - max.		
MV/ICE/4t petrol or LPG 10 persons max.	10 modes 11 modes	CO 2.7 g/km 85 g/test	HC 0.39 g/km 9.5 g/test	NOX 1.6 g/km 11 g/test
idem, but 2t	10 modes 11 modes	2.7 g/km 85 g/test	0.39 g/km 0.5 g/test	0.5 g/km 4 g/test
MV/ICE/4t, 11 persons and more or lorries of 2500 kg max. when laden	10 modes 11 modes	17 g/km 130 g/test	2.7 g/km 17 g/test	2.3 g/km 20 g/test
idem, but 2t	10 modes 11 modes	17 g/km 130 g/test	15 g/km 70 g/test	0.5 g/km 4 g/test

- Schedule : 1 April 1975 for new models
  1 December 1975 for existing models
  1 April 1975 for 2-stroke models
- It is estimated that, in comparison with 1973, the reductions in emissions are of the order of: CO-89%, HC-91%, NOX-45 %.
- Although the US and Japanese techniques are not comparable, it is generally considered that the restrictions regarding CO and HC are equally severe, while the Japanese standard is more tolerant with regard to NOX.

4. GASEOUS EMISSIONS FROM LIGHT MV/ICE/SI IN AUSTRALIA

- Collection of gases: CVS
- Standard sequence: CVS/C/1972
- Restrictions imposed by standards: HC-2.1 g/km, CO-24.2 g/km, NOX-1.9 g/km for model approval.

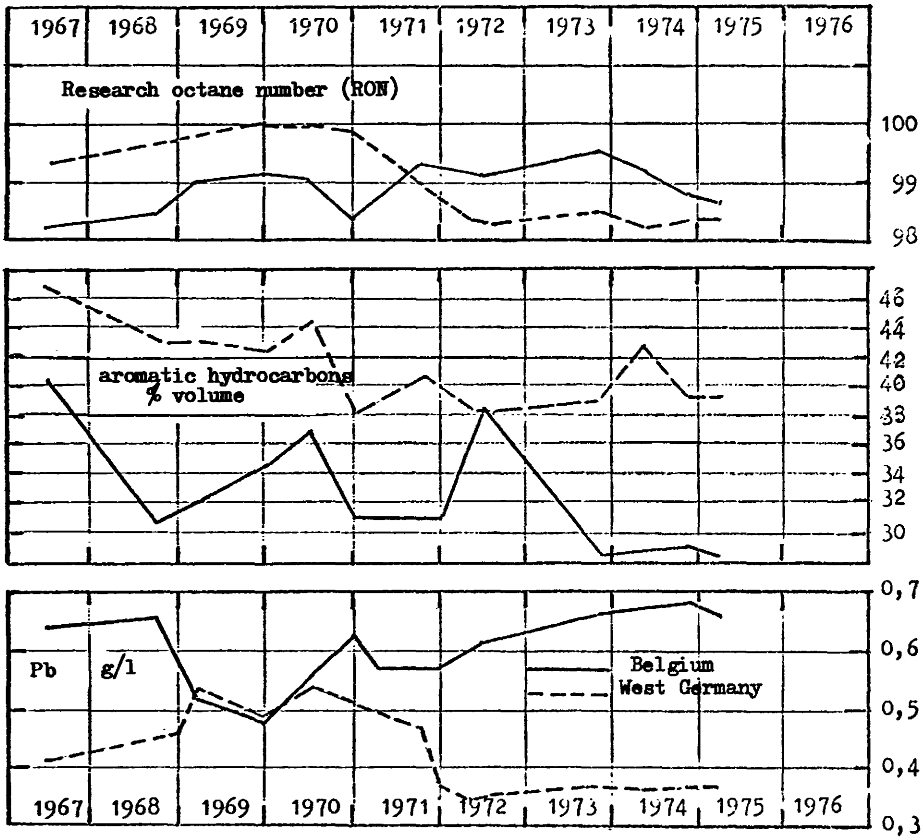
PARTICULATE EMISSIONS OF LEAD COMPOUNDS

1. LEAD (Pb) CONTENT OF PETROLS USED IN THE EEC AND ELSEWHERE

Country	Current situation - remarks	Maximum concentration (g/l)	Date
EEC	Draft Directive - progress very slow, if not blocked altogether	0.4	1 January 1976
		0.4 super 0.13 ordinary	1 January 1978
Belgium	Preparatory stage - situation to be reviewed on 1 January 1976 in the light of the EEC Directive	0.55	1 December 1975
France	Legal - no new reduction envisaged	0.55	1 January 1975
United-Kingdom	Legal - proposed new reduction due to takeeffect on 1 January 1976 deferred	0.55	1 January 1975
Netherlands	Industrial specification	0.64	
West Germany	Legal	0.4 0.15	1 January 1972 1 January 1976
Italy	CUNA specification - the law (1973) provides for a tax reduction on petrols containing less than 0.4 g/l	0.635	
Ireland Denmark Luxembourg	Industrial specification	0.4	
USA	Lead-free petrol - legal Leaded petrol - gradual reduction of lead content now suspended	0.013	1 January 1974
Austria	Legal	0.4	1 January 1972
Finland	Industrial specification	0.7	
Greece	Legal	0.84	.. April 1966
Norway	Legal	0.4	1 April 1974
Spain	Campsa specification	0.72	
Sweden	Legal - proposed gradual reduction to 0.4 and subsequently 0.15 temporarily suspended	0.7	
Switzerland	Legal	0.4	1 January 1975
Japan	Leaded petrol - legal Unleaded petrol - legal	0.31	.. July 1971 .. February 1975
USSR	Unleaded petrol in large towns and cities		
Canada	Legal no future plans	0.77	1 January 1976
East Germany	Legal Legal	0.4 0.34	Currently 1 January 1980

2. COMPARATIVE STUDY OF DEVELOPMENTS IN WEST GERMANY AND BELGIUM

Belgium is a big exporter of petrol, a substantial part of which finds its way to West Germany.



The above grades clearly show a continuous increase in the lead content of premium-grade petrol in Belgium since January 1972 and a very substantial reduction in the aromatic hydrocarbon content since July 1972. The effects of pumping the aromatics from Belgium to West Germany may go some way toward*r* explaining these developments.

3. EFFECTS OF LEAD CONTENT ON THE COMPOSITION OF PETROLS, POLLUTANT EMISSIONS AND ON FUEL ECONOMY

3.1. These are questions which the rapporteur dealt with in 1972 in a report drawn up at the request of the Commission of the European Communities (Directorate-General for Industrial, Technological and Scientific Affairs) and the trends revealed at the time have now been confirmed. Moreover, it should be borne in mind that a reduction in the lead content of petrol upsets the balance of pollutant emissions as well as affecting one of the means available to the engineer for meeting the technological requirements.

3.2. <u>Increase in the quantity of crude oil requiring processing after reduction of the lead content and in the light of motor-vehicle octane requirements</u>

(For the record: cf. sixth session of the symposium).

3.3. Recent studies on the possible replacement, by purely organic products, of lead additives as anti-knock additives have met with no success.

3.4. In another connection, the conclusions of a CONCAWE report entitled "Effects of gasoline aromatic content on polynuclear aromatic exhaust emissions" (September 1974) could usefully be quoted:

- "an increase of 34-44% in the aromatics present in petrol results in a mere 9% increase in polynuclear aromatic hydrocarbons (PNA)";
- "vehicles which have been adjusted in order to ensure the effective control of HC emissions discharge lower PNA concentrations";
- "the increase in aromatic hydrocarbons needed to satisfy European legislative requirements is manifestly lower than the 30% figure cited in the test programme and consequently will have little effect on PNA emissions";
- "since motor vehicles are responsible only for a very small fraction of PNA emissions, any increase in aromatic hydrocarbons in petrol will have no more than a negligible effect on PNA levels in the atmosphere".

5. <u>DEVELOPMENT OF LEAD TRAPS</u>

5.1. It should be pointed out that the EEC draft Directive on the lead content in petrol stipulates that the requirements be reviewed at regular intervals, particularly in order to monitor the development of lead traps. In 1972 the test findings were supplied by the lead additive producers, but since then independent laboratories and other bodies have carried out test programmes and published their conclusions. While it is a well-known fact that the manufacturers are busily tackling the problem, their findings have not been made public. Among other studies on the subject, the following are of some significance:

- "Les possibilités de limitation de plomb par les véhicules automobiles" (The possibilities of limiting lead emissions from motor vehicles) (Roth/Revue de l'IFP, March-April 1974).

  This report is based on tests carried out at the UTAC in France:

  - vehicle performance, noise level and exhaust gas pollution remain practically unaffected when the existing silencer(s) is (are) replaced by lead traps for a total distance of 31 000 km (over this distance a slight rise occurs in the exhaust back-pressure);
  - the trap reduces the quantity of lead emitted by about 65% (at 31 000 km the quantity is still 60%).

- "Assessment of a lead trap for motor vehicles" (Environment Division, Transport and Road Research Laboratory - TRRL - 662/1974). This programme covers 20 motor vehicles either on the road or on a dynamometer chassis and also a number of engines on the test bench. The study is supplemented by research on the lead-trapping process and the development of an appliance to take direct measurements of the lead concentration emitted:

  - on the whole, emissions from motor vehicles fitted with a lead trap and propelled by a fuel containing 0.52 g/l of lead are equivalent to the emissions which would be produced by the use of a fuel containing 0.3 g/l in conjunction with conventional exhaust systems;

  - operation may be affected by variations in temperature, gas velocity and effective trap length;

  - the device would appear to have a life of more than 38 000 km;

  - the device is most effective when used in urban traffic conditions;

- lead-trapping has not had any appreciable effect on power output, gaseous emissinns, noise levels and exhaust back-pressure;
- when conditions change radically, the accumulated lead may subsequently be dispelled into the atmosphere (this "purging" continues until the creation of a new balance).

- "Exhaust gas filter systems, their development and efficacy" (Octel Ltd, January 1975).

  This report describes and corroborates a number of studies and conclusions arising out of earlier programmes. Furthermore, recent research would appear to indicate that the effects of purging, together with white smoke under high-speed and heavy-load conditions following an urban build-up, can be attributed to the high temperatures associated with these operating modes. It has also been demonstrated that the addition of phosphorus compounds to the aluminium oxide coating on the steel wool has the effect of considerably reducing the purge. The report also looks at the question of how much the consumer would have to pay and picks up some of the points already elaborated in the previous study (TRRL/662/1975). Assuming a service life of 64 000 km, the percentage increase per vehicle would be between 1% and 2.3.

5.2. A fundamental objection often raised in connection with the use of lead traps concerns the ultimate destination of the lead compounds which have accumulated during the life of these devices. This perfectly legitimate cause for concern has been taken into consideration and the main conclusions of the TRRL report are as follows:

"There would not appear to be any future in promoting the reclamation of lead traps. Existing processes for the recovery of waste metals are the best method to apply after normal wear. Simple disposal is unacceptable".

5.3. More is now known than was the case in 1972 on the granulometry of lead particulate emissions and the complete results of a series of test programmes are set out in a very interesting report to the Fuel Committee of the European Coordinating Council for the Promotion of Motor Oil and Fuel Testing (CEC/EFTC).

5.4. Although the fifth session is not concerned with noise pollution problems, it should be pointed out that the "Octel" review mentioned above concludes that lead-trap exhausts are at least as efficient as existing conventional exhaust systems.

Noise pollution recorded in accordance with BS-3425/1966			
Cylinder capacity in cm^3	Transmission	Noise level (dB-A)	
		Standard exhaust	Lead-trap exhaust
1200	manual	85	82
1600	manual	84	83
1600	automatic	78	78
2000	automatic	79	77
1300	manual	82	80
950	manual	78	77

Type of lead trap	Test sequence	Vehicle	% total lead emitted in relation to lead consumed / % emission reduction due to lead trap								
			MMED – mean mass equivalent diameter (μ)								total aerosol at 5μ MMED
			> 5	4	2.5	1.5	0.9	0.4	0.17	< 0.17	
Ethyl A.V. Trap	FTP – 1970	Plymouth		0.5 / 16.7	0.4 / 20	0.6 / 25	1.3 / 46	7.3 / 53	12.5 / 17.7	3.0 / −30	25.6 / 31.5
"	"	Ford		1.3 / 83	1.6 / 50	1.6 / 33	1.2 / 33	3.3 / 31	6.2 / −7	2.1 / −50	17.3 / 36
"	"	Chevrolet		0.2 / 78	0.2 / 60	0.2 / 71	0.6 / 50	2.7 / 48	6.6 / 19	2.0 / 0	12.5 / 33
Ethyle trap + agglomerate	"	Toyota		0.2 / 87	0.3 / 85	0.6 / 81	0.6 / 84	1.0 / 87	2.4 / 72	1.7 / 84	6.8 / 82
"	EEC/70/220 sequence	Fiat		0.1 / 80	0.3 / 25	0.5 / 50	0.7 / 59	0.5 / 93	0.7 / 85	0.6 / 54	3.4 / 80
Ethyl T.A.V.	FTP – 1970	US cars		0,2 / 93	0.3 / 79	0,3 / 77	0,5 / 72	1.6 / 81	2.8 / 71	1.2 / 37	6,9 / 75
Octel	FTP – 1972	UK -cars (average : 5 tests)	0.3	0.5	0.8	0.8	0.6	0.3	0.1 / 83,3	0.5 / 96,6	3.9 / 77,3
Octel	EEC/70/220 sequence	UK – cars (average : 10 tests)	<0.1	<0.1	<0.1	0.1	0.2	0.4	0.3 / 62.5	2.9 / 78.7	4.0 / 75.3
Dupont	AMA driving cycle		≥ 9			1 – 9			≤ 1,0		
		Chevrolet	0.00076 / 98			0.0024 / 89.5			0.0177 / 64		
		Chevrolet	0.00056 / 98,5			0.0031 / 86,5			0.0150 / 68		
		Chevrolet	0.00074 / 98			0.0021 / 91			0.130 / 70		

A6/07

TASKS OF THE MOTOR-VEHICLE ENGINEER - DEVELOPMENT AND RESEARCH

1. THE ENGINEER AND THE ICE/SI

1.1. The current tasks of development, research and production engineers in the motor industry is basically to optimize all of the parameters for the complex system "AFM-engine-exhaust-vehicle", which in the absence of any combustion faults (detonation, pre-ignition, running-on, misfiring, etc...) must meet very stringent requirements with regard to :

- performance,
- operating flexibility,
- fuel economy,
- user safety,
- noise pollution,
- gaseous and particle pollution,
- service life,
- purchase price, running and maintenance costs.

The pursuit of these aims has become enormously complex, not only because the requirements are stringent and interrelated, but also because the number of parameters is extraordinarily high and interference is frequent (Annex A3/02 is significant in this respect, although the parameters concerned only relate to the AFM, the engine and the exhaust). There must be no illusion that this optimization is simple, quick or economical, and in addition a solution which is not wholly satisfactory is automatically challenged each time that a requirement or parameter comes under pressure.

Things being what they are the engineer is forced to treat the parameters or groups of parameters separately and to determine the influence of each one on all of the effects covered by all of the requirements. This way of tackling the problems raised is not without risk since it takes no account of interference. Therefore, experimenters acting in good faith sometimes reach apparently incoherent conclusions and furthermore "a sum of individual truths" does not necessarily yield an "overall truth".

1.2. The vehicle engineer and broad principles

The engineer instinctively mistrusts those broad principles which his day-to-day experience too often contradicts, e.g. :

- A fuel-saving policy necessarily implies a reduction in pollutant emissions and vice versa

  In general the engineer does not share this view, since regardless of the effect of fuel economy on requirements not concerning air pollution, he can quote examples which negate this assertion. Of these NOX emissions are among the best known and although the assertion generally holds good for CO it does not necessarily apply to HC or their composition (species and content). Raising the compression ratio is still the best way of reducing a fuel consumption, hence the need for petrol having a high lead or aromatic-hydrocarbon content. The President of the United States is fully aware of this situation and his recent recommendation to Congress is probably based on this fact.

- The best way of reducing a particular type of pollution is to eliminate its source

  I do not think that many engineers in the world are able to subscribe to this view and to its incorporation into current practice. They cannot willingly accept the application of regulations to the "cause" parameters in order to attain the objectives set (requirements) . The engineer is forced to accept the restrictions imposed by standards (governing) effects but he does so more willingly if they are scientifically justified and if he has a choice as to method. It should also be noted that,within the scope of this principle, the best method of eliminating emissions of hydrocarbons is to no longer use them as fuels or else to prohibit the use of internal combustion engines as a source of motive power.

1.3. State of the art as regards the optimization of the sub-system "air-fuel mixture - spark-ignition engine"

1.3.1. The rapporteur definitely prefers this system to that of "fuel-engine", since although the quantitative and qualitative physical preparation of the fuel-air mixture and its even distribution among the cylinders depend on the engine, the kinetics of the chemical reactions taking place after the ignition process and throughout combustion are basically characterized by the component "fuel-richness". Both of the parameters in this component are inextricably linked in this respect and are independent of the engine. In addition, the system "Fuel/air mixture-spark-ignition engine" has been separated from the exhaust system since it is felt desirable that the maximum effort should be applied to all of the events taking place before the exhaust valve or port opens.

1.3.2. The parameter "air-fuel mixture" incorporates the parameters for composition of fuel and richness of AFM

1.3.2.1. The situation with regard to petrol has changed very little since 1972, except perhaps for the refining potential to be geared to the demand for aromatic hydrocarbons. The conclusions drawn from some recent studies should, however, be noted :

- the production of petrol having a very low sulphur content for the purpose of eliminating or at least reducing secondary emissions of sulphates and sulphuric acid from motor vehicles fitted with catalytic converters (see below) is not economically viable (SAE/750092).
- a motor vehicle tested according to the 1974 constant volume sampling-cold and hot technique using a 10% hydrogen (H_2) fuel and richness ratios between 0.55 and 0.65 yielded the following results (SAE/740187) :

	results	75-76 limits	EPA recommendation 1980	EPA recommendation 1982
HC g/mile	0.8	1.5	0.9	0.41
CO g/mile	3.4	15.0	9.0	3.4
NOX g/mile	0.4	2.0	2.0	2.0

It is, however, pointed out that the future of this technique largely depends upon the development of on-board hydrogen generators.

1.3.2.2. The other sub-parameters for the air-fuel mixture are its physical preparation and its even distribution from qualitative and quantitative points of view. They also include the air-petrol ratio. The trends already emerging in 1972 have been confirmed. The great advances made in the development of carburettors should also be noted (such as the small-diameter single-choke carburettor having a mechanically operated throttle, coupled with a twin-choke carburettor of the same diameter the opening of which is controlled by the depression at the venture in the first carburettor) together with the improved vaporization and homogenization of the air-fuel mixture by means of mixing and heating, particularly under low-speed and light-load conditions.

It nevertheless remains true that fuel-injection systems(cyclic or continuous fluid/mechanical or electromagnetic/electronic injection or a combination of these systems) are the best solution as regards :

- preparation of the air-fuel mixture ;
- precise metering of the air-petrol ratio in all vehicle operating modes as a function of cylinder filling and engine temperature ;
- even qualitative and quantitative distribution among all of the cylinders.

Unfortunately, fuel injection is still extremely expensive.

1.3.3. The optimization of the overall air-fuel mixture - spark-ignition engine system has of course been the subject of recent research (and is still being studied).This research has often been aimed at the technological application of the theoretical know-how acquired before 1972 (sub-parameters mentioned in Annex A3/02). It will, however, be useful to mention the following :

(a) progress made on electronic control of the ignition advance and thereby better control of cylinder filling, air-fuel mixture richness and engine temperature. It would seem that in this connection progress is expected shortly.

(b) The studies carried out in order better to understand the thermo-chemical-kinetic combustion processes resulting in the travel of a flame front from a point ignition source.

(c) Determination of the effect of the system parameters on improper combustion due to detonation, particularly at high speeds (type of sparking plug and location in combustion chamber, cooling, structure and design of manifolds, thickness of cylinder liners at end nearest cylinder head, play between piston and cylinder at piston ring, ignition advance,etc.)

(d) The research into the reasons for the freezing at medium temperatures of nitrogen oxides produced at high temperatures, which has, for instance, highlighted the effect of the location of the sparking plug in relation to the exhaust valve and also the role played by heat transfer. Similarly the degree of ionization of the flame seems to exert a beneficial influence on reaction speed $2.NO \rightarrow N_2 + O_2$. It is also possible to increase the degree of ionization by passing on intense electric current through the fluid slightly before and during combustion.

1.3.3. However, owing to the practical limits to the anti-knock properties of petrol, which will apply for a few years yet, the turbocharging of spark-ignition engines seems to have no future, at least as far as the reduction of pollutant emissions is concerned.

1.4. <u>The work on the treatment of exhaust gases following the power stroke</u>, which could fail to satisfy a given requirement is still being directed towards the use of oxidation converters (afterburning or catalytic), the catalytic reduction of nitrogen oxides and, in the case of the latter, perhaps the recycling of the exhaust gases through the induction system. By 1975 a large proportion of American products were already using catalytic converters, but some manufacturers still feel that the use of afterburners is possible. In each case the problem of the resistance to chemical/thermal/ mechanical shocks, and thus also of the reliability, of the special alloys required has not been completely solved. A number of papers were presented at the "Automotive Engineering Congress" held in Detroit, USA in February-March 1974 . One can provisionally conclude from the studies under way that high Ni-content austenic steels behave well, but they are expensive ; certain ferrite alloys can be used, but no type of wall coating (Cr-Al, Ni-Cr, ceramics, etc..) has proved suitable. On the other hand the shape of the converter chamber sometimes makes a significant contribution to long life.

It is also well-known that afterburners are subject to overheating when they receive excess unburned hydrocarbons or carbon monoxide as a result of misfiring, prolonged use of the choke, faulty carburation, blocking of the induction filter etc...

A lot of work is therefore being devoted to the development of alarm and safety systems protect vehicles, and more particularly their passengers, from excessive temperatures, e.g., the development and testing of probes which constantly analyse the richness of the exhaust gases. Such probes transmit signals to the electronic computer which controls the fuel injection, thereby adjusting the air-petrol mixture metered into the induction system. Nevertheless, the reliability of such systems would have to be checked closely during type approval and conformity tests. The Japanese authorities have in effect made provision for such a check (1974). Overall it is as follows :

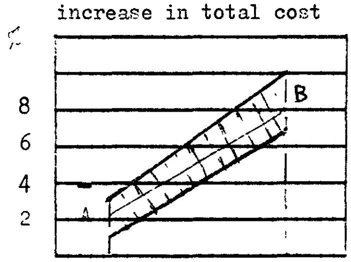
- experimental check on the alarm system (legal requirements) ;
- measurement of temperature at a large number of points in the system during four types of tests, namely :
    1. idling after a cold start,
    2. high speed (100 km/h) under steady-state conditions, direct gear,
    3. two-mode cycle at 50% of the speed which the vehicle can attain on gradients of 5 and 8%,
    4. down-town cycle with heavy traffic density.

Note

The relatively recent detection at the exhaust outlet of motor vehicles fitted with catalytic converters of sulphuric acid and sulphate emissions is receiving a certain amount of attention, particularly since it was the outcome of research by the EPA. In Europe it would therefore be wise to take account of this in any planning of restrictions imposed by standards on CO and HC.

1.5. Anti-pollution devices for motor vehicles driven by spark-ignition engines and their cost

increase in total cost



In view of current trends the diagram opposite is generally accepted, i.e.,

1. Optimization A is purely that of the "air-fuel mixture - spark-ignition engine" system.

2. Optimization B concerns the most sophisticated air-fuel mixture - engine - exhaust system according to the current state of the art.

3. The uncertainty as regards future motor-vehicle design is represented by the hatched area.

In A one can also reasonably assume a reduction in CO and HC emissions of 20-30% as compared with the situation at the end of 1975, but the NOX emissions will remain static. Vehicles driven by spark-ignition engines of this type could be available in 1980.

2. THE ENGINEER AND MOTOR VEHICLES POWERED BY COMPRESSION-IGNITION ENGINES

2.1. The engineer involved with this type of vehicle is scarcely in a better situation than his colleague working in the spark-ignition field. Development and research projects in this field are also numerous. They mainly concern the engine and, to a lesser extent, fuels and exhaust systems.

2.2. It will be useful as far as the parameter "fuel" is concerned to note the weighted conclusions arising from a number of recent studies. These are:

1. It is difficult to quantify in either direction the effect of the physico-chemical characteristics of fuels on emissions. The cetane number (CN), however, seems still to be the most significant both for smoke and gases. For years this number has been falling dangerously. The aromatic hydrocarbon requirements of petrol for spark-ignition engines explains this trend which, to a certain extent, can be slowed down by the use of ignition improvers, provided that their secondary effects on emissions are controlled.
2. Although a reduction in the sulphur content of gas oils is contemplated the contribution of motor vehicles to the total emissions of this pollutant does not seem very great and so it justifies neither the price which will have to be paid nor the energy to be expended.
3. It is interesting to note that tests have been carried out on motor vehicles whereby up to 40% LPG was mixed with the diesel fuel before injection. Smoke (EEC/72/306) was reduced significantly, but this did not apply to the gases. The total (HC+NOX) could in no case satisfy the 1977 Californian standard, but the studies are continuing, since optimum results have not yet been achieved.

4. It is now quite certain that progress will not be made via the parameter "fuel" alone.

2.3. The parameter "engine" is much more significant and it is justly receiving close attention. Apart from the continuous research into combustion chamber shape, injection systems, and ignition and combustion processes which can be controlled to varying degrees, the following developments are worthy of mention :

- It is now quite certain that the essentiel need to reduce fuel consumption (which has now become quite urgent) has boosted the popularity of direct-injection compression-ignition engines. Engines of this type yielding optimum power and efficiency, emit total HC+NOX of about 8 gr/hp/h (13-mode method). By slightly retarding the injection timing this figure can easily be brought below the five gr/hp/h specified in the 1977 Californian standard, but the loss in power and efficiency is about 6%. It is, however, felt that this sacrifice is largely compensated by :

    1. No increase in smoke emissions.
    2. Considerably reduced peak pressures and thermal stresses and hence an increase in specific power, reduced noise pollution and an increase in service life.
    3. If required a spark-ignition engine fitted to a heavy motor vehicle could be converted into a direct-injection diesel without any basic modification.

- The turbocharging of high-speed automotive diesel engines is under constant development, i.e. :

    - Supercharged, direct-injection diesel engines with efficient intercooling which perform well as regards gaseous emissions and there is no marked increase in smoke. An increase in cooling of this type decreases NOX emissions and fuel consumption and helps to keep peak pressures in check as the supercharging ratio increases. Any loss in power due to the "cleaning-up) of such engines is also less pronounced if there is a high degree of intercooling.

- Mathematical models which simulate the thermodynamic or thermo-chemical-kinetic processes taking place during combustion, mainly in direct-injection engines, are also in vogue. The aim is to determine the effects of quite a large number of parameters (stroke bore/ratio, valve timing, mass flows at the compressor and turbine, pre-injection, rate and duration of injection, coolant water temperature, air-ratio, exhaust back pressure, etc...) on peak and average pressures and temperatures, on rates of pressure rise during uncontrolled combustion, and engine power. Despite their scientific appeal, the value of the information derived from these theoretical developments has so far been rather disappointing.

2.4. On the other hand, progress has been made on odour. The determination of TIA (Total Intensity Aroma) or "odour demerit" has for a long time been purely subjective (odour jury) and so has not enabled the products responsible for the odour of emissions from compression-ignition engines to be identified qualitatively and therefore to be avoided. It would now appear possible to do so (see SAE/750216) and, in particular, to measure the following contents of an emission :

- LCA/µg/l for the entire "oily-kerosene"group
- LCO/µg/l for the entire "smoky-burnt" group.

Generally speaking LCO is 10 times greater than LCA and since the products concerned are the most disagreeable, this is used as the specific reference for diesel odour. By comparing the physico-chemical measurement of LCO with the subjective TIA the following law has been formulated :

$$(\text{TIA subjective}) = 1 + \log \text{LCO}.$$

If this correlation is confirmed this new identification and measuring technique will be of great use to research workers.

2.5. There has been no significant development in the treatment of gases and smoke between the end of the power stroke and their ejection from the exhaust tailpipe. Research workers have apparently directed their efforts towards optimizing the "engine" parameters and it must be acknowledged that this is the best course.

III. MAINTENANCE OF VEHICLES AND ENGINES

These matters are mentioned for the record - not that they are without interest - but they relate more to vehicle use than to vehicle design, which is the subject of this symposium.

PLANNING OF RESTRICTIONS IMPOSED BY STANDARDS ON MOTOR VEHICLES DRIVEN BY INTERNAL COMBUSTION ENGINES

1. INTRODUCTORY REMARKS

The chief of the objectives assigned to the rapporteur is worded as follows : "proposals for a rational choice with a view to introducing Community rules and data in support of that choice" ; in practice it results in a personal commitment. From this point of view, the rapporteur's sole aim in the following is not to persuade but to provide information and material for debate.

2. PLANNING RELATING TO LIGHT MV/ICE/SI

2.1. It is understandable that priority has been accorded to these MV, since they account for the great majority of vehicles in towns and it is in the latter - or in certain areas of large cities - that pollution (be it gaseous or particles) is at its worst ; thus in the city where this Symposium is being held petrol-engined cars account for 83% of all vehicles and 98.5% of all cars.

2.2. The bases of an unchallengeable forward policy on emission standards are given in the diagram on page A2/01. The nerve centre of the model is "data processing", whose chief role is to supply the rates of reduction to be imposed on emission sources and thereby to permit the preparation of a programme of restrictions via standards; this assumes a degree of practical certainty of the information forwarded to the centre, this requirement is not met at present in any country or community. The EEC, as already mentioned, is at present assembling the components of such a model but no date has been set for the start of its operation.

2.3. Since any such tool is lacking and forward planning is generally desired, it is essential to gather information from all quarters without delay, to assess how rigorous and important it is, and then to make a decision ; aside from health-related information (still fairly fragmentary in the case of certain pollutants) which affects the severity of standards, those responsible for planning should not forget that it must :

(a) avoid improvisation or anything provisional - otherwise it is better to dispense with planning completely;

(b) provide for a series of stages, liberally spaced, to give manufacturers the time needed for technological development and to enable them to amortize their investments ; the latter portion of each stage could be made equal to the fleet-replacement time, i.e., (3 to 4) + (8 to 9) = (11 to 13) years ;

(c) have regard to the facts of technology as they now exist, as they are humanly foreseeable and also of demands other than those relating to air pollution ;

(d) provide a stimulus through its objectivity by spreading responsibility for executing the plan in all directions, and not only in that of the motor industry.

2.4. Very often in Europe when a justification is being given (sometimes post facto) for a programme, or a new one is being formulated, reference is made to the air pollution situation in large cities in 1969, the year before publication of Directive 70/220/EEC which embodied the first restrictions via standards. Since 1970 fell at the beginning of a decade it has seemed logical to make the programme-period 1969-80. At the present time, in the EEC, practical implementation of the two stages of restriction (1970-1974) arising from Directive should - according to some people - result in emissions being reduced by 60% in the case of CO and 40 % in the case of hydrocarbons (HC) compared with the 1969 situation, this is hard to believe, but the rapporteur is prepared to accept it. What remains to be done, if the overall reduction generally contemplated for 1980 (i.e., 90 % relative to the 1969 level) is to reduce residual emissions, post second stage, by 75% in the case of CO and 83% in the case of HC. Under these circumstances, if the 1980 deadline is to be met, it is a matter of urgency that these new and very stringent restrictions should be published before mid-1976 at the latest, making 1 January 1980 their operative date. In objective terms, such a programme is well outside the bounds of the reasonably possible. Furthermore, this argument takes no account of the fact that reduction in the maximum permitted levels will not necessarily result in a proportional reduction in emissions by a given fleet or that the number of motor vehicles in that fleet goes up and down in the course of time.

2.5. Another fairly common way of thinking in Europe is that of implicitly trusting the manufacturers to improve the emission performance of motor vehicles and adopting restrictions via standards ex po t facto to progress in engineering ; many persons connected with public health and a section of public opinion in Europe are convinced that the progress of European standards results from such a philosophy ; seen in this way, restrictions are totally useless.

2.6. Division of responsibilities within a programme

2.6.1. Basic formula

$$E = e.(z/100).k$$

E : Total emission of a pollutant at the critical time of day in a given period (year) in the city or the critical area of a large city while down-town traffic conditions prevail (e.g., the standard sequence given in Directive 70/220/EEC or some other sequence ; the remainder of the argument set out below will show that the choice of standard cycle is of secondary importance) ;

e : Emission at the same point in time, and for the same duration, in the city or part of the large city by 100 light MV/ICE/SI of the "type" representative of the local fleet and assumed each to perform the standard sequence ;

z : Number of vehicles in movement at the critical time in the city or the critical area of a large city ;

k : A factor for manufacturing tolerance and deterioration due to mileage for the fleet as it is at the time, relative to the same fleet if consisting of the "type" ; there is no reason to believe that k varies with time.

2.6.2. Application of the basic formula

- at present : $E_o = e_o.(z_o/100) . k$
- at the end of the Programme Stage (in x years) : $E_x = e_x . (z_x/100) . k$
- desired $E_x = \varphi . E_o$

and therefore $\varphi = \frac{e_x . z_x}{e_o . x_o}$

- the previous relationship can be written in the form shown opposite

$$\frac{T_\alpha + 100}{100} = \frac{T_e + 100}{100} \cdot \frac{T_z + 100}{100}$$

$T_e = 100(e_x/e_o - 1)$

$T_z = 100(z_x/z_o - 1)$

$T_\alpha = 100(E_x/E_o - 1) = 100(\alpha - 1)$

Where :

T_e is the percentage reduction to be required ($T_e < 0$) or tolerable increase ($T_e > 0$) of the mass of pollutant emitted by 100 light type MV/ICE/SI, each performing the standard sequence at the same time.

T_z is the percentage reduction required ($T_z < 0$) or tolerable growth ($T_z > 0$) of the local fleet in movement in the city or the critical area at the critical time of day.

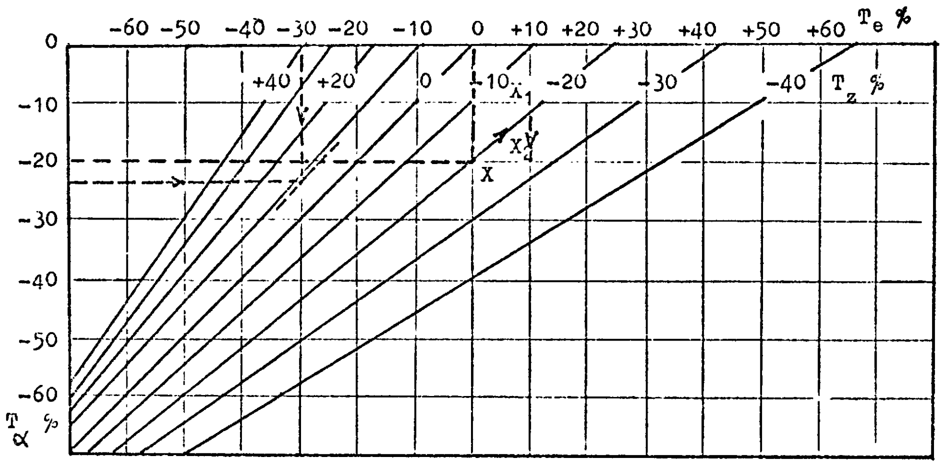
T_α varies with (E_x/E_o) which (for want of anything better) is assumed to be equal to ($\varepsilon_s/\varepsilon_o$) where ε_s is the health-risk level most commonly assumed (e.g., in the case of CO : 45 μg/m3 on average over 30 minutes) and ε_c is the level of the pollutant at the critical point in time in the city or the critical zone in the most seriously affected large city in a country or the Community (ε_o is expressed in the same system as ε_s).

$$T_\alpha = 100(\varepsilon_s/\varepsilon_o - 1) \begin{cases} \text{if } \varepsilon_s < \varepsilon_o \rightarrow T_\alpha < 0 & \text{reduction required ;} \\ \text{if } \varepsilon_s > \varepsilon_o \rightarrow T_\alpha > 0 & \text{tolerable increase.} \end{cases}$$

T_α is therefore the required percentage reduction or tolerable increase (i.e., tolerable as regards air quality) of the pollutant in question to be achieved within the x years of the Programme Stage. With the extension of monitoring networks in Europe it should be possible within a fairly short time to fix the minimum algebraic value of T_α, at least with regard to "priority"pollutants.

2.6.3. A coherent emission programme for a particular pollutant, results partly from the solution of this equation, which contains three unknowns ; if two are fixed the value of the third flows automatically from them ;

there are therefore two degrees of freedom. From this it can be concluded that responsibilities are shared. Cleaning-up the city of the critical zone is not the concern solely of the manufacturers (through T_e) but also of the realism of public-health circles (T_α), central and local governments or agencies (T_z) and the users and their sense of civic duty (also through T_z). The chart below could therefore be termed "the shared-responsibilities chart" :



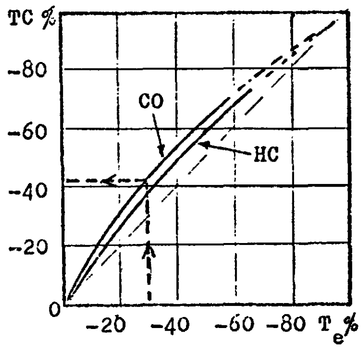
2.7. The relationship between T_e and the rate of reduction in the restrictions (TC) relative to the standards by Directive 70/220/EEC (unamended)

The present fleet of light MV/ICE/SI consists chiefly of vehicles type-approved between 1969 and mid-1975, hence the choice of the 1970 standards as the starting point.

2.7.1. Assuming (as many people in Europe seem to assume) that a reduction in restriction levels automatically brings about the same change in the quantity of pollutant emitted by the control batch of 100 MV of the standard type in the period of the standard sequence, the definition of T_e (from T_α and T_z) automatically entails the levels varying in the same proportion : (the levels of 1970-T_e%).

The rapporteur does not believe that TC - T_c but rather TC = f(T_e) and that the relationship between these two rates takes the form of a curve of the shape shown in the graph below; to the rapporteur's knowledge the concavity of the curve lies in the direction of negative TC values and the curvature is more pronounced for CO than for hydrocarbons. Without going into detail, the rapporteur would point out that these curves were plotted from the following data :

- restrictions via standards (in this case those of 1970);
- the results of as many as possible type-approval tests on motor vehicles put on the market since 1969 up to the date of publication of the new standards, plus 12 months;
- fleet distribution frequency by equivalent inertia weight.



The study can be further refined by taking into account, for example, the age of the vehicles which make up the fleet and the frequency by make and by type. To provide a numerical illustration of the line of reasoning followed, the curves opposite are regarded as being those for the national fleet which gave the greatest curvature.

2.8. Outline study of a programme for restrictions imposed by standards on CO emissions by light MV/ICE/SI

2.8.1. Assumptions

(1) The worst city in Europe for this emission is known, as is its critical $\mathcal{E}_o$ (in the case of Cologne, for example, the critical $\mathcal{E}_o$ is 59 mg/m^3 on average for 30 minutes - see EG/Enquête/Untersuchung der Umweltbelästingung und Umweltschädigung durch den Strassenverkehr in Stadtgebieten/Lärm und Abgase/VDI Kommission Reinhaltung der Luft/ Düsseldorf - 1974/In Auftrag des Bundesministers für Verkehr/Teilstudie II.1.1./page 51).

(2) In the absence of any EEC air quality standard, a concentration of 45 mg/m^3 on average for 30 minutes is assumed to constitute a health hazard.

(3) Type-approval tests conducted between 1969 and mid-1975 and the 1970 standards constraints are used as the basis for plotting the curve of TC = f(T_e) in paragraph 2.7.2. above.

(4) The publication of further standards is planned for the first half of 1976, their operative date being 1 July 1979; they will remain in force at least until 1 July 1986.

(5) Technological developments now in hand, together with demands other than anti-pollution requirements, would appear to rule out the use of catalytic converters and the recycling of exhaust gases and give grounds for hoping that optimization of the AFM-ICE / SI-MV system will bring about a reduction of some 30 % in CO emissions by light MV/ICE/SI in the most common ranges of reference weights, and that this will occur before 1 July 1979.

2.8.2. Determining the programme elements

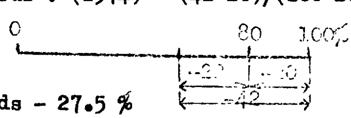
- T_e = -30 % (see assumption 5);
- TC = -42 % relative to 1970 standards contraints (see graph 2.7.2.);
- $\varepsilon_s/\varepsilon_o$ determines T = 100 ($\varepsilon_s/\varepsilon_o$ -1);

$\varepsilon_s/\varepsilon_o$	1.00	0.95	0.90	0.85	0.80	0.76	0.75	0.70	0.65	...
$T\alpha$	0	-5	-10	-15	-20	-24	-25	-30	-35	...

- From $T\alpha$ for the city or the critical area and from T_e, each agency infers T_z from the graph in 2.6.2.; thus, in the case of Cologne, T_e = -30 %, $T\alpha$ = 100(45/59-1) = 100(0.76-1) = -24 % and the chart of shared responsabilities gives T_z = +9 %; this means that, under the programme/arrangements the city of Cologne cannot allow traffic density in its critical zone to increase by more than 9 % in the next 10 years.

2.8.3. The resulting programme for CO emission from light MV/ICE/SI

- Fresh standards : (1974) - (42-20)/(100-20)



1974 standards - 27.5 %

- date of publication of the amendment in the Official Journal of the European Communities : 1 June 1976;
- operative date : 1 July 1979;
- period of validity : at least until 1 July 1986;
- N.B. : an Annex to the amendment should tell local authorities how to determine the T_z values corresponding to the critical ε_o for their city or city area.

2.8.4. Remarks

Obviously, a different line of argument can be put forward, e.g. :

- Tα is imposed by ε_s (air quality) and the critical ε_o (example: -24%);
- Traffic density is an extraneous variable which the local authority cannot cause to vary in either direction : T_z = 0; from this it is deduced (see the nomogram of shared responsibilities) that T_e = -24 % and can be nothing else;
- by reference to the graph in paragraph 2.7.2., T_e = -24 % results in TC = - 34 %;
- hence, the new constraints relating to CO : (those for 1974 - 17.5 %).

2.9. Outline study of forward planning of restrictions imposed by standards on HC from light MV/ICE/SI)

The scheme is the same as in paragraph 2.8.; it could be quantified fairly easily as soon as the critical ε_o for HC is known and an air quality standard in respect of HC is also available.

2.10. NOX emissions by light MV/ICE/SI

In this case the problem is more difficult but it still goes without saying that the CEC should amend Directive 70/220/EEC as soon as possible by embodying the GRPA's proposal in it. It should be borne in mind, however, that the proposed constraints are designed chiefly to prevent any increase in NOX emissions by motor cars which are also obliged to comply with more stringent requirements relating to CO and hydrocarbons. It is far from certain that this aim will be achieved by means of a directive amended in respect of NOX and providing for constraints which will remain unchanged until 1986. Similarly, $T\alpha$ this time constitutes a current reserve with $T_e = 0$ at the time; these rates determine a point X on the responsibilities chart and thus a margin of manoeuvre in terms of traffic density T_z (example : $T\alpha = -20$ %, $T_e = 0$ % and $T_z = -20$ %); if within 10 years the traffic is unchanged, X moves along the iso-T_z line, thus reducing the gap between the present NOX concentration and the concentration that constitutes a health hazard; it will therefore be highly beneficial to keep a close eye on variations in T_e during type-approval tests. Note also, in connection with these intangible constraints relating to NOX, that local authorities are able to restore the separation in question by taking steps to reduce the critical traffic density ($X_1 \longrightarrow X_2$).

2.11. <u>Particulate lead-compounds emissions from light MV/ICE/SI</u>

Investigations in progress both on the effect of these compounds on man and his environment have not yet resulted in full agreement between the people concerned with air-quality criteria. The rapporteur, like many, believes that the promulgation of a directive limiting the lead content of petrol is not advisable at present; each country has laid down maximum values, or intends to do so, in order to safeguard "national" petrols against abnormal increases. Furthermore, when a health-hazard level for airborne lead is fixed, and when monitoring networks determine the status of air pollution due to lead from mobile sources, the establishment of standards limiting emissions can comply with the scheme set out in the foregoing. Meanwhile it will be very helpful to continue, and if necessary support, the development of lead traps, with special attention directed to the purge effect, their bulk and the development of a simple, fast and cheap method of testing for type approval purposes and checking the conformity of production examples.

2.12. With regard to other emissions for which light MV/ICE/SI are responsible, investigations and research are not yet sufficiently advanced (with the possible exception of HC-EVP) for consideration to be given at present to a method of testing and to restruction via standards.

3. Formulation of a programme in respect of light MV/ICE/CI

As already pointed out, 98.5 % of cars in Brussels are of the spark-ignition variety, leaving 1.5 % diesel-engined; these figures probably vary between one EEC country and another, but they do not warrant submitting these motor vehicles to the requirements of future standards on NOX under Directive 70/220/EEC (CO and gaseous hydrocarbons are no problem). Nevertheless, if it is decided to include them, it is reasonable to grant them some tolerance relative to the limits proposed by the GRPA since this proposal has no other aim than to contain any increase in NOX that might result from the increased stringency of standards relating to CO and HC; an increase of 20 % on the proposed limits seems acceptable.

As regards smoke emissions, Directive 72/306/EEC applies; the question of tightening up the standards obviously arises. Official notification of the Directive actually took place as long ago as 2 August 1972 and the Member States were to comply within eighteen months, i.e., 2 February 1974; those are still fairly recent dates, indeed too recent for anything at all to be contemplated for 1976 or even 1977. In the rapporteur's opinion the free acceleration test should in no event be abolished before another simple, fast and economical test for checking the conformity of production samples has been developed.

4. Formulation of a programme in respect of heavy MV/ICE/SI

Vehicles of this kind account for 5 - 8 % of national fleets in Europe; the situation is considerably different in the USA. Equipment in laboratories and test centres in Europe is generally not capable of simulating the equivalent inertias in question, and no standard urban traffic sequence has been officially proposed; the problem is therefore not yet ripe for a directive with a standard operating cycle, and even less for legal restrictions.

Nevertheless, technical facilities are available in Europe to run tests under steady-state conditions and the rapporteur sees no reason for not profiting from US experience. Furthermore, the rapporteur does not yet fully understand why nine - and thirteen - mode cycles should co-exist, the one for ICE/SI and the other for ICE/CI. Although there is no problem with a test using either of those methods, the same does not apply to emission standards; 1976 might be the year for an EEC-supported study directed towards the selection of a method and the formulation of a preliminary draft set of standards. It does not appear physically possible for a decision to be taken before 1978.

5. Formulation of a programme in respect of heavy MV/ICE/CI

- Smoke emission : see paragraph 3 above.
- Gaseous emissions : a study to be tackled on the programme for heavy MV/ICE/SI.

DISCUSSION BY THE PANEL

Intervention of Mr. BOURDEAU

I shall try to be fairly brief and tell you in a few words about the research carried out by the European Communities on the protection of the environment and of health. The Commission is responsible on behalf of the Community for implementing several programmes in this field which cover physical, chemical and radioactive pollutants.

This research is carried out in two different ways, i.e., by means of contracts with research organizations in the Member States or by the Community's Joint Research Centre and in particular the ISPRA establishment in northern Italy.

We are more particular as regards the research into the various pollutants, using the roll-back technique which Professor Sibenaler has just mentioned i.e., we are tracing the logical path from the determination of sources of pollution, measurements in the environment and the various recipients, the problems of transfer and the physico-chemical conversion of pollutants in the environment to, finally, the effects on man and the environment in order to arrive at the chapter on anti-pollution technology which Mr. Sibenaler has just talked about, at least in connection with motor vehicles fitted with petrol or diesel engines. Since 1974 the research programme on chemical and physical pollutants (but not radioactive pollutants which are covered by a separate programme) has enabled some research to get under way which has in any case certain connections with motor vehicle emissions. I would like to go through these very quickly and then ask Mr. Garibaldi to provide some details on one of the projects which is perhaps of special interest to you.

This research is clearly concerned with carbon monoxide, nitrogen oxides, hydrocarbons and noise. Very briefly on hydrocarbons : we have a project on the development of a system for the multidetection of micro-organic pollutants including hydrocarbons in the air, water and various other matrices. We are also carrying out some studies on hydrocarbon variants, and in particular polynuclear aromatics, which can be found in urban areas in order to find out to what extent their sources can be determined.

Finally, we are also conducting a certain number of tests on the long-term effects, and more particularly the mutagenic and calcinogenic effects of various polynuclear aromatics. I shall not say much about carbon monoxide and nitrogen oxides : only that the emphasis has been placed on the interactions between these various pollutants and in particular between lead, carbon monoxide and nitrogen oxides.

The research into noise has taken the form of epidemiological surveys on the longterm reaction of a population exposed to noise from airports or urban traffic.

Finally, on lead in particular there are two main avenues of research : one on toxicity as such and the other on its transfer within the environment and the determination of the levels due to (a) motor vehicles and (b) foodstuffs, and industrial sources found in the average human body in the Community. On toxicity we have a number of laboratory and clinical tests on the effects of the chronic inhalation of lead on pulmonary tissue, its effects on the central nervous system, and also epidemiological surveys which are attempting to throw some light on the link between the exposure of children and mental backwardness and peripheral neuritis. Tests have also been carried out in order to determine the teratological effects, if any, of lead - naturally on laboratory animals and finally the precise role of lead in cardiovascular diseases, renal function, gastrointestinal symptoms, virus infections and certain other pulmonary functions.

Placental lead transfer is also under investigation both in laboratory animals and human beings in order to see to what extent foetuses suffer from exposure of the mother to lead. The intestinal absorption mechanism is also under study, as is the effect of various dietary components on lead absorption.

I shall now come back more specifically to the origins of the lead found in human blood and in the various compartments containing lead in the human body. Here we are carrying out a series of studies and tests with the aim of determining (a) the transfer of lead in organic form in the atmosphere and its conversion and (b) the transfer of lead emitted in the form of particles from industrial sources and from motor vehicles. A specific project being carried out jointly by our Joint Research Centre at Ispra and by SNAM progetti, of which Mr. Garibaldi is the representative today, consists of a full-scale experiment which after two or three years should enable the real contribution of lead emitted by motor vehicles to the total lead content of the blood and of the human body in general to be exactly determined via the study of the variations in the stable isotope ratio of the lead found in man, the environment and fuels. Here, Mr. Chairman, if you will permit me, I would like to hand over to Mr. Garibaldi, who will be able to provide further explanations on this project.

Intervention of Mr. GARIBALDI

The research project which I am about to describe in the very short space of time allotted me is an example of the kind of projects which the Commission of the European Communities has put in hand in support of the Directives it is proposing.

Lead is formed from four natural isotopes having atomic weights of 204, 206, 207 and 208 whose relative abundance depends on the age and nature of the mineral deposit.

Slide 1 shows some examples of the isotopic compositions of samples from different countries expressed as the ratio between the 206 Pb and the 207 Pb isotopes. A determination of the isotopic composition is therefore capable of identifying a particular species of lead, even when it has undergone the most diverse chemical transformations. This study is based on the use over a wide area in Italy of gasolines containing lead which is isotopically different from the natural lead present in the ground or the lead imported for other purposes than being added to gasoline. The study hopes, on strictly scientific bases, to define the motor vehicles contribution to the pollution of the entire environment and, in particular, of the human body according to the following points (Slide 2) :

1. A determination of the contribution of motor vehicle traffic to the lead content of the aim in cities and industrial areas.

2. The identifications of the critical pathways through which lead from the motor vehicle is transferred to man.

3. An assessment of the amount of lead contributed by the motor vehicle to the total amount of lead absorbed by man (including infants) via the processes of inhalations and ingestion.

4. A calculation of the distribution of the lead of motor vehicle origin in the various environmental sectors.

In order to attain these objectives the largest manufacturer of lead alkyls in Italy (Societa SIAC) has, since April last, been working exclusively with Australian lead from the Broken Hill mining area which has a constant isotopic composition and is distinguishable from lead mined anywhere else.

Through commercial agreements with the other companies distributing lead alkyls it has been possible to cordon off completely two large areas of Italy (Piedmont and Sardinia) in which gasoline containing the Australian lead was and is used exclusively.

Suitably programmed periodic samplings of the following types of samples were carried out :

- total and fractionated atmospheric particle matter;
- soil;
- vegetation;
- surface water and drinking water;
- atmospheric precipitations;
- blood (a total of about 20,000 samples)

The determination of the variation of isotopic composition plotted against the measurements of the total lead concentration should enable the planned objectives to be attained.

The study can be subdivided into the following four periods (Slide 3) :

Phase 0 : Identification of the character of the environment before the Australian lead is brought into use.
July 1975 to September 1975.

Phase 1 : Transitional period during which there is a gradual phasing-out of the lead used previously and a corresponding phasing-up of the Australian lead.
October 1975 to December 1975.

Phase 2 : Australian lead used exclusively.
January 1976 to July 1977.

Phase 3 : The old type of lead returned to use.
July 1977 to December 1977.

The results of Phase 0 are now available and show the clear distinction between the isotopic composition of the Australian lead now being distributed and the isotopic compositions of the various types of environmental samples examined before the Australian lead was brought into use (Slide 4).

The final results of the study are planned for the end of 1977, but valuable information will be available by the end of 1976.

One of the more important problems dealt with in Professor Sibenaler's interesting paper is the emission of lead particles by gasoline motor vehicles. .
We all know the importance of the problem of the lead content of gasolines, a problem which directly affects the motor vehicle, oil, health and energy sectors and which, just because it is so complex has not yet found a final solution despite the many studies carried out and the proposals put forward .

We should like to emphasize certain points :

1. Lead traps

The problem of reducing the lead content of motor fuels can be viewed from two aspects :

- Elimination or reduction of the lead in order to prevent or slow down the poisoning of the catalyst which reduces the CO and HC emissions
- Elimination or reduction of emissions of lead since this element can, in certain circumstances, cause injury to the human body.

In the first case, the only solution for the moment appears to be the elimination of lead alkyls from gasolines, even though recent studies carried out by Du Pont seem to have identified a range of catalysts insensitive to lead.

In the second case, the emissions could in fact be reduced downstream from the combustion chamber.

Two varieties of lead pollution are distinguishable :

(a) environmental pollution caused by the whole of the lead emitted in every chemical form and associated with particles of every size; the emitted lead finding its way into the environment, soil, water, plants, etc., can enter the alimentary chain and can therefore be absorbed with food and drink via the process of ingestion;

(b) atmospheric pollution caused by the lead compounds associated with fine particles of sub-micron sizes which can remain in suspension in the atmosphere for a long while; the lead is inhaled with the breath and absorbed by the body directly.

The s econd aspect assumes a particular importance in large cities where the intense traffic gives rise to high lead contents in the finally divided atmospheric dust.

In order to eliminate, or at least reduce, the amount of lead emitted in the exhaust gases without, on the other hand, lessening the lead contents of the gasolines, the main firms manufacturing lead alkyls have tackled the designing and construction of prototypes of particular eliminating systems to be mounted directly on the motor vehicle in place of the customary standard exhaust silencer. There are currently in existence two kinds of trap : the cyclone trap (Ethyl and Du Pont) and the filter trap (Octel).

From the results now available of trials carried out by some laboratories it is possible to draw certain conclusions, even though there exist some substantial differences between the two kinds of trap :

- the traps are efficient in urban traffic conditions (say, in the conditions of the European cycle);

- In rural or motorway traffic conditions the efficiency declines appreciably and, in particular circumstances, the lead emissions can be of the same order of magnitude as the emissions from a motor vehicle having a standard silencing system.

Any introduction of the new traps, even to a limited extent in new models, would not therefore completely solve the problem of the general pollution of the environment by lead, but would have as its immediate effect a reduction of the current levels of lead in city air, and that reduction would gradually become more appreciable as the years go by and the motor vehicles in use today are replaced.

2. Effects of a reduction of lead content on the emissions of pollutants

As the speaker has shown with exhaustive data from the comparison between Belgium and the Federal Republic of Germany, reducing the lead content of gasolines would at present mean increasing their aromatic content.

We know from the few studies carried out all over the world, that an increase in aromatic content (even though some differences of interpretation exist) causes an increase in PNA emissions.

Do you not think that a problem of such importance needs to be investigated more thoroughly ?

First of all we need to know, I would say as accurately as possible, how much the European motor vehicle contributes to the total PNA burden in the air of Europe's cities, in order to assess the dangerousness of any increase in the PNA originating from motor vehicles.

3. Possibilities of replacing lead alkyls

Whilst at additive level (up to 1%), as the speaker has pointed out, hundreds of other compounds have been studied but none of them has produced satisfactory results, at competent level (10-20% in the gasolines) there exist organic compounds with high octane numbers suitable for replacing the octane contribution of lead in part or in full.

Examples of these are certain ethers, already widely tested in practical use, which have produced satisfactory results without calling for the vehicles now in circulation to be modified in any way. The lowest alcohols, methanol and ethanol, offer interesting prospects and an alternative source, but necessitate modifications to present day vehicles and refining techniques.

ISOTOPIC RATIO 206/207 OF LEAD SAMPLES
FROM DIFFERENT MINING DEPOSITS

U.S.A.	Missouri	1.28
Mexico	-	1.21
Greece	Samo	1.21
Peru	Cerro de Pasco	1.20
Bulgaria	-	1.18
Italy	Sardinia	1.18
High Silesia	-	1.17
South Africa	-	1.16
Canada	-	1.16
Australia	Broken Hill	1.04
Terranova	-	0.93

1) Determination of the contribution of automotive traffic to atmospheric lead pollution in selected urban and rural areas.

2) Identification of critical transfer pathways of automotive lead to man.

3) Evaluation of the contribution of automotive lead to absorption in man (including children) through inhalation and ingestion

4) Estimation of the distribution of automotive lead into the various compartments of the ecosystem.

TIMING OF EXPERIMENT

- Phase 0, background definition	July 1974 - September 1975
- Phase 1, transitional period	October 1975 - December 1975
- Phase 2, special lead use	January 1976 - July 1977
- Phase 3, initial isotopic conditions restauration	July 1977 - December 1977

PRELIMINARY RESULTS (PHASE 0)

	206/207 RATIO	
	Mean Value	Standard Deviation
Australian Lead	1.0399	0.00088
Gasoline until 30.4.75	1.1831	0.0154
Total airborne particulate	1.1769	0.0149
Soil	1.1720	0.0045
Vegetation	1.1700	0.0100
Blood	1.1693	0.0136

In conclusion, may I summarize my remarks as follows :

1. To prevent intolerable economic burdens or wasted expenditure, it appears to be absolutely necessary that the future standards for the limitation of emissions shall be drawn up by a process as rigorous as possible.

2. The application of the process presents many difficulties. The motor vehicle industry represented in the CCMM is demonstrating that it is able and willing to help in solving some of these difficulties and is ready to cooperate with Community legislative bodies in order to solve the others.

Intervention of Mr. KLAMMER

In the time available to me, I would like to deal with what appears to me to be the most important point in the work of the rapporteur, this being his attempt while adhering to quite a strict interpretation of the aims of the symposium, to show ways of formulating requirements leading to a better environment, for which he gave deadlines and values and made the laudable attempt - which, by the way, is the first attempt in this field of which I am aware - to evaluate to that effect the research work financed by the Commission and called "Enquête (Survey) 1974" and to ascertain, using the city of Cologne as an example, how great the need for a reduction is.

I myself have studied this reduction from another angle, i.e., existing technology. It is interesting that I came to the same results as the rapporteur , albeit from quite a different starting point. In terms of carbon monoxide, this would mean that, technologically and economically, reductions of 25-30% are possible without using catalysts, merely by improving mixture preparation. Such solutions even have the advantage of also saving energy since they reduce fuel consumption.

The deadlines mentioned by Professor Sibenaler also seem to me to be completely justifiable. In this connection, it should be mentioned that, in the Federal Republic of Germany, there is an environmental protection programme which came into being around 1970 and is, a concrete expression of the political aims. In the programme, this is conveyed by the effort to reduce the release of undesirable components of exhaust gases from motor vehicles, with effect from year of manufacture 1980, by 90% to a residual 10% as compared with motor vehicles manufactured in 1969. This aim coincides with that of other countries, for example Sweden, Switzerland and the USA. Where the Federal Republic of Germany is concerned, it is important to point out that the Federal Government have taken pains to leave no doubt in the minds of representatives, including representatives abroad, that they intend to pursue this aim only within the framework of uniform, harmonized EEC regulations and have no intention of drawing up national regulations of this type on their own.

Following this study by Professor Sibenaler, we must now ask : what form will further measures, what form will the further improvement of existing Community directives take ? If the final aim is to be a 10% reduction of pollutant emissions from 1980 onwards, then the time remaining only allows this change to be made in one fell swoop. This change would have to be announced in the first half of 1976 and be applied from 1980. With the technology known to us today, however, this aim could only be achieved by the industry with catalysts, after-burners, etc. i.e., technical solutions that I personnally find extremely unattractive.

If, however, solutions more attractive to the engineer are taken into consideration, as Professor Sibenaler said, the improvement of mixture preparation for instance, then an attempt would have to be made to achieve the aim in at least two stages. This would mean that the first stage would be announced also in the first half of 1976 and applied from 1980 on, while a solution for the second stage would be found subsequently. Such a procedure would have certain advantages, since, to my knowledge, intensive work is being carried out on the improvement of catalysts and similar devices.

All these questions will certainly be dealt with by the Commission and also the Member States in the first half of the year. We will by no means have cause to complain of lack of work or subjects for discussion in this period, since we will have to hurry if the deadline of 1 July 1976 is not to be missed.

Mr. Chairman, in view of the time available, I believe I have said all that is necessary on what appears to me to be the most important point and I should like to thank all those present for their attention. Thank you very much.

Intervention of Mr. Allan AITKEN

Director of Product Development, Ford Motor Co. Ltd, of the United Kingdom

Air quality standards in the EEC

I would like firstly to say how much I appreciated the excellent paper presented by the Rappo teur, Prof. Sibenaler. Many of the most important features of this difficult and controversial subject have been excellently illustrated.

I speak to you as a representative of one of the largest automobile manufacturer in Europe. We manufacture all forms of automotive transportation-cars, trucks farm tractors and buses - and also we are,I believe the second largest diesel engine manufacturer in the world. Thus we are concerned that this problem should be seen in its true perspective.

Prof. Sibenaler's paper pointed out the need to determine Air Quality standards. I believe that this is paramount to the search for a solution. The figures given in the table N° 2.3 for those Member States are not truly comparable since they are for different purposes, but they do indicate that some consideration has been given to this essential question. The proposals of the World Health organisation are of interest; they are applicable for pollution from all sources but principally for industrial rather than automotive.

I am informed by the W.H.O. that their figures are intended as those for a long term target, possibly over 25-30 years. They are closed to those of the United States, which are already under review as being too severe. Indeed there are reports that they are exceeded by natural phenomena in some parts of the United States. Clearly it will be easier to come closer to them in those urban areas where there is relatively little heavy industry or chemical/ oil plants; conversely those areas of Europe such as Rotterdam of the Ruhr will be much more difficult. The real question of interest to this symposium if the relation of pollution from Automobiles to that from other sources. The only real indicator of this balance in Europe which I know of is that conducted in the West German city of Cologne by the Ministry for Works, Health and Social Affairs of the Landes Government of North-Rhine Westphalia, through the years 1969 to 1972.

This Cologne survey covering industrial areas, residential streets, autobahn and farmland showed that the automobile was far from being the most important source of the total pollution. Industrial pollution is far more important. Indeed 81% of the nitrogen oxide - NOx - came from industry, 10% from automobiles and the remainder from homes. For sulphurous oxides, 82% came from industry, 17% from homes and only 1/2% from automobiles. However, on carbon monoxide the automobile produced 49% of the total. Even then the highest concentration due to any source was less than 1.30 milli-gram per cubic metre. I note Prof. Sibenaler regards 45 mg/m3 as the danger level. It is reasonable to suppose that Cologne is a fairly typical European city with possibly greater than average industrial complex.

This makes the need for an Air Quality Survey and Standard of overwhelming importance. Thus, before the European Community embarks on any further reductions in the emissions from automobiles, the Cologne survey should be repeated right across the Community-and possibly the whole of Europe at several thousand points - including industrial areas, shopping streets, residential areas, farms and the seashore, to determine the effect of the two EEC Directives already in operation, that is 70/220 and 74/290.

This should be completed within 2 years and cover each season at least once. The work could be undertaken by university undergraduates throughout the Community with suitable standard equipment provided from central EEC funds.

This could then establish :

- The location of the problem areas in the EEC)
- The level of the pollution in these areas (
- The source of these pollutants)
- Any seasonal effects (

SLIDE

In addition, it might be appropriate to point out that the average vehicle life in the Community is 11,3 years. A study of the emission levels in European cities after part of this lifetime, beginning Oct. 1975, could determine the effect of the increasing number of emission controlled vehicles. This study should take 2 to 3 years. After this time meaningful recommendations could be made. How much better this would be than the "Guess and throw bricks" of the present thinking which continues to specify reductions without determination of the effect of previous regulations or often without the full knowledge of the technology to make this effective.

In his paper Prof. Sibenaler stated "rates of pollution are inevitably increasing" - this may well be true for industrial pollution, but the opposite belief is true for automobiles. My colleague, Signor Pollone, has some data from Paris on this point.

In addition, the size of cars, and consequently the absolute volume of exhaust gas from them is falling. Proof of this is the following :

New registrations for Small Cars

BRITAIN			GERMANY			
		Sept.YTD			Sept.YTD	
1973	1974	1975	1973	1974	1975	
11.5%	15.0%	15.8%	9.8%	11.8%	12.6%	SLIDE
MEMO			MEMO			
- September 1975 - 17.2%			- September 1975 - 14.2%			
- 37% increase 1973-1975			- 29% increase 1973-1975			

These are percentages of the total new car registration in each country. A small car is one of less than 1000 cc engine capacity approx.

Small cars consume less fuel than large cars. Additionally, more often than not the small engines burn the fuel more efficiently.

Exhaust gas production is proportional to fuel burnt; less fuel used and more efficiently burnt, must mean less pollution.

This is why the Establishment of correct levels of control for nitrogen oxides (NOx) is so important. The Community has to date spoken of containment - that is ensuring that levels of NOx remain at today's levels. To reduce NOx emission from automobiles by legislative action is to <u>increase</u> fuel consumption and the carbon monoxide and to some extent the hydrocarbons emissions. In the USA this has been partly overcome with the use of noble metal catalysts.

To use catalysts similar to those used in the USA on European vehicles would mean increases in the customer price of vehicles of the order of 10% for small cars of say 1200 cc or less. Also, they require the use of very expensive zero-lead fuel, which of itself uses more energy to produce in the refinery. I expect Panel 6 to comment on this.

Before closing, I would address a few remarks to the diesel engine question. To some people the diesel engine seems the perfect answer. This is not the case. They too have problems. They are heavier engine-for-engine and the nitrogen oxides content of the exhaust gas is higher. The majority of present day diesel-engined cars are used as taxis or for business purposes. In order to be acceptable to more car owners the diesel engine needs considerably further refinement. In addition there is the question of fuel availability.
I am informed that the situation there would be difficult, because of problems in the oil refineries. I hope Panel 6 will discuss this.

To sum up, I believe we should :

- Establish the extent of the pollution problem across Europe.)
- Determine the proportion due to the automobile and to Industry (SLIDE
- Establish a plan for the reduction of the industrial problem)
- Establish a plan for the reduction of the automobile problem (

These actions should bear in mind economic facts therefore they must be truly cost effective.

I would like to thank the members of the Commision and the Directors of Directorate-General XI-Internal Market for inviting me to speak at this Symposium. Thank you.

Intervention of Mr. Derouane

I would like first of all thank Professor Sibenaler for his treatment of the problem of pollutant emissions from motor vehicles. It is clear that as regards public health, a reduction of such emissions is desirable. The rapporteur mentioned, in particular, responsibility scales : in order to effectively reduce pollution, it would be necessary to be able to apply the model presented and one of the important factors in being able to do so in a scientific manner would be to know the levels of the health risks i.e., the levels which the air we breathe must not exceed. This is an immission problem but assessment of these levels raises several problems. Cause and effect relationships must be traced, the cause being the pollutant concentration multiplied by exposure time i.e., the dose received by human beings and the effect of the modification of certain parameters e.g., physiological or pathological. The problem is thus two-fold; there is a technical problem at the analytical level i.e., for the analyst who must determine pollutant concentrations, and there is the medical problem for the doctor who must be able to evaluate effects.

Since several studies have been carried out, for example at places of work in the case of certain pollutants such as carbon monoxide, the problem is fairly simple, particularly since CO is reputed to cause little reaction. Studies of this pollutant should however take into account certain habits such as tobacco smoking etc. The problem is compounded when one wishes to lay down such health risk levels for nitrogen oxides since what is known as "NOx" is a mixture of several compounds and in particular NO and NO_2 and since in vehicle exhaust gases NO is preponderant and NO_2 only accounts for a few per cent. However, of the two, the latter is the more dangerous to man.

It must however be borne in mind that NO can be converted into NO_2, particularly under the influence of sunlight or other pollutants already present in the air such as aldehydes or ozone. Therefore although NO itself is much less dangerous that NO_2 it can under certain circumstances give rise to an increase in the NO_2 content of the ambient air. The extent of such conversion depends on temperature, sunlight; etc. Another major problem is that of hydrocarbons. These are very numerous and range from highly volatile compounds having a small number of carbon atoms to very heavy compounds such as the polycyclics, coronaries etc. This wide range far from simplifies the problems of the chemist who must determine atmospheric concentrations, and it can be said that each hydrocarbon is almost a species unto itself. If all of the medical problems are added to this chemical problem you will see that the laying down of what are known as the criteria i.e, the dose-effect relationships, is a very complicated problem.

Account must also be taken of certain facts if from a public health point of view it is felt desirable to reduce lead emissions. It is also to be feared that this could increase polynuclear aromatic contents as a result of modifications to fuels.

You will see from all this that the contribution of the studies and in particular those sponsored by the European Communities which Mr. Bourdeau has just talked about can only be beneficial in explaining all of the obscure points which one frequently comes up against during the study of these parameters.

Intervention of Mr. GAUVIN

I fully agree with Professor Sibenaler in that there are no simple conclusions nor will any rational programming for 1980 be possible. It is clear that we do not have any objectives i.e., no air quality standards. The atmospheric measurements currently being carried out are highly fragmentary and totally inadequate in number and the on-the-vehicle emission measurements have very little absolute value since they are closely linked (a) with the cycle used for measurements and (b) the method of measurement. Under these measurements the figures can be doubled and total hydrocarbons then measured whereas Mr. Derouane has just said that each hydrocarbon raised a specific problem. In conclusion there are few rational bases enabling decisions to be taken. This means two things : the first is that if there are short-term decisions to be made one will be obliged to make them within the limits imposed by public opinion and not on a scientific basis. This raises a difficulty because pollution is not seen by all the public in the same way as by engineers, who speak of carbon oxides, nitrogen oxides and hydrocarbons whereas my neighbour or caretaker sees pollution in the form of fumes and smells. Although it has been possible to make considerable progress as regards fumes one fears that whatever decision is taken nothing will happen as regards odours. Secondly one must work not logically but, as Mr. Klammer has said, within the limits of technical potential.

In France, we have nothing as structured as the German programme and we intend to study the matter during 1976 within a working party similar to the one set up in 1971 which enabled amendmends to be made to the Directive and which are currently in force. I am not as certain as Mr. Klammer that carbon oxide emissions can be reduced by 25-30% by improving carburation and reducing the consumption of fuel in the EEC. Paris and Bonn do not share exactly the same views on this matter and in any case I do not feel that if a reduction of such scope were to be envisaged this could not be carried out as in the past i.e., by means of a homogeneous reductions in accordance with the existing classification.

One thing is certain : a 25-30% reduction from small cars would raise extremely tricky technical problems. We are running the risk of selective reductions, i.e., greater reductions in the case of large motor cars which at present are dealt with much more lenienly than small cars. Going on from there we must as part of the activities of the Commission, discuss a final namely : when Mr. Klammer told us that there was a very precise German programme providing for reductions in pollutant emissions by 90% as compared with the 1969 bases and added - and we naturally congratulate him - that Germany would only act within a Community framework wondered how it would be possible to reconcile the aims of the German Governement with those of the Community which, one feels, can only be less ambitious.

Intervention of Mr. STORK

Mr. Chairman, the United States have since long had an aggressive motor vehicles air pollution control programme. We perhaps have some experience in this area, experience which may be useful for the Common Market to consider, but which we in no way suggest you should follow, because air pollution from automobiles is primarily, if not exclusively, a localised problem, not a world wide problem. Yet it affects each locality about the same way in the world, as if affects our lives in cities in the United States.

I was most interested in the remarks made this morning by several of the speakers. I was particularly grateful for Prof. Sibenaler's paper which provides good basic background information, which is very hard to come by. Prof. Sibenaler's paper does not go deeply into policy and what should be done; Mr. Aitken went further in that regard. In Prof. Sibenaler's paper there is a statement that there is need for ambient air quality standards worldwide since there is no fundamental physical difference between American, on the one hand, and European and Japanese on the other. I would expand that to suggest that there is no fundamental difference between American automobile manufacturers on the one hand, and European and Japanese on the other hand. Typically, all say the same :"may be, but not now; let us make a study". I agree that a good study never hurt anyone, but all of us who have participated in studies probably will agree that the general outcome of a study is that there is need for several more studies. And, indeed, there always is need for several more studies.

I was also interested in Prof. Sibenaler's comment on page 63 of the English version, which makes a rather puzzling statement; puzzling that is to me, as an American. A fairly common way of thinking in Europe is that of implicitly trusting the manufacturers to improve the emissions performance of motor vehicles and adopting restrictions by a standards exposure factor, will provide progress in engineering.

Many persons connected with the public health, as well as sections of public opinion in Europe, seem to be convinced that the progress of European standards results from such a philosophy and that, similarly air quality restrictions are totally useless. If I understand that statement correctly, it is wholly contrary to the experience, we feel an extensive experience, that we have had in the United States with how manufacturers act. It has been our experience in the United States that in the absence of emission control requirements, manufacturers will typically, do nothing to reduce emissions. And why should they ? If I were a manufacturer, I surely would not take action to reduce emissions from my vehicles, which might make my vehicles more expensive, which might make them perform somewhat less well, which would place me at a disadvantage in the market place.

Unfortunately, when it comes to the field of emission control, individual optimization and social optimization is 180 degrees out of phase. Even in the field of safety it is reasonable to expect manufacturers to voluntarily improve their vehicles and to persuade vehicle buyers through advertising and through magazine articles that they will be safer in the new vehicle. But when it comes to emission, there is really no incentive that can be provided to the automobile buyer to make him buy a cleaner vehicle, and therefore there is no incentive whatsoever for the manufacturer, as we see it, to build a cleaner vehicle. This is not only my view; I have heard Mr. Aitken's chief executive, President Iacocca of Ford, make that statement time and time again in public forums, and I am fully in agreement with that statement.

There are a number of other statements in Mr. Aitken's paper I would like to comment on. He states that the United States ambient air quality standards are already under review as being too severe. They are indeed under review and our standards will be continuously reviewed to see if progress in knowledge has made it necessary to change them. They are not under review because they are deemed too severe; if anything they will be deemed not severe enough. As medical science in this area progresses, the medical community typically identifies adverse health effects at increasingly lower levels and, in fact, most recently the medical community, at least in our country, appears to have come to the general conclusion that there are not threshold levels below which there are no adverse health effects from pollutants, rather that as air pollution goes down, the population at risk goes down; but it does not go down to zero.

I was interested in Mr. Aitken's suggestion that extensive monitoring of air pollution should be carried out in industrial areas, shoppings streets and residential areas, of course, but also farms and sea shores. Why farms and sea shores and, I believe Mr. Aitken interpolated, forests as well ? Air pollution is an urban problem, carbon monoxide in particular is a downtown urban problem. If, in the United States, we were to monitor air pollution on farms, at the sea shore, in our mountains and in our deserts, we would find little carbon monoxide, and if we then averaged the levels of carbon monoxide across the United States, we would surely be under the ambient air quality standard. Yet a man can drown in water of an average depth of one foot ! Mr. Aitken suggests how much better it would be to approach the problem in this manner than quote deaths and throw bricks. I do not think that in the United States we are throwing bricks .

We know that we have extensive air pollution from automobiles in our major cities. We know that it is thoroughly unlikely that the maximum degree of emission control that is feasible on automobiles would be enough to clean up our cities, at least our very largest cities. For that reason, we are pursuing maximum feasible control of emissions from automobiles knowing that this will not solve the problem at short term, but that it will go a long way to solving the problem. We believe that it will reduce to the minimum possible the number of the population that are at risk from air pollution, but do not believe for a moment that we shall be able to avoid any risk for anyone, particularly the aged, the infirm,those with cardiac conditions, respiratory illnesses, and so forth.

I was also interested in Mr. Klammer's remark that it is not possible to achieve a goal of 90% reduction of certainly carbon monoxide and unburnt hydrocarbons from uncontrolled cars without catalysts. In our experience, it is entirely possible to achieve that reduction because in the State of California where, at present, we have the most stringent air pollution standards, a number of vehicles meet those standards without catalysts. I am sorry to say that no American vehicles meet those standards without catalysts, but we are fortunate in the United States than 20% of our automobile market is comprised of imports of about half from Europe and half from Japan.

To a very large degree, on account of the imaginative engineering in European and in Japanese factories, it has been possible to achieve standards as strict as the California standards without catalysts, and conversely it has made it possible for us in the United States, to use a vernacular phase, "hold the feet of our domestic manufacturers closer to the fire".

The first administrator of the US Environment Protection Agency had on his wall a statement saying that if one were to delay action until one can be sure that one could act in a manner that none can criticize, then one would never do anything at all. It is for that reason that we in the United States believe that we need to continue to press forward as aggressively as it is possible, to require manufacturers who sell cars in the United States to reduce emissions of those cars substantially. We are very pleased at the progress which has been made by engineers in the United States and in the worldwide auto industry; perhaps it changes the emphasis in the companies from styling to engineering, but that does not trouble us at all !

Thank you Mr. Chairman.

Intervention of Miss ROBERTS

Thank you Mr. Vice-President. I am described in the paper as coming from the United Kingdom, but I am here as Director of an organisation called the Bureau Européen des Unions des Consommateurs, (which we have never yet got around to translating) which is an organisation consisting of mostly comparative testing consumer organisations in the Common Market countries .

Our only aim, in this organisation, is to impress the point of view and the desires of consumers in Europe on the officials of the Commission, and we spend our time doing that.

I am also a member of an organisation called the Economic and Social Committee, and as a member of the Trade and Industry Section of that, and a special Working Group on Technical Barriers to Trade, I am very well aware all the time of the work and the research being done by European car manufacturers to make cars less polluting, and all consumers are very grateful for that. Also I am very well aware of what we think of as the extremely high standards of anti-pollution, which are set by the European Community. Some of the members of the Community are more progressive from our point of view than others, but in general we are all impressed with the goodwill of the Community in this direction.

I am also very much aware that we in Europe must get, firstly, harmonization of our standards in the sphere of anti-pollution from cars. If we do not, if all Americans are as energetic as Mr. Stork, and I think quite likely many of them are, they will overtake us, and we, that means you, will have to follow in their steps and probably adopt standards which may be magnificent for the United States but entirely inappropriate for Europe. In so far as I managed to understand Prof. Sibenaler's paper, it seems, from the consumer point of view, to be fine. If I understood it rightly, he was suggesting mathematical models which could be used for designing legislation which could be made flexible according to different situations. If that is right, this seems to me to be fine and I am totally unequipped to make any other comment whatsoever. I just want to make a very small number of consumer points of view to put in front of you.

The first is that we think that all studies on pollution should be total; that is to say that emissions, for example of lead, should not be looked at in isolation from the lead pollution from other sources : cars is one source, water another, food another, paint another. All the studies should take all the sources which impinge on the environment together. Secondly, we think that the studies should be taken in another way; it is no good simply studying the effect of carbon monoxide on the human body, then the effects of nitrous oxide, then the effect of lead. You have to take into account the interaction between these pollutants because they may exaggerate or, I suppose, occasionally, even cancel each other out, and we are not aware that that is always done. The next point I want to make is that we should be given specific and precise estimates of what our consumer demands on pollution are going to cost. Mr. Aitken gave us one figure saying 10% increase in the cost of a small car. That is fine, but what happens in the Economic and Social Committee is that the manufacturer-influenced members say :"You can't have that because it will be too expensive". He will never put a figure on it. Consumers would say :"If it is going, for instance, to cost 0.001 of a penny on the cost of a gallon of petrol, we don't care -"let's have our pure air". If it is going to cost 6 p. on the cost of a gallon of petrol, then we might mind".

The next point I want to make is that we want laws and regulations, when you make them, to be thought right through, so that we know that the laws can be observed. For instance, it is no good simply having a regulation which would give type approval to a car which is magnificent when it is new, but after 5 years would be polluting. This has happened in the United Kingdom with noise regulations. The new cars are all right but after 5 years there is no control of the noise emission.

My final point is : we would like you to use your influence on the lesgislation to consider firstly, legislation about designing traffic flows in town, so that traffic moves faster, for instance, there are fewer stops; because we think that this kind of urban planning takes much shorter time, really, than any imposition on industry for redesigning a car. If the pollution can be reduced in some way by that kind of urban planning, let us go for that because it is simpler, instead of placing all the burden of improved vehicle design for antipollution on industry.

Intervention of Mr. Carlo POLLONE

Thank you, Professor Sibenaler, for giving us, in a manner so concise and yet so clear and complete a rundown of the problems involved in defining and applying the standards for reducing the emissions from motor vehicles.

A full commentary would take up very much more time than I have been allotted; I shall therefore confine myself to a few general remarks on the methods by which emission standards are defined.

Before such a gathering as this I feel that it would be superfluous to emphasize the need for the legislation concerned with motor vehicle emissions to be as international as possible, because the development of European laws is the declared purpose of the Commission of the European Communities which has organized this Symposium.

On the other hand, I think it worth noting that the second generation of regulations for limiting motor vehicle emissions, the theme of today's discussions, must be developed in general circumstances vastly different from those which saw the birth of the first generation regulations.

The general economic difficulties, especially those of industry, and the energy situation leave ever less room for improvization and possible errors and require that the new regulations be defined by a rigorous process which would determine the need for them, their technical feasibility and their effects on the economy and the energy balance.

The phases of this process can be stated briefly :

- a list of toxic or harmful substances is drawn up and the "standard of air quality" is laid down for each substance;
- these standards are compared with the present air quality and the degree of improvement necessary is assessed;
- next, the motor vehicle's contributions and the relationships between emissions and atmospheric concentrations are identified by means of appropriate models, after which the emission reductions to be achieved are defined;
- an implementing programme is established with due regard to the technical and economic possibilities (costs versus benefits), the times required for developing and producing the necessary modifications (for major modifications, four to five years) and the time required for the effects of the

regulations to become manifest.

I should like to add that it is also necessary to keep the air quality constantly under observation during the phase in which the measures are implemented in order that any corrections that may be required to obtain the desired improvements can be carried out in time.

The difficulties in carrying out the process just outlined are very great, particularly because there is so little information available concerning hygiene and health, the cost of damage due to atmospheric pollution, the cost of the modifications necessary to reduce the emissions, and the break down of the contributions from the various sources of polluting substances.

European industry is so convinced of the necessity of applying the process outlined above as closely as possible, and thereby overcoming the difficulties just enumerated, that some time ago, in addition to stepping up fying its traditional programmes, it launched entirely at its own expenses special programmes to acquire the information that is lacking.

I have only time to mention one or too of them. I make no claim of completeness and hope that some colleague here present can complete the picture.

On behalf of the Committee of Common Market Motor Vehicle Manufacturers (CCMM), I should particularly like to mention :

- the studies entrusted to four eminent European scientists, to assess the effects of pollutants on human, animal and plant health;
- an initial assessment of the cost versus the efficiency of devices for reducing the emissions;
- a study on the diffusion of NOx in the atmosphere of a city, using a model developed in the USA under the auspices of the EPA.

The summaries of the first two studies and the detailed programme of the third study are contained in a publication issued by the CCMM.

Likewise, the Italian research group known as FEEMAS (Alfa Romeo, ENI, Esso, Fiat, IIP and Mobil) is designing model of urban co-diffusion and it monitored the atmospheric concentrations in four Italian cities for one year; it has followed the patterns of emissions on a fleet of about 250 motor vehicles run by customers over distances of 25,000 to 30,000 km; it has installed or is installing a network for monitoring the air-borne Rb in five Italian cities.

Then again, in Turin, set up under the auspices of FIAT, there is the most comprehensive network in Italy for "monitoring" air pollution, whether originating in the atmosphere or from fixed installations.

I should finally like to mention a study carried out in France, in which they measure the CO concentrations and the flow rates at the entrance and exit sections and in the ventilating shaft of the St-Cloud tunnel and work back from the CO balance in the tunnel and from the number of vehicles passed through to the average emissions per kilometre. The averages of the measurements in the last three years (13-20 measurements a year) are 32g/km in 1973, 27g/km in 1974 and 21 g/km in 1975, and show very appreciable reductions.

Work of a like nature can never be sufficiently encouraged.

I end with a remark on the method which Professor Sibenaler calls the method of "apportioned contributions" for calculating the reduction in emissions necessary for obtaining a given improvement in the quality of the air. The proposed method has the great merit of demonstrating even in quantitative terms, that the air quality can not only be improved by a reduction of the emissions but also by a reduction in the flow of vehicles passing a given point.

This may be a way of solving the problems of areas with particularly high atmospheric concentrations without having to penalize the remainder of the Community on account of strictly local problems.

As a practical means for the drawing-up of standards the method deserves very thorough discussion and,perhaps, improvement in certain details.

GENERAL DISCUSSION

STATEMENT AND QUESTIONS BY MR. PAHNKE

In October of this year Dr. Cantwell of the Dupont Petroleum Laboratory presented a paper in California which cited information on the relation between air quality and automobile emission standards.

Slide 1 shows the vehicle CO emission rate needed to meet the US air quality standard of 9ppm. In our most heavy traffice cities, New York City, Los Angeles and Chicago, where traffic density is 300,000 vehicle miles per day per square mile, a vehicle rate of 26 grams per mile would be needed. Our present standard of 15 grams per mile is more than sufficient and we certainly do not need the 3.4 gram standard now legislated for 1978.

In cities like Washington DC, Boston, Cincinnati, Philadelphia, whose traffic density is 200,000 vehicle miles per square mile per day, a vehicle rate of 35 grams per mile would be all that is required. For most US cities and the Canadian cities of Montreal and Toronto, traffic densities are usually 100,000 vehicle miles per square mile per day or less. Thus even higher rates coule be allowed.

All the cars in the US have vehicle CO rates averaging from 80 to 90 grams per mile as shown in slide 2. Replacing these cars with cars of low emission rates from 1968 to 1975 has lowered the average CO emission rate. These curves are shown for the period 1976 to 1985, the top curve represents what will happen if the vehicle emission rate was standardized at 28 grams per mile, the US standard being used in 1974. The middle curve represents what would happen if one would retain the current 15 grams per mile standard. The lower curve is for the 3.4 gram per mile standard.

Superimposed on these graphs are projections of when the air quality standard of 9 ppm will be met for with traffic densities, even for our three major cities, New York City, Los Angeles, Chicago. Lowering the standard from the current 15 grams per mile to 3.4 grams per mile would appear to make a difference of several months. Incidentally, studies of carboxyhaemoglobin levels of people living in Chicago support the above projections.

These studies carried out by Dr. Stewart of the University of Wisconsin were cited in a recent paper on this subject by Dr. Larry Goldmans of Economics and Science Planning. In summary there are two main points which can be made before I raise the question :

1. Any actions on vehicle emission standards should be related to air quality requirements, and

2. It is important to set standards based on what is needed rather than what is technically possible.

The penalties in terms of fuel consumption, vehicle cost and vehicle performance are too great to do anything else. This is why I have raised the question - what is being done to directly relate automobile standards to air quality needs ?

Comments by Mr MÜLLER

I have noted with interest the points made by Professor Sibenaler and also the remarks from other Panel Members. As you know, Switzerland is especially interested in the problem of combatting motor vehicle exhaust gases, because public opinion in our country is urgently calling for improvements. In fact, what has so far been achieved - that is to say ECE Regulation No 15 or even the corresponding EC Directive - gives no particular cause for pride especially when it is considered that very wide tolerances on the permissible levels are still conceded. So we can really only speak of an initial small step which must be followed by large steps. It will not surprise you if I say that the points made by Mr Stork of the EPA in this connection were particularly pleasing to me. He told a few home truths here which would be worth framing, gilding and hanging on the wall !

As you know, the Swiss Federal Council has produced a Report for Parliament. In it are set out fundamental and technical objectives as well as proposals for the progressive tightening up of the provisions concerning noise and exhaust emissions. In the autumn session of this year, Parliament adopted this report and it is now up to us to implement the measures envisaged therein. As far as exhaust emissions are concerned the objectives stated in the Report are roughly the same as those prevailing in other European Countries. I should especially like to call your attention to the points made by Mr Klammer concerning the government programme of the Federal Republic of Germany, as well as to Annex 8, section 2.4 of Professor Sibenarler's paper. The issue there is primarily one of reducing the emission of toxic exhaust gases by about 90 % with respect to motor vehicles whose exhaust gases are not detoxified, and to do so by about the year 1980, or by 1982 according to our Swiss report. It has been said here that this is not really feasible, or that it is unrealistic. I do not altogether share this opinion; I am convinced that the need is not to ascertain with scientific accuracy how little should be done, but rather to utilize the technical resources fully and to do everything that can contribute to an improvement of the situation. Certainly, the position as regards air cleanliness can and must be taken into account as well. It must nevertheless be admitted that even the experts hold differing views on the subject, and thus it will still be the case in ten year's time. And I should therefore like to say, in application of a well-known legal principle : in dubio, pro securitate ! (in case of doubt, play it safe !).

It is, of course, very important that the measures to be taken be made known in good time. In this connection I should also like to quote from the introductory words in the invitation to this Symposium, where it is stated that : "The guidelines for regulations applying to motor vehicles from 1980 must therefore be laid down now in order to enable the motor industry to plan its future production". We should therefore cease to play a waiting game and to call for studies and more studies; we must now finally go forward.

Switzerland especially is keenly interested - you can take it from me - in seeing that the proposed measures are implemented within the framework of existing or impending international arrangements. Switzerland has already put forward appropriate proposals in the ECE Working Party 29 and it is planned that the initial discussions thereon should take place in December.

We shall, of course, also transmit the proposals to the Commission of the European Communities for its information. It would be extremely regrettable if you were to show little or no sympathy for our wishes in this respect and if Switzerland were therefore compelled to go its own way. We cannot rule this out completely, but we should like to avoid it and would merely take it into consideration as a last resort. On the other hand, we are sure that joint efforts to reduce noise and exhaust emissions will lead to the goal, because the technical conditions are fulfilled.

The European motor vehicle industry is capable of solving the problems; it is no less capable than are the motor vehicle manufacturers outside Europe : of that I stand completely convinced. The motor vehicle industry is nevertheless waiting for the governments of the European countries to agree in this connection and to set clearly defined objectives.

Here I should perhaps interpose that Mr Stork's statement is certainly valid : the manufacturers would perhaps do little or nothing of their own accord. They have no cause to do so, and it is also very understandable that they do not want to distort the conditions of competition.

If however, criteria initiated by governments are laid down jointly for everyone in a uniform manner, then there is no doubt that the industry will collaborate. Certainly some costs will be incurred, but these will be all the lower if everyone cooperates and if motor vehicles in every country must comply with the same requirements.

And, ladies and gentlemen, is it not true that a little sacrifice can aslo be expected of us in the interests of a better quality of life, an improvment of our well-being and of the health of everyone as well as that of our children.

Not least, however - and I should like to stress this particularly - it also lies in the interests of the motor vehicle manufacturers themselves, because if we bring in really stringent regulations we take the wind out of the sails of the true opponents of the motor car and individual transport, for whom, as you are aware, the injurious and troublesome effects of motor vehicle operation are welcome grounds for attacking the car. Thank you for your kind attention.

Question from Mr SCHÖNFELD

Since time is short I will be very brief. We know that the motor vehicle industry possesses engine designs which make it possible to achieve, without the use of catalysts, the objective of the Federal German Government, namely to reduce emissions of carbon monoxide and hydrocarbons to one tenth of the 1969 level and at the same time to bring about an identical reduction in the emission of oxides of nitrogen. These designs do not seem to entail any significant increase in fuel consumption (a point to be borne in mind for the afternoon session). These designs were developed in the motor vehicle industry for the purpose of fulfilling future legal requirements in the USA. Is it reasonable that motor vehicles with less toxic emissions should in future be exported from Europe to the USA whilst European citizens are not allowed to benefit from the successful development of such motor vehicles ?

Comment from Mr KRAFT

I almost have the impression that my comments are somewhat too late, because the pernicious effect of Mr Stork's words, particularly on our Swiss representative, was already obvious. Moreover, it was very interesting to hear in the meantime that the authorities in the Federal Republic of Germany have at their disposal more sensational information concerning industrial developments than we ourselves do. My comments ought really to be quite brief, and I only wished to mention that although in California there are motor vehicles operating without catalysts, these motor vehicles are equipped with other exhaust gas clean-up devices which are at least as costly and, which, in the case of a small car, easily account for the figure - mentioned by Mr Gauvin, I believe - of about 10 % of the car's costs.

In addition, it must be pointed out, in connection both with this afternoon's session and with this one, that these motor vehicles consume up to 30 % more fuel than their European counterparts. Should our Swiss friends be induced to create a kind of European California, I can only say : poor Swiss !

Question from Mr CLAVEL

Beyond a certain level, rendering an internal combustion engine less polluting entails an increase in fuel consumption and the cost of buying and servicing the vehicle. In this period of scarce, expensive energy and of inflation, does the EEC Commission and WP 29 have a compromise policy in this situation of conflict in which the future reduction of polluting amissions is balanced against the need to save energy derived from oil and to control prices to consumers.

Answer from Mr GAUVIN

I believe that all that can be said now is that we are in a situation of conflict and that it is really too soon to say what the outcome will be, because the first discussions on any subsequent reductions of the limits specified in the regulations on pollution are to be held in Geneva next week. Fuel consumption, especially, is a fairly knotty problem which incidentally, is the subject of a very specific Commission policy, and it is certain that not many Member States of the Community would be induced to contemplate reductions in pollution which would be offset by an increase in fuel consumption.

Question of Mr CUTTING

I have here a newspaper report by Mr Russel Train, an Administrator of the "Environmental Protection Agency", to which, I understand Mr. Stork belongs . Speaking to reporters, Mr. Train said : "Photochemical oxidants, or smog, are more widespread than originally believed and are occurring in some rural areas". It is now being recognised that these natural emissions are not truly pollutants, instead they are the principal elements in nature's cycle whose performance is essential to the well-being of the planet. CO is the largest contributor to the world total with 3,500 million tons being produced each year. 93 % of this total is produced by the action of ocean waves, oxidation of methane gases in marches and the photosyntheses process of vegetation. I would be glad to hear Mr Stork reply to this.

Answer of Mr STORK to Mr CUTTING'S question

Mr Cutting, I am sorry I do not have this particular clipping in front of me, so I cannot understand the context. In fact what you quoted is familiar to me. As the "Environmental Protection Agency" has expanded its network of air quality monitoring equipment, we have identified photochemical oxidants in other areas than urban ones. I am not a specialist in this area but those colleagues of mine who are specialists tend to conclude that the principal cause of this phenomenon is a far greater transport of photochemical oxidants away from major cities than had earlier been expected and anticipated. I am also fully aware of the data on CO which is indeed generated from tje decomposition of plants. About three years ago, perhaps four, we had a very intersting piece of data put forward by one of our major automobile manufactures to the effect that hydrocarbon which comes from a one or two acre plot of vegetation is equal to that of the emission from an automobile. That may be true, yet we have very few acres of vegetation in our congested urban areas. We continue to be persuaded that in our urban areas CO in particular is caused by automobiles' exhaust to a level well over 90 %, that 50 % to 60 % of all hydrocarbon in the US comes from automobiles and that automobile HC is a major contributor to photochemical oxidants. And for these reasons these pollutants continue to need to be controlled.

Mr JACOBSON'S question

Air pollution controls on urban environment can only be effective as long as vehicles start and proceed without lack of driveability. My organisation attends to roughly 2.8 million breakdowns annually - most of them due to ignition defects and poor carburation, particularly so in bad and damp weather far less so in the height of a dry summer. With increased cost of motoring maintenance levels are falling. This is a question to Mr Aitken : is the industry taking steps to improve this cyclic falling off in combustion control ? This is of course a question of ignition systems being maintenance-free to a large extent because we appreciate that before long we will not be able to do what our patrols are doing at the moment and that is they increase the richness of the mixture to get stranded motorists started again. Obviously we do not intend to encourage the breaking of rules and laws - but the average motorist wants personal mobility at almost any cost and certainly will not be motivated by altruism to such an extent that in a moment of crisis he will be prepared to walk rather than infringe the CO emission regulations.

I would like Mr Stork to tell us what is his experience of the maintainability and the actual levels of pollution of cars in service in competing systems in different parts of the world, particularly California, Chicago, Detroit, New York and, if he has any information, on Europe. Perhaps he could tell us to what extent the standards set when the vehicle is new are in fact maintained in service now, as compared to what they were two or three years ago. Is it not possible to find standards which are achievable purely at the factory gate and which fall off dramatically in service in various parts of the world ?

Question from Mr H. DALIBOR

In contrast to Mr Klammer, you mentioned the possibility of reducing emissions to 10 % without the use of catalysts and you argue that this is necessary in order to meet the current Californian standards for California.

For the reduction to 10 %, the Clean Air Act lays down a standard of 3.4 g/mile. The current California standard in respect of CO is 9.0 g/mile - which therefore corresponds to a reduction to about 30 % as compared with unmodified motor vehicles.

This is precisely the level considered by Mr Klammer to be attainable by 1980 if it is desired to dispense with the use of catalysts. Could you also claim that present-day petrol engined vehicles are able to meet the CO standard of 3.4 g/mile without catalysts ?

Answer of Mr STORK

Thank you for giving me the opportunity to be clear on this point. I understood Mr Klammer had spoken of a reduction compared to the emissions of "uncontrolled automobiles" from 1969. If I am incorrect in that, I stand corrected. The 3.4 gram per mile CO standard, that is called for by law in the US is substantially more stringent than a 90 % reduction from uncontrolled automobiles. It is in fact approximately a 97 % reduction from uncontrolled automobiles. This means a 90 % reduction from allowable emission levels in 1970, at which time in the US there really had been substantial progress, and I stand by my statement that a 90 % reduction from uncontrolled automobiles as concerns HC and CO has to some extent already been achieved in our State of California with some cars that do not use catalysts. I am quite persuaded from what I have learned about the international automobile industry, and we have had the opportunity to learn a great deal about the marvellous work being done worldwide that, given reasonable lead time, all of the industry can be capable of using the best technology that is already being used in California for HC and CO control.

On the question of Mr Jacobson, I think that he is quite correct that cars that are not properly maintained, do not retain low emissions in the field. We have conducted studies which show quite clearly that the emissions from cars that are normally maintained, or perhaps normally not maintained would be more accurate, to tend to go up, in some cases substantially. Other studies in which we have tuned up old cars before testing, however, show that when cars are in a proper state of tune even though they have substantial mileage on them, they are capable of meeting the standards to which they are designed. What does that tell us ? It tells us, of course, that cleaning up the air is not something that we can look exclusively to the automobile manufacturer to do, it requires action on the part of each of us who owns an automobile. It will require in the US annual or semi-annual inspection of automobiles with failing cars required to be repaired. But we must never forget that at the repair shop the mechanic cannot reduce the emissions below the level at which the automobile designer and the automobile manufacturer made it possible. Therefore, we must start with the automobile manufacturer requiring him to design cars that if properly maintained and operated, are capable of meeting the environmental standards that are needed to protect the public health.

Comments by Mr DREISSIGACKER

As the official in the Federal Ministry of the Interior in Germany with responsibility for clean air, I should like to add a few remarks to what has been said here in the Panel. It is not stated in the Programme that this is question time; what is stated there, at least in the German version, is that now is the time for a free discussion.

First of all, a comment on Mr Kraft's intervention with reference to my colleague from the Federal Office of the Environment. Here Mr Kraft somewhat ironically implied that the Federal German Government clearly had at its disposal better information regarding technical possibilities than did the industry itself. In this connection I can state that our research and development programme for attaining the 1980 objective is being carried out in close collaboration with the motor vehicle industry, with a whole lot of firms in fact ; hence it is quite conceivable, Mr Kraft, that the Federal German Government is better informed on the whole than any one contributor from a single undertaking.

Mr Stork has already anticipated much of what I whould have had to say in general. I should nevertheless like to discuss a few points, especially the plea from Mr Aitken, who believed that we must first await the consequences of the present arrangement, then launch comprehensive research progammes to ascertain what atmospheric pollution problems exist, if any, and then still allow the motor vehicle industry sufficient time to adjust itself to the results. At the same time, Mr Aitken quotes the life-expectancy of a motor vehicle as 11 years, and, this in itself is a clear indication of how long the first stage of his programme alone would take. If things were to be done in this way, the next EEC directive would be a lifetime's work for the people concerned, and those people would have to be very young if they were to see it through.

We down here at least, cannot comment specifically on Professor Sibenaler's report. I only received this report today - in this respect the Panel is better off than I - but I should like to say in general that we in the Federal Republic of Germany cannot allow the fixing of emission values to be made dependent on the imissions - we refer to these as the "air quality standards", as well as on the contributions made thereto by individual air polluters, and this in accordance with the motto : "Here is the motor vehicle and there is the rest of the world; let them clean themselves up first ! ".

From the standpoint of an official who is responsible for air pollution as a whole, things nevertheless look somewhat different because, for me, industry and also household fuel are not simply the "rest of the world". Take for instance, the power utilities, which, when required to do something, first tell me : "O.K., but the motor vehicle industry contributes much more to pollution." In the Federal German Government we have thus been clievied around like this for years; one party would point to the other and say : "Let him do something first, because my particular contribution is very small." In Germany we have now broken this vicious circle with the Federal Law on Protection from Imissions, which was passed last year, and by applying the principle of precaution. This principle of prevention means that whatever is possible according to the "state of the art", as we say in Germany, shall be required. It also means, however, that a measure must not only be entirely feasible from the technical point of view but that it must also be economically commensurate with the desired effect.

If I am now supposed to say something here about this Cologne survey and the plea that now at last something similar should be done all over Europe, then I am bound to say - unpalatable though it may be - that this Cologne survey is perhaps not even representative of Europe. As you know, in Germany we have very strict standards for industry, and I could imagine that in other European industrial centres the proportion of pollution attributable to motor vehicles is even appreciably smaller than in Cologne.

Finally, I would point out that the objective of the Federal German Government's Environment Programme for 1971 is not merely a bureaucrat's brain child at the time the Federal Government set up several working parties which have assisted it. In particular, the objectives of the Environment Programme for 1980 stemmed from a working party which was drawn substantially from the German motor vehicle industry; it was offered to us as an alternative to the demand we were making at the time, under pressure from the public, that the American values be attained by 1976. For reasons of economic expediency - and because at that time we would not see any technical means of attaining the American values other than by the use of catalysts - we then accepted the industry's offer.

Cooperation with industry so far under the research programme financed jointly by the Federal German Government and industry seems to indicate that it is still being taken seriously by both partners. I may aslo add that this research and development programme not only covers technical development but that we also carry out cost-benefit analyses at regular intervals. The last such analysis has shown that, through optimum combination of the technical means, the extra purchasing cost can be kept within the range of 5 to just under 10 %; depending on the technique used to reduce emissions; that the maintenance expenditure, calculated and capitalized over the expected life of the motor vehicle, is less than 5 % of the present purchasing cost; and that fuel consumption can be reduced by about 5-10 %. The study was based on data pertaining to a car in the DM 10,000-13,000 price range which we obtained by questioning firms. This too will have to be updated; now, however, we are resolved as a matter of principle - let me emphasize it here once again - to join with our motor vehicle industry in order to see how this objective in the environment programme, which has still been kept at the level of generalities, will now crystallize in the form of limit values. Mr Gauvin said that in the Community people will be more modest; I think, - and we especially have learnt this - that we must be more modest as regards environmental protection in the Community whan we come to Brussels with our ideas. Nevertheless, I should like to appeal to you all not to refuse us cooperation in this important field, but to try jointly to produce something which we can offer to the citizens of our respective countries, lest - as has already happened in Germany - we come under strong political pressure to do something, and it may then once again be the case that a government does not know how to cope with such pressure.

Reply by Mr KRAFT to the comments of Mr DREISSIGACKER

Having been addressed directly, I should like to reply directly. Of course, we know - and I personally know - what we have given our Federal German authorities quite frankly in the way of information. I nevertheless thought it unfair to give the impression here - indeed at an international gathering - that the German motor vehicle industry as a whole now had within its grasp, for its entire range of models, technical solutions for complying with these regulations. We already have cars on the market of which some would comply with these provisions, but these are mostly prestige models with sophisticated injection systems and suchlike whose market penetration will amount only to a very small percentage, because the consumer cannot afford them. I feel, therefore, that we must be somewhat more cautions in future in our cooperation with the Federal German authorities, especially with the "protectors of the environment".

Dr MARCIANTE

Pollution from other sources

On the subject of sources of pollution I should like not so much to raise a question as much as to make a very brief intervention. This morning there was talk of air quality and of the measures that already have or will have to be taken in respect of motor vehicles in order to ensure that the quality of the air improves.

Unfortunately, pollution from motor vehicles is certainly high in many countries of the Community, but it is not one of the main forms of pollution. I have in my possession some statistical data on what is happening in Italy; I can speak of Turin, of the work carried out by FIAT and that done by FAEMAS in three or four Italian towns(to which Mr Pollone has already referred).

Industrial pollution and the pollution from domestic heating are unfortunately very significant. Oxides of nitrogen, for example, drop by 60 % from winter to summer; evidently, therefore, it can be assumed that the 60 % is due to domestic heating.

Reference was made to polynuclear aromatics. Turin apart, we have started determintations of polynuclear substances. In Leghorn, we found alpha-banzpyrene concentrations ranging from 23-27 g/m^3, whereas in summer we found the values to be 0.5-1.2, that is to say, there are enormous decreases. It is true that the diffusion of the pollutants is greater in summer; it is true that in summer some degradation reactions may occur in the case of polynuclear aromatics, but it is equally true that the differences are really large and hence that other sources of pollution also contribute very considerably.

Consequently, when someone wishes to speak of air quality I, as a private citizen, want an air quality which suits me well, but I also have to remember the other sources of pollutions which, in my opinion, are of really considerable importance.

Statement and question from Mr VAN BECKHOVEN

My comments really consist of a short statment of opinion and a small question. Now, most of what I wanted to say has already been ventilated by previous speakers; I shall therefore be quite brief.

Quite a lot was said this morning about the use of mathematical models with which you can calculate what must be done in order to keep atmospheric pollution within acceptable limits. What it more or less amounts to is that limit values are set in the light of medical investigations, the measurements of air quality are carried out and these show whether or not anything needs to be done. Should the limit value be exceeded, something has to be done about it and the situation is then simple; but implicit in this idea is the incorrect use of "limit value". Should the limit value not bee exceeded, this does not mean that nothing needs to be done. It would in fact mean that limit values are completely respected throughout the country. I did not think that such was the intention of an environmental hygiene policy.

Another point is, of course, that if it is found that limit values are not being exceeded, we will ascertain the costs of combatting the pollution and weigh them against the effects. Now it is my belief - and here I come to the question I wanted to put to Mr Stork - especially with regard to carbon monoxide and hydrocarbon emissions from cars, that there is the prospect of a development which may make it possible to achieve substantial reductions at a fairly low cost. And in that connection the remark made by Mr Stork this morning is important; he said that in California there were cars on the road whose emission levels were about 90 % lower without the need for a catalyst in the exhaust gas system. If I understood him properly, he also said that these were not American-built cars but Japanese and European.

My question now is, Mr Stork, are you not being too modest ? I thought, on the basis of recent literature, that there was also talk in the United States of meeting very stringent emission requirements without any need for a catalyst or for gas re-circulation.

Answer of Mr STORK

I want to be sure that I am not misunderstood. I did not say that all cars in California meet those standards without catalysts, far from that ! Most cars in California use catalysts. I said that some cars in California are able to meet those standards without catalysts, which suggests to us that it is possible to do so. One of tha main problems for American automobile manufacturers, as well as all automobile manufacturers, is the current uncertainty about the ultimate emission standards for NOx. That standard at the present time in our law is very stringent, more stringent that we believe is necessary, at least in the near term. If that stringent standard is to be met, there is for practical purposes no way of doing so, except with a catalyst that reduces NOx into its elements and if a manufacturer has to use a NOx catalyst for technical reasons that are too complex to go into at this meeting, he will also in almost all cases have to use an oxidation catalyst. If there are established in Europe emission standard for NOx, that are not more stringent than the current emission standards in the US, then it is technically possible to meet what we call our statuary HC an CO standards without catalysts. It is not easy but no-one said that it need be easy - it is possible.

One other quick word about the economics of emission control. I believe that the economics of emission control are talked about far more than necessary. In the US the cost of emission control on cars today ranges from about 100 to 250 dollars in proportion to the size of the car. That is in the range of 3 to 4 %. We consider that to be an excellent investment, and compared to many of the things that go on cars that provide far less public good, such as super deluxe chrome, vinyl roofs, air conditioning, power windows, power seats, automatic transmission, power steering and all the other many things that we buy on our cars - they increase the price of the car in our showroom many many times more than the costs of the air pollution equipment. We believe that we, in fact, cannot afford not to have air pollution equipment on cars.

Statement of Mr DARTNELL

My first slide demonstrates the sort of lead levels measured in the Champs Elysées in Paris by the Préfecture of Police. It shows the maximum and minimum values together with the average value. The yellow line represents the traffic pattern taken over a period of time which is about a year or a year and a half. Basically this slide shows very little correlation with lead in air measurements and the traffic pattern. This work has been going on for about four years by the Préfecture of Police in Paris.

The next slide shows that, in fact, only in this period of time, this is 1971 — 1975, the average lead in air levels in Paris has decreased substantially from something over an average of 2 micrograms per m^3 to 2.7/2.8 say down to 1.5, and in that time there has been no change certainly in the number of vehicles in Paris, nor in the quantity of lead used in petrol. So, basically, we have a situation where measurements have been made, where there has been a downward trend in the lead in air levels, and this change is mostly ascribed to meteorological conditions. Nevertheless, it does stress the importance of taking measurements, a point made by Mr Pollone earlier on.

The next slide shows a little on particulate emissions. A motor car without lead measured 0.82 grams per miles of particulate, with lead it measured 0.03, a Diesel engine car about 1, and a two-stroke motorcycle 2.5. In other words the two stroke motorcycle, in terms of particulate emission, was emitting something over 100 times more than an average size motor car.

The next slide shows the CO situation : measurements made by Dr Cole on the carboxyhaemoglobin levels of people on the Island of Sark in the Channel Islands where no motor traffic is allowed. He demonstrates the relatively low levels in terms of carboxyhaemoglobin of non-smokers on this island. Then he moved to the Outpatient's Department of St. Bartholomew's Hospital right in the middle of London. Again this was a no-smoking area and he measured the carboxyhaemoglobin level of the outpatients - those that were non-smokers. There was not much variation from the people of Sark who did not smoke and where there is no motor traffice to the people in this hospital where there is an extraordinary lot of motor traffic. He then moved to a city office where he measured smokers and non-smokers, and in practice, of course, the smokers had at least five times higher levels of carboxyhaemoglobin levels than the non-smokers.

He concludes that even in the most stringent control of gaseous emissions from motor cars in terms of CO, this will have very little effect on people who smoke, and in practice, certainly in the UK, 70 % of the adult population smoke.

One final point, Mr Chairman, very briefly. I would like to refer Mr Stork to a little pamphlet on vehicle emissions published only a few months ago in the States. I consider Mr Aitken's comments very justified about taking emission levels in the farm-yard and in the forest, because this pamphlet demonstrates that 95.7 % of hydrocarbons are generated naturally, 92.8 % carbon monoxide and 95.4 % nitrogen oxides.

<u>Question of Mr George DONALD</u>

Mr Aitken said that a reduction of NOx emissions would definitely lead to increased fuel consumption. The CCMC report indicates there is no overall change in fuel conbustion provided only engine modifications are required.

Could Mr Aitken say whether he was considering reductions greater than those proposed by the CEC when he made his statement, or does he consider the levels proposed by the CEC will require more than engine modification ?

Answer of Mr AITKEN

I can answer that in two ways : the proposal that I put forward this morning was aimed basically at NOx levels, beyond the present levels promulgated by the European Communities, but even those, in some certain classifications of vehicles, will definitely and specifically reduce the fuel consumption beyond its present levels. I am thinking in terms of vehicles which are in the bigger and heavier classifications and for the light commercial vehicles. But I can also state quite categorically that if the NOx levels are proposed on the present levels in the Community then that will definitely and specifically worsen the fuel consumption of most vehicles by anything up to 10 %.

Statement by Mr FÖRSTER

The Federal German Government's announcement that it will enact the emission provisions not unilaterally but under EEC auspices is to be welcomed. When the Government's Federal Programme was being drawn up in 1969, there were few scientific investigations on emission and imission problems in the Federal Republic. The objective of attaining a 90 % reduction of the toxic substances in Otto engine exhaust gases could therefore be no more than a declaration of intent. Since then, however, new facts and further research results have come to light which permit a better definition of the objective.

Answer from Mr KLAMMER

Ladies and Gentlemen !

In answer I should like to say the following : of course the Federal German Government takes into consideration any interim results obtained from investigations and research. The participants from the Federal Republic of Germany will certainly be aware that it is the Federal Government's earnest desire to update this programme. By "updating" I mean adaptation to the latest state of knowledge. So naturally the investigations in Cologne, which have already been mentioned here today, and the research conducted jointly by the Federal German Ministry of the Interior and industry will be embodied in this environmental programme. I believe that the figure of 10 %, described here as a declaration of intent, should certainly not be abandoned, and for the simple reason that - as Professor Sibenaler has already pointed out - there are several factors that determine the situation as a whole.

It can be said that on the one hand there is a desire to reduce emissions from motor vehicles as far as possible having regard to the state of the art and to economic considerations. On the other hand, it is desired to control the overall pollution burden of the air, which should not exceed the values that medical opinion considers to be harmful.

For the motor vehicle buyer and the motor vehicle user, there is even a positive aspect here which - when he has been made aware of the problems involved - will surely induce him to accept more readily and cheerfully the extra costs due to the application of technical measures on the motor vehicle in order to reduce the undesirable consituents of the exhaust gas, because the overall pollution burden of the air is really determined by the quantity of noxious substances that the individual motor vehicle emits and by the total number of motor vehicles passing a given point in the town per unit of time and burdening that point. And the lower the value for an individual motor vehicle, the greater the freedom of the motor vehicle owner to travel without restriction. Or, to put it the other way round, the higher the proportion emitted by an individual motor vehicle, the greater is the need to limit by means of regulatory measures the number of vehicles allowed to circulate there per unit of time.

Such is the problem, and I believe that I have answered the question accordingly.

Question of Mr E. J. CUTTING

Lead traps

Prof. Sibenaler speaks of the need for a simple, fast test for lead traps. Present indications are that a test to determine the effectiveness of a lead trap take 700 hours of engine running time.

Can Government people confirm this and say if they think this reasonable ?

Question from Dr Franco MAGI

Is it right to adopt for the pollutants emitted by motor vehicles an order of priority such as that mentioned by the author ? Is it not advisable to decide on the principles to be applied in compiling such a list of priorities, if it is necessary to compile one at all ?

Answer from Professor SIBENALER and Conclusions

Dr Magi's question should, in my view, have been put to public health people rather than to an engineer. An engineer can only ascertain; he can listen and receive advice, and on the basis of what he hears he reacts and establishes his order of priorities.

This order of priorities is not forced upon him. However, to come back to light vehicles powered by spark-ignition engines, the order set out on page 17 of my written report makes sense at the present time.

As No 1 priority you have carbon monoxide total hydrocarbons and evaporation hydrocarbons.

These levels gave rise to regulatory restrictions which are now in general application in most countries. Oxides of nitrogen concern almost everybody, so do particulate lead emissions; and as regards the hydrocarbons, one of these days it will really be necessary to distinguish those which are reactive from those which are carcinogenic and from those which are completely harmless. Sulphur oxides also pose some questions, as do total particles. But the engineer himself is waiting for the public health people's reaction and it is to them that you should put such questions.

Mr Cutting's question concerns more specifically the trapping of lead during laboratory tests. Mr Cutting points out that in order to do this it is absolutely essential to have tests lasting 700 hours. It is obviously out of the question that a type-approval test should last 700 hours ! That is why, in my own laboratory, we have carried out a considerable number of studies and investigations in recent years to ascertain whether it is possible, on the basis of European and American type-approval tests, to determine the ratio of lead emitted to lead consumed.

On page 25 (? page 28) of my report I point out that the lead concentrations in the emitted exhaust gases are in the region of 150 g/m^3. Given, for example, the European sequence, the lead is distributed in two different ways, part of it being washed by liquid condensation coming from the combustion reaction.

A heat exchanger is placed between the vehicle and the bag and much of the water is condensed. Of the total quantity of lead emitted, up to 90 % is collected, the other 10 % remaining in the bag. We meticulously collected the condensate and determined the concentrations of lead in the bag by mixing in an oil which we rendered super-dispersant. The two condensates were then subjected to emission spectra, this being a relatively simple and easy approach to the problem and one which gives positive results. It should perhaps be refined, but that is a proposal which we have made.

As regards the general conclusions for the day, I can really only mention my own, namely that it is difficult to sum up simply and incisively the diverse subjects discussed today, which, incidentally, have gone well beyond the objective of this Symposium, because that objective is : motor-vehicle design.

Air quality standards are one thing, motor-vehicle design is another. There is obviously a link between the two. This link mus be established, but I believe that in that context the public health people and the people responsible for defining air quality are lagging behind the motor-vehicle designers.

Nevertheless, it is not necessary to wait until all the data on air quality have been ascertained before trying to improve it, and I believe that the diagrams I showed this morning demonstrate that it is possible to do so in a logical manner without unduly hampering motor-vehicle design.

Conclusions of the Chairman

Mr VERDIANI

A point to be taken into consideration for the forthcoming stages, which appear to me to be a common feature of all the statements we have heard this morning : it is necessary to plan the constraints to be introduced in the standards for the years ahead and some have urged the need for such planning to be done far in advance to enable industry to meet the demands in full. This could also encourage industry to adopt a less defensive attitude to short-term constraints that oblige it to modify rapidly and at high cost models which must remain on the market for some years to come.

The possibility of introducing environmental constraints at the vehicle design and planning stage could well break down the opposition sometimes encountered which has been referred to by Mr Stork. Mathematical laws of the type referred to by Mr Siebenaler in his paper can be established and used as a basis for the reduction of the main gaseous pollutants. The logical approach is to establish for the various pollutants the relationship between their actual concentration in the atmosphere and the levels of health hazards, taking into account the growth rate in the number of vehicles and traffic density. Once these various factors are known it will be possible to establish and use " the shared-responsibilities chart" referred to by Mr Sibenaler.

I believe that that should encourage you, although it is difficult to assess its manageability at the present stage. I would add to the principle of shared responsibility the idea put forward by several that the vehicle should be considered not in isolation but against the background of pollution in general. At this stage in the discussion, in view of the lateness of the hour, I merely wish to make a few comments promted by what has been said here today. The vital point is to assess the contribution of the various sources to pollution so as to establish the best possible strategy for reducing its effects on man which is always our ultimate aim. This means that the regulations to be established in the future, whether they be amendments of old ones or the introduction of new factors (such as the nitrogen oxides referred to by some speakers) must be defined as strictly as possible on valid scientific bases.

Studies and research are therefore necessary to establish the state of existing pollution and to define the share attributable to the motor vehicle in that pollution so as to provide the decision-making authorities with all the data they need for assessment. I believe that this point is particularly important because only if they are familiar with all existing data and know how they have been obtained can the authorities take decisions. However, this may well be a lengthy process which means that when urgent public health requirements emerge, steps will have to be taken rapidly and they must be dictated by good sense and the definition of a cost-effectiveness ratio. Then there is another aspect which I should mention, the question of alternative solutions.

I should like to go back to something said by Mr Stork, who admitted that, after setting very ambitious aims, further thought on additional assessment data might at some time make it necessary to correct one's aim to be sure of hitting the central target. Seen from this angle, I consider that some of the studies proposed here, in particular on the effects of polycyclic hydrocarbons and their relationship with the aromatic hydrocarbons in petrol, are of very great interest.

Before closing the meeting, I should like once again to thank on behalf of the Commission and all participants our Rapporteur, Professor Sibenaler, for the extremely interesting study he has presented to us, and also all the journalists for their interesting contributions.

We shall speak of these conclusions again tomorrow. I thank you all and I close the meeting.

CONCLUSIONS OF SESSION 5

by

Professor Sibenaler

The Rapporteur for Session 5 has taken account of the arguments put forward during the discussion, weighed the pros and cons of what were sometimes diverging opinions and thinks it would be useful to draw the following conclusions :

1. The provisions of Directive No. 70/220/CEE as restrict CO and HC emissions from motor vehicles; they were tightened up by an amendment in 1974 and we should now include standards restrictions for NO_x so as to fix the overall mass emission at the present time.

2. It is vital to draw up a multi-stage programme for the introduction of standards restrictions in respect of the polluants already mentioned and perhaps for others with priority for individual emissions.

3. This standards restrictions programme may be drawn up on a mathematical basis and share responsibility for the fight against pollution between the manufacturer, the administration, the health authorities and the user consumer. The time allowed to the manufacturer should be proportionate to the increase in requirements and the implementation periods long enough for them to make the most of any investments made.

4. One of the bases of this mathematical analysis is the results of the vehicle type approval tests and it is therefore desirable to the Commission to set up a centre to gather, sort and use these data in respect of the current vehicle population and to the vehicle population subjected standards for 1974.

5. Moreover, since motor vehicles are a major item of Community trade, and increasingly the subject of harmonized standards, restrictions should be determined by joint agreement with the Member Countries.

6. In addition, the Community should encourage, and even finance :

   - development studies on lead traps;
   - research into how far the motor vehicle is responsible for PNA emission, linked to the aromatic contents of petrol;
   - an examination of the possibilities and limitations of type 1 tests as regards measuring the individual emission of PNA and other pollutants found in small quantities in exhaust gases.

   Furthermore, studies in progress - particularly the one on determining how far vehicles are responsible for emitting Pb components on the basis of isotopic properties of that element - should be continued and even extended.

7. A number of speakers thought it was extremely important to ensure that Directives were properly implemented and the effects on the quality of air and on vehicle design techniques evaluated. Such data could be extremely useful for the definition of new standards restrictions.

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