URBAN TRAFFIC NOISE

Strategy for an improved environment

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT - PARIS 1971

URBAN TRAFFIC NOISE

strategy for an improved environment

Report of the
CONSULTATIVE GROUP
ON TRANSPORTATION RESEARCH

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The Organisation for Economic Co-operation and Development (OECD) was set up under a Convention signed in Paris on 14th December, 1960, which provides that the OECD shall promote policies designed:

- *to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;*
- *to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development;*
- *to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.*

The Members of OECD are Australia, Austria, Belgium, Canada, Denmark, Finland, France, the Federal Republic of Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States.

FOREWORD

On several recent occasions the OECD Council has addressed itself to the complexity of the problems which modern society faces as a result of rapid economic growth, expanding population and accelerating urbanization, and spoke of the urgent need to develop effective solutions to these problems. Responding to the Council's concern, the Organisation for Economic Co-operation and Development has been conducting a co-operative programme designed to provide Member governments of OECD countries with blueprints for action to cope with selected problems of the environment, including those which affect the welfare of the urban community and the quality of urban life.

Noise represents one such problem. Unwanted sounds, created by the proliferation of machinery, have become a major intrusion on urban life and a source of annoyance and discomfort to a large number of city dwellers. Noise from traffic in particular, invading as it does the quiet of an ever-growing number of communities and neighbourhoods, has led to increasing dissatisfaction and complaints among urban and suburban residents. Mindful of the undesirable implications of this trend, the OECD Consultative Group on Transportation Research has undertaken a study to assess the scope and magnitude of the urban traffic noise problem, to review the state-of-the-art of the technology of noise abatement, and to recommend practical and realistic measures for the control and reduction of traffic noise levels. The report which follows presents the results of this inquiry.

The report was conceived when a group of experts from Member countries met in OECD to review and assess the adequacy of the existing methods of traffic noise control. Out of that meeting came many of the basic conclusions of the present report.

Subsequent work was carried out under the guidance of a small team of experts consisting of the following persons:

M. Dumesnil, Délégation Générale à la Recherche Scientifique (France),

Dr. Peter Franken, Bolt Beranek and Newman Inc. (US),

Mr. Rolf H. Jensen, Institute for Urban and Regional Planning (Norway),

Dr. E.A.G. Shaw, National Research Council (Canada),

M. Robert Thiébaut, Préfecture de Police, Paris (France).

The resulting draft report was submitted to the Consultative Group on Transportation Research for comment and revision. After approval by this Group it was endorsed by the Committee for Research Co-operation[1] and submitted to the OECD Council which approved the publication of this report on 27th January 1971.

1. This Committee has since been replaced by The Environment Committee.

CONSULTATIVE GROUP ON TRANSPORTATION RESEARCH

Chairman: B.T. Price
United Kingdom

G. Lelièvre	*Belgium*
C. Beaumont Lewis	*Canada*
M. Frybourg	*France*
B. Arnold, E. Nakkel	*Germany*
N. Whelan	*Ireland*
C. Tosti	*Italy*
M. Tashiro	*Japan*
W. Horn	*Netherlands*
V. Johannessen	*Norway*
L.G. Lobato	*Portugal*
T. Eriksson, S. Samuelson K.O. Wennerhorn	*Sweden*
P.R. Jordanis	*Switzerland*
H. Gownley, H.W. Merritt	*United States*
E. Corbin	*ECMT*

CONTENTS

Part One

THE ROLE OF GOVERNMENT

Part Two

TECHNICAL BACKGROUND

Note: Figures given in brackets [1], [2] etc., throughout the text refer to the bibliographic references on page 63.

Part One

THE ROLE OF GOVERNMENT

INTRODUCTION

Noise is a classic example of an "externality" – the side effect of a private action, imposing an unwanted cost upon third parties who are not partners to the action and who receive no benefit from it. Because market forces alone do not provide the producers of externalities with sufficient incentive to avoid their undesirable effects, control over such activities becomes a matter of public policy.

The present report attempts to provide an analysis which can serve in the national formulation of such policy in relation to one type of noise-generating activity – the operation of motor vehicles.

The uncontrolled growth of activity in modern cities is degrading the quality of the urban environment – not only through polluted air and water, traffic congestion and disappearence of open space, but also through a mounting volume of noise. Noise intrudes upon the privacy of an increasing number of people and is reaching levels which interfere with their activities. It may soon rank among the major sources of dissatisfaction with urban living.

Motor vehicle traffic is the predominant source of urban noise and constitutes its most pervasive element. Although there has been no dramatic increase in traffic noise in terms of sound levels, its influence has grown steadily. Each year noise from traffic invades a larger number of previously quiet neighbourhoods and each year it is heard for a greater proportion of the day and night. In terms of man-hours of exposure the noise environment has been deteriorating quite steadily.

Although many imaginative techniques can be brought to bear on the problem of traffic noise, relatively little effective action has been taken to date. Transportation is essential to modern life; furthermore, traffic noise has been increasing at a gradual rate; this is perhaps why society has largely ignored it. But noise – at least at its present level – is not an inevitable or unavoidable by-product of urban mobility. Traffic noise levels can be reduced without impairing the desirable features of the transportation system.

Of course, noise levels can be reduced only at a price. What is often forgotten however, is that a price is being paid each day for the

noise which has been allowed to mount as a result of past inaction. The nature of this price escapes conventional analysis, for the stress that traffic noise brings to the individual cannot be convincingly expressed in monetary terms. Noise levels generated by traffic are not sufficiently high to pose a direct and immediate threat to the health of the general population. However, continued exposure to noise may affect sleep and lower the working efficiency of urban residents; it may affect people in terms of their peace of mind, well-being and aesthetic enjoyment of life. The invasion of privacy by noise may deprive people of some of the intangible qualities that enhance the human environment and make life worth living. There is no economic value that can be attached to these qualities. But this does not make the need for reducing noise levels any less real.

What targets for traffic noise abatement are we to adopt in the light of the many competing interests and values? Undoubtedly, we cannot afford to provide a noise environment that will meet the sensibilities of everyone. But we can and must at least ensure that the present trend is arrested. In the longer run we should strive, within the limits of our resources, to reduce the present levels of traffic noise until we can provide a range of improved noise environments that will satisfy the reasonable expectations of those who live and work in cities. We therefore take the following as suitable goals of public policy for traffic noise control:

i) **to prevent further increases in traffic noise;**

ii) **to work towards a reduction of traffic noise from its present level as much and as rapidly as technology will allow, seeking a realistic balance between the aspirations of the public and its willingness to pay, and ultimately striving for improved noise environments that will meet the reasonable needs and expectations of the community and the individual.**

We shall examine in broad outline what might be done to achieve these goals. The recommendations are grouped under the following headings:

Vehicle Noise;

Traffic Noise and the Urban Environment;

Economics of Noise Abatement;

Research, Development and Training;

International Co-operation.

I. VEHICLE NOISE

Efforts to abate traffic noise fall into two main categories: reduction of noise at the source and reduction of the area in which noise can be regarded as intrusive. The latter, though certainly important in urban design, is of local significance only; the former brings benefits

to the whole urban community. It is therefore self-evident that measures to make motor vehicles quieter should be accorded high priority.

As is often true where social considerations are involved, market forces alone do not provide a sufficient incentive to avoid the production of noise. The consumer has no economic reason for wishing to own a quieter automobile since he does not have to pay for the discomfort he causes to others. The motor car industry, in turn, faced with the consumers lack of interest, has very little incentive to introduce improvements in this field: public-spirited firms making the necessary effort to reduce noise would find themselves at a competitive disadvantage compared with those not doing so. In such situations it is clear that externally imposed constraints in the form of public legislation must be the necessary starting points for any national policy for controlling traffic noise at the source.

Noise Emission Standards

A number of countries already have, or intend to enact standards concerning permissible noise emissions. (See Annex I to this Report). To be realistic, these standards should reflect a compromise between social considerations, what the public is willing to pay and what industry can manage to produce in the light of available technology. Some reductions in noise emission could be achieved in the fairly short run simply by adding acoustical absorbers and by detailed attention to silencers, air intakes and cooler fans. More significant noise reductions would in many cases require alterations in the design of the engine, and could therefore become effective only after a longer period. The important point is that standards should be set, and set on a sliding scale, so as to continue to reflect the current state of noise reduction technology.

Enforcement of noise emission standards presents no insuperable difficulties. A number of countries, in fact, already have noise type-testing requirements, which in some cases also apply to silencers, the closing of doors and trunk lids, and the permissible loudness of horns.

Annual tests for safety reasons are compulsory in a number of countries. The extension of such tests to deal with noise nuisances such as defective silencers would obviously be beneficial, though it might impose additional administrative requirements, for example as regards instrumentation and the provision of trained operators. Nevertheless, Denmark, for example, has compulsory noise inspection whenever cars over 5 years old are sold, and for this purpose maintains a chain of 50 testing stations.

Roadside spot checks, to be effective, raise questions of instrumentation, of manpower, and also of the means through which the penalty is to be brought home to the offender. Experience in a number of Member countries suggests that the problems are perhaps less daunting than they might at first sight appear, particularly as the police are free to choose the time and place where they make their

checks – they do not necessarily have to try to identify noisy vehicles in a busy traffic stream, where the instrumentation problems are also the most severe. In many Swiss cities, including Lausanne and Zürich, there are regular noise patrols which are empowered to confiscate temporarily vehicles that are clearly defective, or that have been modified with the obvious intent of increasing the noise of the exhaust. These examples show that, in the end, the main problem is not one of technical difficulty but of public policy, particularly as regards making the necessary manpower available.

Recommendation 1

Governments should enact standards for maximum permissible noise emissions and should adopt effective procedures to enforce such standards. Standards for new vehicles should be expressed in terms of maximum permissible noise levels as measured by test procedures recommended by the International Standards Organisation. Standards and enforcement procedures for vehicles in use may additionally specify requirements for the efficient maintenance and operation of parts of the vehicle such as the exhaust silencer and the horn.

Standards should be initially set and enforced at levels consistent with the technology available at the time, but should be made progressively more stringent to reflect advances in noise reduction technology. The most rapid rate of reduction in permissible noise emission levels should be applied to the classes of vehicles which are at present the noisiest.

Enforcement of standards should be carried out through type-testing of new vehicles and of replacement silencers, coupled with periodic inspections (which may be concurrent with safety inspections or as a requirement for resale) and roadside monitoring and spot checks. Reliable standardized instruments as simple and inexpensive as each type of test permits, should be used.

Government Procurement Policies

Control over the considerable number of vehicles procured directly or indirectly through the use of public funds could also be usefully employed as a stimulus for progress. The city of Stockholm, for instance, requires its buses to pass a noise emission test; vehicles which exceed a certain limit are rejected. Experience with automobile safety features in the United States has also shown that the purchasing power and practices of the government can indeed have an important effect. Although the United States federal government purchases directly only 80,000 of the 10 million vehicles manufactured in that country annually, the requirement to incorporate safety features in government-purchased vehicles stimulated manufacturers' and public interest and was followed shortly by safety requirements covering all vehicles. The imposition of noise performance specifications on publicly owned ve-

hicles could play a similar role in stimulating the development of quieter automobiles. Governments might also use research and development contracts as a means of promoting noise consciousness among industrial developers.

Recommendation 2

Governments should consider incorporating stringent noise emission standards within specifications for all government vehicle procurements, vehicle-related research and development efforts, and transportation subsidies. Such noise emission standards should be set in consonance with the standards advocated in Recommendation 1. Progressively more stringent standards, however, can provide the stimulus for the development of quieter motor vehicles and alternative transportation modes which offer the long-term solution to traffic noise.

II. TRAFFIC NOISE AND THE URBAN ENVIRONMENT

The above recommendations have dealt with the problems created by individual vehicles; but noise reduction can also be obtained by minimizing the adverse effects of vehicles collectively, through improved planning and highway engineering, appropriate traffic restraints, and other measures aimed at lessening the impact of automobile noise emissions on the community. This will require an awareness on the part of municipal authorities as well as urban planners and traffic engineers as to what measures can realistically be taken.

Recommendation 3

Governments should encourage:

a) restrictions on noisy traffic, and its rerouting away from residential and "quiet" zones (e.g. the closure of certain streets, as in some Swiss and Danish towns, to motor cycles or heavy lorries at night);

b) development and application of improved methods of traffic flow control to avoid the disturbance that comes from noisy acceleration;

c) noise abatement-oriented zoning and land use planning (as, for example, the deliberate creation of industrial buffer zones);

d) location of major urban roads in such a manner that noise effects on surrounding neighbourhoods are kept to a minimum (e.g. aligning roads to take advantage of existing natural acoustical barriers);

e) more extensive use of tunnels and open cuts;

f) use of noise screens and other artificial noise-attenuating barriers (bearing in mind their visual impact upon the environment);

g) noise-abatement-oriented layout and sound insulation of individual houses or groups of houses adjacent to major traffic arteries and major intersections;

h) development of alternative modes of transportation which produce less noise impact on the urban environment.

A start could be made now to apply most of these steps, without waiting for the results of additional research and technical developments, or for new legislation.

III. ECONOMICS OF NOISE ABATEMENT

While the desirability of noise reductions is unquestioned, the cost penalties of more stringent noise emission standards and other noise control measures must not be ignored. To aid policy makers in their decisions a systematic attempt must be made to provide an economic appraisal of alternative noise abatement measures. This means identifying the various technical, procedural and regulatory means of abating noise, evaluating these options in terms of their cost and effectiveness, and analysing how these costs would fall on the general public, the community, industry and automobile owners affected.

Such analysis would not only assist in setting realistic goals for traffic noise control, but should indicate which strategy offers the best social return on investment. While precise cost-benefit evaluation might cause considerable difficulty because of our present inability to express the effects of noise exposure in monetary terms, useful policy guidance could be obtained from comparing the relative costs of alternative noise reduction measures and the levels of effectiveness which these alternatives provide.

Recommendation 4

In order to provide a sounder basis for policy decisions, governments should support detailed studies of the cost of noise abatement. In particular, studies should be undertaken in co-operation with the automotive industry, of the economic impacts of alternative noise emission standards. Such studies should attempt to:

a) define present technological capability to meet initial standards;

b) identify technological improvements in engine and vehicle design required to meet a range of more stringent standards, and develop realistic estimates of the research, development and production costs of such improvements;

c) explore how the costs associated with the development of vehicles with reduced noise emission characteristics might be equitably allocated between the taxpayers and the driving public.

IV. RESEARCH, DEVELOPMENT AND TRAINING

The application of the best current technology, effective environmental planning, and the enforcement of existing legislation should be capable of preventing the further deterioration of traffic noise conditions; but increased research and development effort will be necessary to achieve a significant lowering of the current levels of traffic noise.

Automobile Design and Engineering

A great deal can be done, through a programme of research, to improve our understanding of the sources of motor vehicle noise, so that the present technical limitations on making vehicles quieter can gradually be removed. This, and the associated development of new technology, are activities which, it might be argued, should lie within the field of private industry. However, until there are internationally agreed and stringent noise emission regulations, with a programmed lowering of noise emission limits, there will most likely be insufficient economic incentives for manufacturers to spend more than the necessary minimum on reducing the noise output of their vehicles. There is, therefore, a case for governmental stimulation through the support of research and development and of the testing, demonstration and evaluation of new approaches to noise reduction.

Recommendation 5

Governments should support research and development and provide adequate incentives for the testing and demonstration of new approaches to reducing the noise output of motor vehicle systems. Research should be encouraged particularly on the following sub-systems:

a) **intake and exhaust,**

b) **engine and transmission, and**

c) **interaction between tyres and road surface.**

More effort might usefully be devoted to the development of weather-resistant, sound-absorbing external building finishes, efficient sound barriers with reduced sound reflection characteristics, and relatively silent, though skid-proof, road surfaces.

Effects of Noise on Man

There is also need to develop a sounder scientific foundation on which noise emission standards can be set. For example, although criteria for desirable limits of noise exposure already exist and can be used as a basis for policy decisions, there is some doubt as to their reliability and completeness (e.g. concerning the combination of noise from different sources), and they need to be further refined. Also, we know relatively little about the possible effects on health of noise

exposure during sleep (especially over long periods) and about cumulative effects of long-term exposure to moderate levels of noise; a better understanding of both effects is necessary if noise exposure standards are to fulfil their essential purpose of protecting the health of the public. Apart from investigating the direct and indirect physiological effects of noise, it is also desirable to improve the understanding of the subjective response of individuals and the community to traffic noise. The eventual aim should be to provide rough measures of social cost which could be built into the planning process in much the same way as the cost of time can now be introduced as a factor in transportation decisions.

Recommendation 6

In order to provide a scientific basis for determining traffic noise levels beyond which health may be adversely affected, increased support should be given to research on the effects of noise exposure during sleep, and on the cumulative effects of long-term exposure to moderate levels of noise. In order to provide a sounder basis for evaluating the social costs of noise, increased support should be given to research on the subjective response of individuals, groups and the community to traffic noise.

Instrumentation and Training

Finally, effective enforcement of traffic noise regulations requires the availability of simple reliable noise-monitoring instrumentation and of trained manpower. The importance of these practical considerations should not be underestimated. Experience attests to the ineffectiveness of the legal enforcement of noise legislation without adequate equipment and manpower. Although the degree of inadequacy may not be the same for all governments, each should carefully assess its requirements and decide how its enforcement needs are to be met.

Recommendation 7

Governments should support research and development of appropriate instruments for monitoring noise emissions in actual traffic conditions, and provide training programmes on the use of these instruments. Professional training related to noise abatement should be stimulated through the funding of academic research and educational development.

V. INTERNATIONAL CO-OPERATION

Since ever larger numbers of motor vehicles move across frontiers and constitute an important element in the international stream of commerce, it is desirable that standards and acceptance criteria governing

vehicle noise emissions should be internationally compatible and that there should be close consultation in their formulation. Faced with a variety of different national noise emission standards, the automobile industry would be obliged to produce different models for different markets, which would tend to raise costs. Hence international agreement on initial common noise emission standards and acceptance criteria, and on a programmed reduction in noise emission limits, would be a highly desirable aim. Care should be taken, however, that such standards should not have the effect of merely underwriting existing manufacturing practices but that they should provide the motor vehicle industry with a real stimulus and incentive to take a step forward.

The activity so far undertaken internationally, for example by the Working Party on Vehicle Construction of the Economic Commission for Europe (ECE) and by the European Economic Community, is encouraging though clearly only a first step. Further consultations at the political level may be required to determine what further progressive reductions in vehicle noise emissions are realistically achievable.

Practical policy and long-range strategy might be facilitated at international level through a concerted programme of exchange of information on national programmes of research, development and demonstration, and through a comparison of experience relating to practical noise abatement measures and their cost.

Recommendation 8

An international conference should be convened at an appropriate date in the near future:

a) to exchange views and share experience concerning progress made in traffic noise control and abatement, and to examine the difficulties and obstacles which may have been encountered when implementing specific measures;

b) to discuss the possibility of taking further action at international level particularly with a view to facilitating the adoption of initial common motor-vehicle noise-emission standards, coupled with a programmed reduction of noise emission limits.

Decision relative to the date of the proposed conference should bear in mind national commitments made in regard to the 1972 United Nations Conference on the Environment in Stockholm.

CONCLUSIONS

We believe that the above recommendations represent a realistic strategy for the control and progressive abatement of traffic noise in cities. The implementation of several of these recommendations could

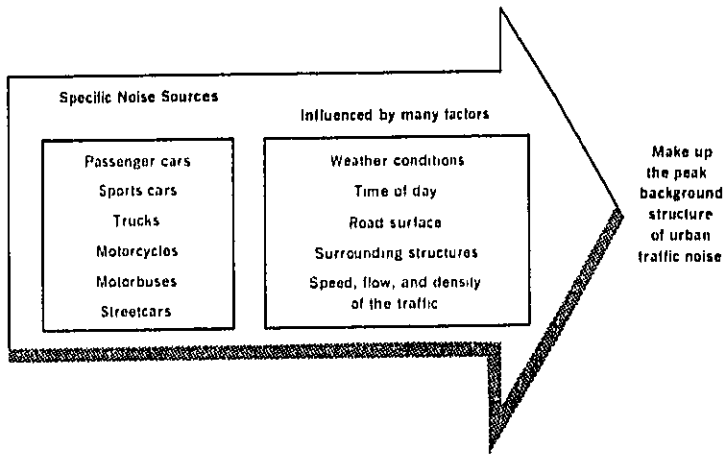
begin at once. The governments of Member countries may wish to take the next step and consider whether they should begin to translate these recommendations into effective action.

Many of the recommendations require action at national level. The central government can provide standardization of criteria and approaches to noise control which will prevent a welter of conflicting local noise-emission regulations. In addition, only the central government can provide the needed resources, the comprehensive national overview and the ability to negotiate with other governments – all of which are essential to the development of an effective traffic noise abatement programme. All levels of government can and should make contributions to the abatement of traffic noise, but a splintering of the responsibility for noise abatement among several government agencies can cause unnecessary duplication of effort. Assigning responsibility for environmental noise control to a single agency might be the most effective means of achieving a positive record of accomplishment.

Part Two

TECHNICAL BACKGROUND

THE COMPOSITION OF URBAN TRAFFIC NOISE



1

THE URBAN TRAFFIC NOISE ENVIRONMENT

A wide range of wanted and unwanted, pleasing and startling sounds make up the general urban noise environment. Electrical and mechanical domestic appliances or intruding outside noises produce noise levels of typically 40 to 50 dB(A)[1] inside urban buildings. Once the individual steps outside this "quiet" home, he is subjected to even higher levels of noise from traffic, construction, airplanes, and other people.

The changing character of these noises makes it difficult to select a single number to characterize the noise environment. Patterns of rise and fall of sound appear according to the time of day or the day of the week, and during any period of measurement there will be a background noise level punctuated by transient noises (noise peaks).

1.1. THE PREDOMINANCE OF URBAN TRAFFIC NOISE

Most urban noise is a result of our highly mobile civilization – one which uses conveyances that dissipate large amounts of energy. A fraction of this energy is dissipated as unwanted sound, or noise. As

1. Decibel: The sound pressure registering on the human ear can vary widely ranging from 0.0002 dynes per cm2 to 1.000 dynes per cm2. The ratio between these two figures is one to five million and can best be expressed logarithmically using decibels. If p is the acoustic pressure of a given sound and p_0 the reference sound pressure level, the decibel difference can be expressed as: $20 \log_{10} \frac{p}{p_0}$

Thus, it must be remembered that decibels are a logarithmic and not an arithmetic scale. Most traffic noise studies choose the dB(A) (the sound level in decibels as measured on the "A" scale of a standard sound level meter) for the physical measure of sound, since the dB(A) is regarded as "statistically indistinguishable from the best psychologically-derived measures in its reliability as a prediction of human responses to traffic noise" [1]. See also the discussion in Chapter 2.

the energy requirements of society increase, the noise levels also tend to increase. And, as the noise levels in the cities intensify, the spreading population and the proliferation of machines extend traffic noise into previously quiet areas.

Surveys of noise in urban areas (even those with large airports – e.g. London, Chicago, New York) indicate that, despite the noise produced by aircraft, *surface traffic* (automobiles, buses, trucks, motorcycles) is the predominant and most widespread source of noise [2].

In 1951 Bonvallet reported the results of a three-year noise survey in Chicago [3]. He concluded that "The most prevalent city noise unquestionably is that of traffic. The most prevalent source of noise in industrial areas is also that of traffic. In many cases, the noise in an industrial area is that due to related traffic, such as the motor trucking identified with a particular plant. In residential areas, the so-called unidentifiable background can usually be identified as noise of distant traffic".

The 1961-1962 noise survey of Central London (results recorded in the Wilson Report [4]) found that traffic noise is an important source of annoyance to people, whether they are outdoors, at work, or in their own home (Table 1). For exposure levels higher than 55 dB(A) mean energy value per 24 hours, the number of individuals considerably disturbed often exceeds 20%.

Table 1. NOISES THAT DISTURB PEOPLE AT HOME, OUTDOORS AND AT WORK

Description of noise	Number of people disturbed per 100 questioned		
	When at home	When outdoors	When at work
Road traffic	36	20	7
Aircraft	9	4	1
Trains	5	1	–
Industry/construction work	7	3	10
Domestic/light appliances	4	–	4
Neighbours' impact noise (knocking, walking, etc.)	6	–	–
Children	9	3	–
Adult voices	10	2	2
Radio/TV	7	1	1
Bells/alarms	3	1	1
Pets	3	–	–
Other noise	–	–	–

Source: adapted from Table V of reference [4].

Thirty-six per cent of those questioned in the survey were disturbed by traffic noise, whereas each of the other noise sources (airplanes,

human voices, radio and television, etc.), were mentioned by less than 10%. The investigators compared the 1961 findings with those of a London survey conducted in 1948 by the United Kingdom Central Information Office. In 1948, 23% of those questioned were disturbed by outside noises; in 1961, the percentage had risen to 50%. The number of people annoyed by external urban noises more than doubled in 13 years.

Table 2 shows the results of a 1968 investigation by the Norwegian Gallup Institute. Motor vehicles were reported to be the most annoying noise source, and the percentage of people annoyed was much larger for urban than for rural populations [5].

Table 2. NOISES THAT ANNOY PEOPLE. RESULTS OF AN INVESTIGATION BY THE NORWEGIAN GALLUP INSTITUTE, 1,600 PEOPLE QUESTIONED

Type of noise	Number of people annoyed per 100 questioned		
	All questionned	Area	
		Urban	Rural
A. Noise from motorvehicles	17	20	11
B. Noise from aircraft	3	4	1
C. Noise from railroads	4	5	1
D. Noise from neighbours	5	6	3

Source : adapted from reference [5].

During a recent survey of community noise made by Donley [6], an effort was made to obtain information that could be reliably compared with results of a study made approximately 12 years earlier. Figure 1 shows the comparison of data – a graphic statement that the noise in the community is increasing appreciably (the data in Figure 1 and some subsequent figures are given as a function of frequency in octave bands. Each such band covers a factor of two in frequency, for example a band from 125 to 250 Hz, or cycles per second).

Noise levels increase as expressways and freeways, carrying more traffic at higher speeds, invade or cut through urban areas. The 1961-1962 Central London survey recorded peaks of 90 dB(A) at the curbside of arterial roads with many heavy vehicles. For 80% of the time (excluding the lowest and highest levels), the noise level ranged from 68 to 80 dB(A) by day and 50 to 70 dB(A) by night [4].

During a Paris noise study by the Centre d'Etudes et de Recherches d'Anthropologie Appliquée cited in ref. [7], continuous 24 hour recordings made *inside* a building on a major thoroughfare described a day-time noise level of between 50 and 60 dB(A) and night-time levels between 40 and 50 dB(A) with frequent peaks of 60 dB(A). During the day the minimum background noise never fell below 45 dB(A) and fell below 30 dB(A) only between 1.00a.m. and 3.00 a.m.

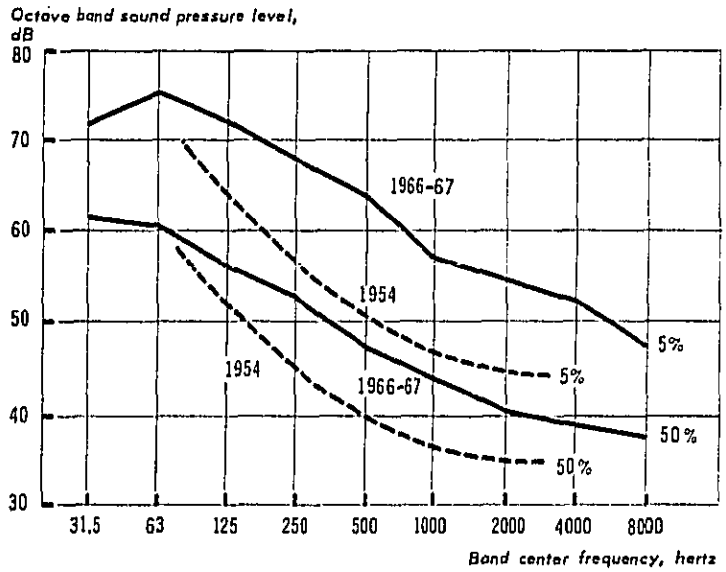


Figure 1. A comparison between the results of the earliest survey of community noise by Stevens and the data from the combined surveys of 1966 and 1967. The curves show the percentage of time that the noise level is exceeded. Donley notes that the numerical comparisons are not fully appropriate, owing to differences in the data collection and changes in notation. However, these differences do not hide the fact that the noise in the community is increasing appreciably.

Source : adapted from Fig. 6 in Ref. [6].

For some idea of how these measured levels compare with desired levels, the Wilson Committee made the following suggestions for maximum noise levels inside living rooms and bedrooms, stating that these values should not be exceeded for more than 10% of the time [4]:

	Day	*Night*
Country areas	40 dB(A)	30 dB(A)
Suburban areas	45 dB(A)	35 dB(A)
Busy urban areas ..	50 dB(A)	35 dB(A)

During the same year, a joint committee from the central building authorities of the four Scandinavian countries recommended 35 dB(A) as an acceptable average noise level in dwellings (measured when windows are closed) [8], [9].

1.2. THE PEAK/BACKGROUND STRUCTURE

Traffic noise is not continuous. As a vehicle approaches an observing point, the noise level rises, reaches a maximum level (a peak) and then decreases as the vehicle moves away. A steady flow of traffic (e.g. average or heavy traffic conditions) on a highway or major road seems to create a nearly constant roar – except that the noise from particular vehicles (such as trucks and motorcycles) reaches higher peak values and, consequently, stands out against the more or less steady "background" noise.

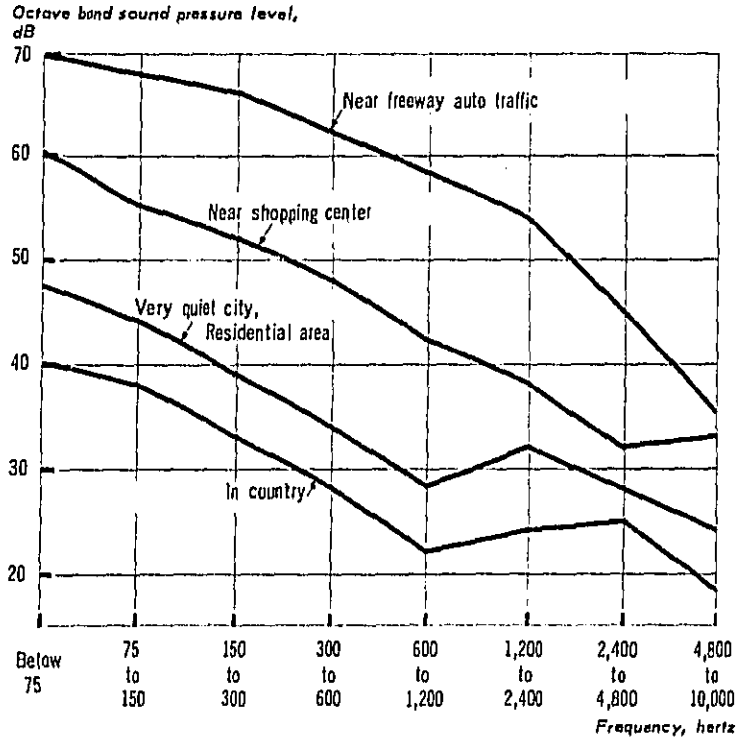


Figure 2. Typical values of background noise in four areas of Austin, Texas (USA).
Source : adapted from Fig. 53 in Ref. [2].

Studies of background noise in quiet residential areas generally measure the noise of distant traffic. One study, in particular, compared

the background noise levels in four areas near Austin, Texas (United States) [2]. In Figure 2, the lowest curve, measured in a remote country location far from traffic, industry, or aircraft, was set by natural sounds from insects, animals, and the wind. The net higher curve plots the background noise in a quiet residential area on a calm summer morning with no traffic or appreciable wind. Near the suburban shopping centre, light traffic and the movement of people in and out of the stores raised the level considerably. A busy freeway with fast-moving automobile traffic created noise levels outside the nearest houses some 30 dB greater than in traffic-free open country. Occasional passing trucks, of course, raised the level still further.

A useful method of displaying the time-varying nature of traffic noise is a statistical distribution. Figure 3 shows such distributions measured by Lamure and Auzou for very light and heavy urban traffic on a motorway [10]. A straight line on the graph represents a Gaussian distribution. In this case, the heavy traffic situation is described well by such a distribution, while the distribution of the very light traffic situation is skewed by the occasional noise peaks.

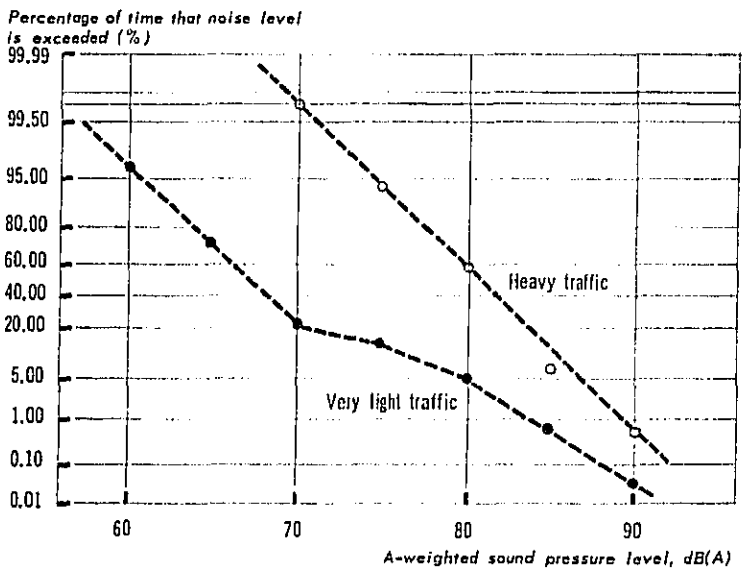


Figure 3. Typical statistical distributions of urban traffic noise.

Source : adapted from Fig. 14 in Ref. [10].

1.3. SPECIFIC NOISE SOURCES

Measurements of urban traffic noise represent a composite of all the noise emitted by many types of vehicles travelling at the same moment. Within the constant noise, both the particular type of vehicle and the traffic contribute to the aggregate noise level.

Bolt Beranek and Newman Inc., in a study for the California Highway Patrol [11], compared the noise levels of passenger cars, sports cars, motorcycles, and trucks for cruising speed and low-speed acceleration tests. All vehicles were equipped with conventional exhaust mufflers. Figure 4 shows some of the results obtained from the cruising

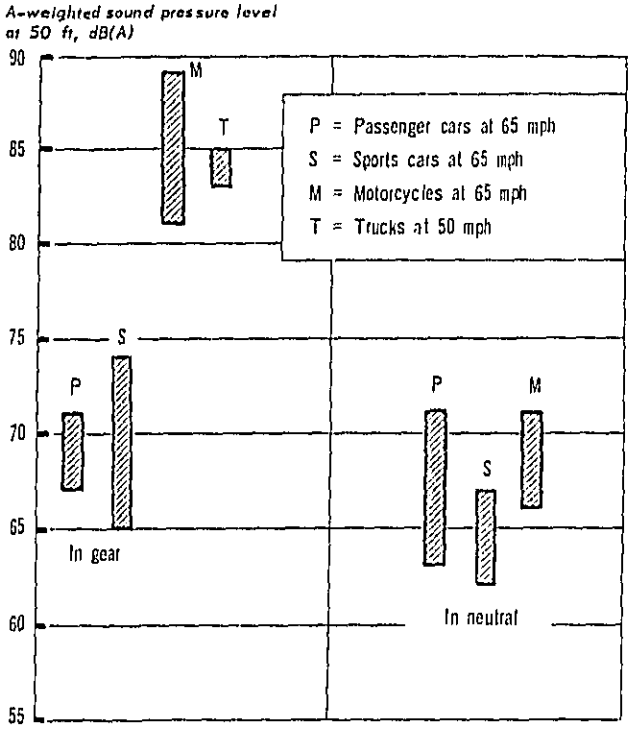


Figure 4. Noise levels of different vehicles at cruising speed.

Source : adapted from Fig. 7 and 16 in Ref. [11].

speed tests. At 65 mph the noise levels produced by passenger cars were in essentially the same range as those produced by sports cars. However, motorcycle noise at 65 mph in gear was much higher than the noise of passenger cars or sports cars. The noise levels measured during a 65 mph run in neutral were about the same for all three classes of vehicles. Noise levels of trucks at 50 mph in gear were 10 to 15 dB(A) higher than those of passenger cars or sports cars.

The National Research Council of Canada [12] recorded the statistical distribution of the noise from passenger cars travelling at speeds between 30 and 69 mph. Measurements were made at a distance of 50 feet. Figure 5 shows the distribution of the noise levels observed, grouped into 10 mph categories. Most of the loud vehicles had obviously defective exhaust-silencing systems.

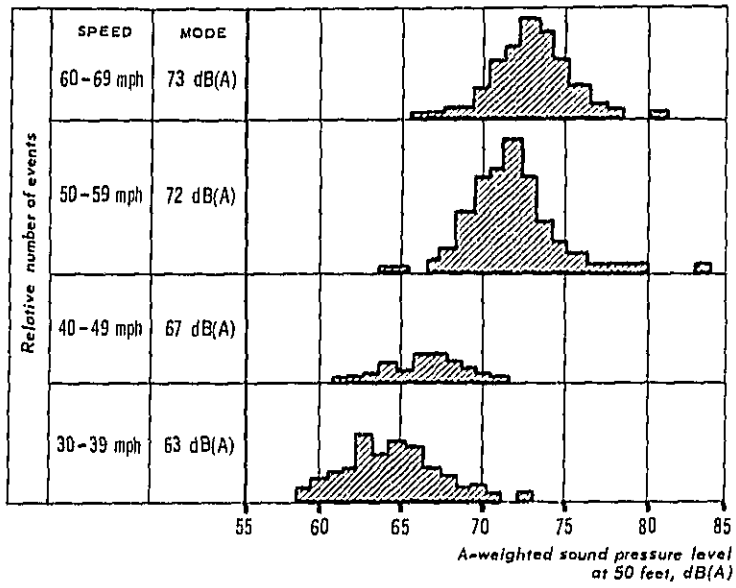


Figure 5. The statistical distribution of noise made at 50 feet by passenger cars travelling between 30 and 69 mph.

Source : adapted from Fig. 4 in Ref. [12].

As discussed in Chapter 2, the noise peaks are the most immediately disturbing effects of traffic noise. Three types of vehicles commonly produce these peaks: sports cars, motorcycles, and trucks.

Sports cars produce more of a low-frequency "roar" than any other vehicle; but probably even that roar would be less annoying if it were not often produced by frequent rapid accelerations, with accompanying noises of squealing tyres and grinding gears.

Motorcycles are a frequent cause of complaint in urban areas. Motorcycles are also more mobile than the other forms of transportation – they can quickly and easily invade almost any area. The noise produced by different models of motorcycles seems to bear little relationship to the size of power of the vehicle but rather to differences in intake and exhaust silencing practices. At a constant speed of 65 mph, as well as during acceleration, motorcycles are typically about 15 dB(A) noisier than passenger cars.

Because of important differences in the design of their engines and auxiliary equipment and because of the considerable differences in size, trucks form a heterogeneous population of noise sources. The addition of trucks to urban traffic skews the time distribution of noise levels upward as the percentage of trucks increases – primarily because of the high peak levels produced by individual trucks [1], [8].

Based on Canadian data [13], the tractor trailers are the noisiest trucks. The upper 10%, the mode, and the lower 10% statistical groups of trailer trucks show levels of 89, 86, and 81 dB(A), respectively, at a distance of 15 metres.

Trucks constitute a major noise source for several reasons. Because of their size and load, trucks often have larger engines than passenger cars; more important, truck engines are generally operated to produce much greater specific power than are passenger car engines. Furthermore, the design trends of recent years towards larger cylinder bores and higher operating rpm tend to produce higher noise levels.

Thiessen and Olson [13] state that from 1% to 2% of all trucks make more noise when empty than when loaded. This noise is due mainly to loose panels, boxes, rattling chains, etc., all of which cause a great deal of clatter and are often the result of carelessness. Noise laws in several countries include a rule on the loading of commercial vehicles [7].

There are comparatively few published data on the noise due to buses. A recent study by Olson [14] indicates that these vehicles produce significantly less noise than trucks of comparable size. This difference is believed to be due to the use of superior intake and exhaust silencers and acoustic treatment of the engine compartment.

Recent studies [46] conducted in Canada show that the growing popularity and number of snowmobiles is giving rise to considerable concern. Snowmobiles are in fact among the noisiest of motor vehicles; the range of sound level is quite large, namely from 79 to 102 dB(A); an "average" snowmobile when cruising may be expected to produce a level of approximately 90 dB(A) at a distance of 15 feet. Noisy snowmobiles when cruising produce sound levels comparable with those of tractor trailers and empty dump trucks at speeds in the 50-59 mph

range. The quietest snowmobiles are comparable in noise output with American passenger cars at 50-59 mph but few are as quiet as passenger cars at 30-39 mph[1].

1.4. NOISE LEVEL FACTORS

Of all the factors that affect the noise level of urban traffic, the two conditions over which man does *not* have control – environmental (weather) conditions and night – can have little effect on the noise level.

1.4.1. *WEATHER CONDITIONS*

While temperature, snow, rain, or ice profoundly affect the safety of a road or highway, such conditions do not consistently affect the noise level of motor vehicles. However, a blanket of snow on the ground effects a drop of about 2 to 3 dB in the middle octave band levels, with a somewhat greater drop at higher and a smaller drop at lower frequencies. It should be noted that in countries with severe winter conditions, studded winter tyres are extensively used. However, when such tyres are used on dry streets there is an increase in the noise generated, especially for the high frequencies. Consequently, in the Province of Ontario (Canada), for example, it is forbidden to retain these tyres between 30th April and 1st October of each year.

The *average* atmospheric attenuation values have only a very small effect on the dB(A) levels up to 600 metres from a noise source, less than 1 decibel at 300 metres and approximately 2 decibels at 600 metres [15], [16]. In a study of sound propagation in urban areas, Wiener [17] showed that wind and temperature profiles only slightly affect the sound transmission along city streets. In particular, sound attenuation up to windows above the street is substantially less than that which can be observed upwind over open, level terrain.

1.4.2. *NIGHT DRIVING*

One might expect that, because of poorer visibility and lighter traffic, there would be a long period of comparative quiet at nighttime. On the contrary, the 1961-1962 Central London survey [4] found that the length of the average "noise night" – the period of reduced noise levels – was surprisingly short, only about five and a half hours (midnight to 5.00 a.m. or 6.00 a.m.). In only about one-quarter of the measuring locations did the noise night start before midnight; in only 11% did the night extend beyond 6.30 a.m. The

1. See Chapter on Canada in Annex I to this report.

predominant noise source at 80% of the locations, *even at night*, was road noise. Bonvallet's Chicago study [3] found that, for night traffic, reductions in the 400-800 Hz band were about 5, 10 and 15 dB for light, average, and heavy traffic respectively.

As night traffic constantly increases, the night-time lull in noise grows shorter and shorter. Such a trend implies that, in time, night noise levels will be as high as those now recorded during the day (cited in ref. [7].)

1.4.3. *NATURAL BARRIERS*

Some sound is absorbed by the natural environment so that, in areas with trees and grass, reductions in noise can be obtained. In general, these reductions are not large. Chapter 3 will discuss the most effective types of noise screens, natural or man-made.

1.4.4. *SPEED, FLOW AND DENSITY OF TRAFFIC*

In a series of measurements made in 1963-1965, the National Physical Laboratory (NPL) (Great Britain) cited in ref.[7] measured the noise during varied traffic conditions, providing data on the effects on noise level of speed, distance, number of vehicles per hour (density), and percentage of heavy vehicles. Particular attention was paid to vehicle speeds. The NPL found that the noise level rises by 9 dB(A) each time the average speed is doubled.

At low speeds and with truck traffic, there are wide variations in noise due to the intermittent peaks produced by trucks. These variations decrease when speed and density increase and truck traffic decreases.

For a density of 100 automobiles per mile, the average noise level at 100 ft. (by computer simulation) for mean speeds of 20 mph is about 56 dB(A); while, at the same density and at 65 mph, the average noise level is about 72 dB(A) [1]. The results of ref. [1] can also be used to describe the noise level distribution as a function of time.

For a constant average speed, doubling the number of vehicles per hour increases the average noise level by 3 dB(A) and doubles the frequency of occurrence of the higher peak levels. Stop-and-go traffic introduces higher peak levels and, often, lower averages. Smooth, but very slow, traffic has a low average level and relatively low peaks. Freely moving traffic at higher speeds creates the highest average levels [18].

The Federal Institute for Roads and Highways (BAST), FRG, Cologne, has conducted studies on expressways in the Federal Republic of Germany, the results of which may be summarized as follows:

1. In a zone near expressways (at a distance of approximately 40-100 metres) the mean noise level increases by approximately 3 dB(A) as the traffic flow doubles and decreases by the same

amount as the distance doubles. Within this range mean noise levels of approximately 65 to 70 dB(A) may be expected on multi-lane roads with heavy traffic.

2. Mean level values or values for the "energy-equivalent permanent noise level" are equally dependent on the absolute traffic flow and on the percentage of trucks.

3. The value for "most frequent noise level peaks" (levels exceeded for 5 % of the time) depends very greatly on the percentage of trucks.

4. The background noise (level registered for 95 % of the time) is predominantly determined by the absolute traffic flow.

2

THE EFFECTS OF TRAFFIC NOISE

Noise affects people and can be considered as detrimental to health; health is defined by the World Health Organisation (WHO) as being "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". One would probably find little difficulty in gaining universal agreement to this statement. There is considerable disagreement, however, concerning the nature, extent, and importance of the effects of noise on people. For this reason, the discussion of the effects of traffic noise will in many cases be brief and suggestive rather than extensive and comprehensive.

The various effects of noise on people can be listed in three general and interrelated groups. The first group includes the subjective effects described by such terms as annoyance, dissatisfaction, bother, and noisiness. It is this group of effects that describes, in some sense, the unwanted character of a noise. The second group of effects includes the behavioural aspects, and involves interference with an ongoing activity, such as speech, sleep, learning, or performing any general task. The effects in the third group are physiological, including those effects that occur during or shortly after the noise exposure, such as startle reactions or temporary threshold shift, as well as those that may occur only after prolonged exposure. As previously mentioned, these various groups are not mutually exclusive. For example, prolonged interference with sleep could lead to a cumulative physiological effect. Similarly, interference with ongoing speech may be a source of annoyance. It has even been suggested that the causal chain is one that leads from interference with ongoing activity to subjective reaction. However, in this discussion, it will be convenient to treat these various groupings separately.

2.1. SUBJECTIVE EFFECTS

"... noise is subjective; a noise problem must involve people and their feelings, and its assessment is a matter rather of human

values and environments than of precise physical measurements. These values and environments are complex indeed. Not only do people vary in their susceptibility and adaptability to noise, but each of us may be annoyed by one noise but not by another of similar physical characteristics." [4]

In a study of urban traffic noise, one is generally most concerned with the subjective effects, that is, a knowledge of what fraction of the population will be annoyed or dissatisfied in certain noise situations. However, as the above quotation from the Wilson Report points out, the highly subjective nature of these effects creates many difficulties in measurement and interpretation.

There can be no completely satisfactory objective measurement of a subjective effect. Mills and Robinson (Wilson Report, Appendix IX) [4] have shown that the subjective impression of vehicle loudness correlates fairly well with the peak vehicle sound level measured in A-weighted sound level. The 'A' weighting emphasizes the frequency components of the sound in the range of 800 to 8,000 Hz and gives little weight to components at vehicle exhaust frequencies, i.e. below 200 Hz. Later research has shown that the A-weighted sound level correlates with vehicle loudness at least as well as more sophisticated measures of loudness or noisiness, and so because of its simplicity the A-weighted sound level is widely used as the basic objective measure of traffic noise.

Given then, as the basic measuring equipment, a sound level meter equipped to measure A-weighted sound levels, the problem is to relate road-side measurements of the fluctuating sound level to the subjective effects the traffic noise is having on the people who hear it. A Bolt Beranek and Newman Inc. study [1] found only a very weak correlation between mean sound level and annoyance expressed spontaneously by residents, in their natural settings near freeways. Sixty-seven per cent of the residents in the quietest area gave a spontaneous objection to the noise; yet only 51% of the residents in the noisiest area objected, even though the noisiest area could be described as about four times noisier than the quietest area (based on laboratory judgments of perceived noisiness).

Obviously, annoyance does not depend simply on average level, and research has been directed to finding a better index of annoyance:

1. The National Swedish Institute for Building Research and the National Swedish Institute of Public Health have found good correlation between a weighted "mean energy value" and a measure of the intensity and frequency of subjective disturbance derived from a survey of the disturbance caused by noise when conducting various activities [8]. Figure 6 shows the relationship between the weighted mean energy value for a 24 hour period and the mean measure of disturbance, obtained as above (the authors do not indicate the degree of data spread about the mean measure of disturbance).

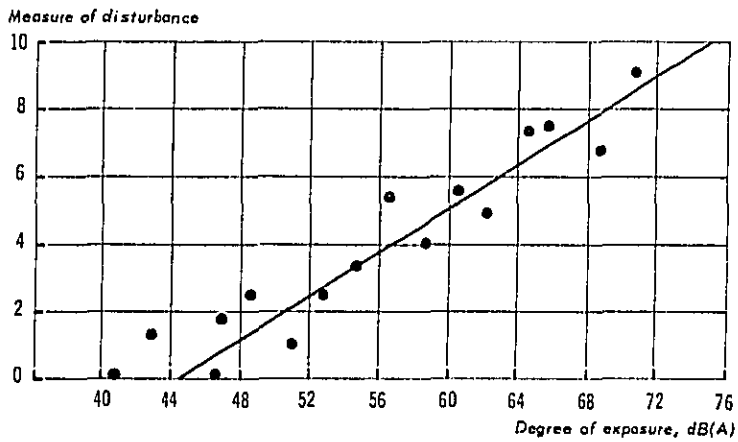


Figure 6. The mean value of the measurement of disturbance as a function of degree of exposure. The mean energy level is corrected for distance and barriers.

Source: adapted from Fig. 1 in Ref. [47].

2. Griffiths and Langdon of the British Building Research Station also investigated the relationship between dissatisfaction arising from traffic noise and the physical characteristics of traffic noise [19]. The dissatisfaction score was based on a seven point attitude scale ranging from 1 – definitely satisfactory – to 7 – definitely unsatisfactory. As shown in Figure 7, they found good correlation between a subjective measure of the dissatisfaction and an objective measure based largely on the amount by which the noise of discreet vehicles intruded over the background traffic noise. This result suggests that, for a range of urban traffic noise conditions, the absolute level of the background noise may be relatively unimportant.

The Swedish and British indices differ in the relative weights given to the mean sound level and the range of sound level. Another index has been suggested recently by Robinson [20]. His approach may be able to reconcile the differences between Swedish and British research but has not yet been tested extensively. Any such test is likely to be a long and complex procedure because of the difficulties in assessing subjective response:

1. *Individual differences in thresholds of annoyance to noise.* For example, while no correlations were found between sound pressure levels and subjective reactions in the Central London

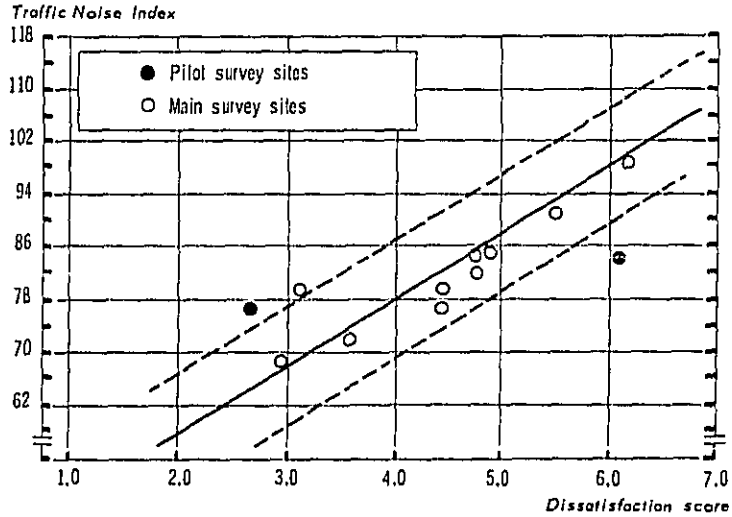


Figure 7. Regression of dissatisfaction on Traffic Noise Index with confidence limits at ± 2 standard errors of the estimate shown.

Source : adapted from Fig. 4 in Ref. [19].

noise study [4], the degree to which people are bothered by noises of different types could be accounted for by their individual susceptibility to noise assessed by self-report.

2. *Adaptation levels to noise as a function of past experience, immediate or long-term.* In this same Central London study, the investigators report a strong effect of personal experience on a person's judgment of what constitutes reasonable noise.

3. *The meaning of the sound.* Intelligible speech can prove more annoying at lower sound levels than unintelligible noise [21].

4. *The meaning of the source of noise.* In the Los Angeles study of free-flowing traffic noise [1], while there was minimal association between exterior noise levels and annoyance, annoyance *could* be predicted with a high degree of accuracy from a knowledge of what meanings a resident associated with freeways. Furthermore, the results of Swedish studies [38] indicate that significant changes in the disturbance reported in laboratory tests can be achieved by changing the attitudes of the subject towards the source of disturbance.

5. *The activity of the listener* (intellectual work, listening to TV and radio, sleep, etc.).

In Vienna, Bruckmayer and Lang have investigated the disturbance caused by traffic noise [22]. The survey was carried out in 1964 on a sample of 400 people. The aim was to find the relationship between the degree of nuisance caused and the noise level by comparing the two. As a basis for comparison two scales were set up: a 5-point nuisance scale – ranging from no annoyance – 0 – to intolerable – 4 –, and a noise equivalence index $\bar{Q}$ obtained by grouping the various components of the noise climate into a single value. From among the conclusions reached, the following may be cited: any given sound level was considered equally annoying in an office or a dwelling; by day, more than half the respondents found indoor noise levels of $\bar{Q}$ = 50-55 dB(A) very annoying or intolerable; by night, more than half the respondents found noise levels of $\bar{Q}$ = 40 dB(A) very annoying or intolerable.

Most of the laboratory studies that have been conducted in the past on subjective response to noise have been concerned with higher-level aircraft noise near airports rather than the low-level urban traffic noise of interest to us here. There have been suggestions that the differences between aircraft noise and urban traffic noise are sufficient so that laboratory results from the former cannot be associated with the latter without further study. A particular area that may be explored by future laboratory studies of urban traffic noise is the effect of the time pattern (duration and repetition rate) on the subjective response.

2.2. EFFECTS ON SPECIFIC ACTIVITIES

2.2.1. *SPEECH COMMUNICATION*

One of the most obvious effects of traffic noise is interference with communication. The degree of this interference is a function of the type of communication, the conditions under which communication must be maintained, the noise levels, and the frequency spectrum and the time pattern of the noise. A noise level that is not intense enough to cause hearing damage may still disrupt speech communication or interfere with the enjoyment of music or television. Also, interference with the ability to hear warning shouts or commands increases the probability of accidents.

Noise interference with speech is usually a masking process. As a result of background noise, a person may hear only a few or perhaps none of the speech sounds necessary for satisfactory intelligibility. Also, noise of a certain level may mask some speech sounds and not others, depending on the talking level, the particular sound, and the relative frequency distribution of the sound and of the noise.

Robinson [39] has stated that a sound level of 48 dB(A) allows conversation in a normal voice at a distance of 4 metres. Beranek [23] quotes a maximum indoor level of 40 to 45 dB(A) if television and radio are to be understood comfortably.

2.2.2. *INTERFERENCE WITH SLEEP*

Social surveys show that conscious interference with sleep is frequently cited as a major reason for annoyance with neighbourhood noise [2], [4]. But sleep interference can exist even without a person being consciously awakened.

In Thiessen's experiments, which are still in progress [24], sleeping subjects are exposed to a recording of the noise from a passing truck, played at a selected peak level several times each night. It is found that there is a 5% probability of awakening the subject at the 40 dB(A) level and 30% probability at 70 dB(A). If, however, one includes significant changes in the electroencephalogram records of the sleeping subjects, there is a 10% probability of a shift in sleep level (including awakening) at the 40 dB(A) level and a 60% probability at 70 dB(A).

In 1957, Steinicke (cited in ref. [7]) analysed the effect of noise on sleep for 350 people of different ages, sexes, and occupations. The initial noise level was 30 dB for a spectrum ranging from 50 to 50,000 Hz; the noise was continued for 3 minutes at each level, and raised successively by 5 dB bands until the sleeper awoke, when the noise-emitting apparatus automatically cut out. His results showed that 52% of the subjects were awake when a level of 45 dB was reached; that sensitivity to noise varied widely with the individual, some subjects waking at 35 dB, others only at 70 dB; and that sleep becomes less deep as age increases.

Research in the USSR reports these results: when noise is at a level of 50 dB, falling asleep is a lengthy process (one and a half hours) and there are fairly short intervals of deep sleep (one hour) followed, upon waking, by a sense of fatigue accompanied by palpitations. The level of 35 dB can be considered as the threshold for optimum sleeping conditions, since at this level it takes only 20 minutes to fall asleep and the period of deep sleep lasts from two to two and a half hours [25].

Preliminary studies have been made of sleep disturbance at the Centre of Applied Physiology at Strasbourg (cited in ref. [7]). The results, although inconclusive at present, suggest that noise affects the depth of sleep and hence its quality, and furthermore that an increase in the number of noise peaks increases the time required to fall asleep, even if the average noise level is lowered.

2.2.3. *EFFECTS ON LEARNING AND TASK PERFORMANCE*

Numerous studies have been made of the effects of noise on task performance; however, most of these involve noises higher in level and different in character from urban traffic noise. Thus, it is difficult to estimate the effect of traffic noise on performance.

As Teichner *et al.* point out [26], the available literature suggests that *i*) noise produces a decrement in performance, *ii*) noise has no

effect on performance, or *iii*) noise produces an increment in performance. The conflict in results probably can be explained by the fact that noise causes an actuation of psychic functions leading to a decrease in performance. Increase in performance under high noise situations could then be attributed to overcompensation on the part of the subject [25]. To the extent that urban traffic noise distracts, we may expect it to reduce efficiency in mental tasks more than in physical tasks.

Teichner *et al.* suggest that two noise factors affect performance: distraction and loudness. But the relative importance of these factors has not yet been determined precisely.

In recent experiments by Glass and Singer (cited in ref. [27]), random noises caused marked irritation and frustration, as well as dramatic declines in work efficiency even after the noise was stopped. Glass suggested that *powerlessness to change a situation* can cause adverse effects: "If the noise is predictable and regular, or if the noise is irregular but the subject is told he can shut it off if it becomes too much for him, then frustration and inefficiency do not appear". For individuals bothered by urban traffic noise, powerlessness to change the situation may be a very important cause of their annoyance.

2.3. PHYSIOLOGICAL EFFECTS

2.3.1. *IMMEDIATE EFFECTS*

There is at present no conclusive evidence that exposure to urban traffic noise under normal conditions produces any harmful effects. However, several immediate physiological effects are observed during exposure to noise levels comparable to those of urban traffic. Lang and Jansen [25] conclude from various research that noise results in increasing sympaticotonic reactions in the human body. Dilatation of pupils is a common noise reaction and can be shown to be linked to sound intensity. Such pupillary reactions are not initial effects of fear or pain, but are due to the somatic influence of noise, apart from its psychic effects.

Temporary threshold shift (TTS) in acuity of hearing varies considerably with the individual and the length and intensity of exposure to noise. Exposure need not be severe – a 12 hour drive in an automobile produces a detectable loss in acuity for many people. It is unlikely that just the normal (although high) urban noise levels could produce TTS; however, little is actually known of the possible slight effects of such noise levels.

An unexpected noise elicits startle or fright reactions. Physiological changes, such as a decrease in peristaltic contractions and a flow of saliva and gastric juices or a rise in intracranial pressure, have been recorded following sharp loud reports or unexpected noises. When

the noises cease, these internal physiological changes subside. However, as Broadbent suggests [28], such widespread physiological responses may be expected to interfere with other activities at the time when the sound occurs. Also, too frequent an occurrence of such change might be detrimental to health.

In the urban noise environment, startle reactions are usually provoked by noise peaks. Whether caused by a backfire or a noisy bus or a swiftly accelerating sports car, the noise is unexpected. And even the high background noise level cannot diminish the effect. Research by Hoffman and Fleshler [29] found that startle reactions of animals were influenced by the background acoustic environment. The responses were stronger against a background of moderate steady-state noise than they were in a quiet background or in one containing moderate level pulses. The fact that less-intense startle reactions occurred under quiet conditions is somewhat surprising. This result suggests that the presence of significant background noise will not increase the tolerance of still higher level peaks.

2.3.2. *CUMULATIVE EFFECTS*

Hastening of presbycusis

One possible important – but as yet unproven – effect of traffic noise concerns the hastening of age-induced hearing loss (presbycusis). As Wakstein [30] points out, things actually sound worse to a noise-deafened person because of the masking of adjacent tones. The quality of the noise environment, as perceived by the individual, is degraded. However, since such hearing losses progress slowly, this effect of urban noise is probably the least apparent, even to the affected person. He continually adjusts to the way that things sound – and thus rarely notices the change.

Three studies of the primitive Mabaan tribe in southeast Sudan provide some inferential and controversial evidence. These studies, condensed in a later paper by Jansen *et al.* [31], appear to show that, with aging, the Mabaan natives' hearing in the high frequencies maintains much higher levels than does the hearing of similar populations in Wisconsin, New York, Düsseldorf, and Cairo. The Mabaan environment is almost free of noise, with an ambient noise level corresponding very approximately to 30 dB(A). Jansen *et al.* state that "noise is undoubtedly a critical factor in the deterioration of hearing in the high frequencies with aging in industrialized and developed societies. Other contributory factors, such as diet, stress, climate, race, and genetic origin, must also be considered". The results of these studies of primitive tribes have been questioned on the basis of possible large uncertainties in the age data.

Sustained sleep interference

As noted previously, people are annoyed by traffic noise if it interrupts or prevents their sleep. Although there is little relevant data

available, increasing urban traffic noise may be changing the sleep habits of urban residents. It is reasonable to suppose that the cumulative physiological effect of a lack of sleep adequate in quantity and quality is damaging to most people.

3

CONTROL OF URBAN TRAFFIC NOISE

An acoustic system may be viewed as consisting of a source, a transmission path, and a receiver. Traffic noise abatement involves modifications of one or more of these elements. These modifications will be discussed in four sections: physical modification of the source, changes in vehicle operation, modification in the transmission path, and architectural modification.

3.1. SOURCE MODIFICATION

Of several possible points of control of traffic noise, source modification is the most universally effective, since it benefits all observers. Under normal operating conditions, the noise produced by motor vehicles contains several components – noise from the engine, air intake and exhaust systems, from brakes or other mechanical components, from tyre/roadway interaction, and from aerodynamic forces. Reduction of noise at source includes:

- Redesign of the engine, intake and exhaust silencers, brakes, gear boxes, engine enclosures, fans, or other parts, or replacement of defective parts;
- Changes in tyres or road surfaces to tone down the noise from tyre/roadway interaction;
- Alteration of the aerodynamic design;
- Elimination of noisier vehicles.

Figure 8 compares the noise during different conditions. The small difference between noise of American automobiles during cruise and coasting conditions at a constant speed (65 mph) indicates that the noise produced is primarily a result of the tyre/roadway interaction.

At lower speeds, under maximum acceleration, exhaust system noise predominates.

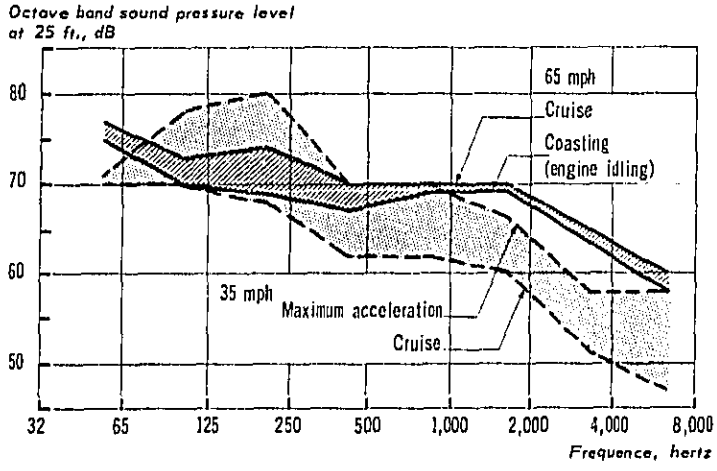


Figure 8. Illustration of the contributions from passenger car noise sources. The authors note that noise from tyre/roadway interaction predominates for 65-mph cruise conditions, particularly in high frequencies, as evidenced by a small decrease in spectrum from cruise to coasting. Engine and exhaust noise predominates for maximum acceleration at 35 mph, as shown by the large increase in the entire spectrum above cruise.

Source : adapted from Fig. B-3 in Ref. [1].

3.1.1. *INTAKE AND EXHAUST SILENCERS*

When the intensity of a source of noise is reduced by the addition of a specific control device, the device is called a silencer or muffler. While most silencers are designed to muffle noise, a few "silencers" are deliberately designed to permit noisy operation of the vehicle. When a major automobile manufacturer allowed an experimental gas turbine car to be driven, the greatest criticism of the car concerned noise; but, while about half of the criticism asked for less noise, the other half wanted *more* noise [32].

As a class, passenger cars are by far the quietest vehicles on the road. Hence, quieter passenger vehicles (although they form the greatest bulk of the traffic) would be of marginal significance and essentially valid only in residential districts with traffic composed of light vehicles, unless measures are taken for the proper muffling of the specific noisy vehicles such as sports cars, trucks, or motorcycles.

Sports Cars

Sports cars, and some new high-powered touring cars, gain much of their prestige and desirability from intentionally noisy exhaust systems. Because of the compact design, it can be argued that there is simply not enough space in these cars for adequate exhaust silencing – using present silencer design. However, manufacturers have been given no incentive for redesigning a system that is adequate for the space. If the noisier sports cars were adequately silenced, their noise output would be comparable to that of passenger cars [11].

No particular correlation exists between the amount of power developed (or the size of the vehicle) and the amount of noise produced by sports cars; but in practice, silencing of the exhaust level is highly variable for an original manufacturer's unit and much more variable in the hands of the users. In particular, noise from acceleration is a problem because of the generally low standards in sports car silencing.

Trucks

The greatest differences among types of silencers may be found on trucks. The presence or condition of a truck exhaust silencer has a major effect on the noise produced. The difference between no silencer and a stock silencer "in good condition" is typically 15 decibels. A very good silencer provides a further reduction of only about 3 dB(A), approximately to the point at which the noise of the engine covers that of the exhaust [11].

Many types of vehicles (such as motorcycles) may be noisy because the manufacturer's standards for silencing are not as consistent as comparable standards for passenger cars. With diesel trucks, as operated by major trucking lines, the opposite is true. Standards of noise control, and certainly the mechanical condition and maintenance of the devices, are generally high. As a truck engine is required to produce more power (e.g. in an upgrade condition), the exhaust pressure rises. As exhaust pressure rises, the efficiency of a reactive silencer increases. Thus the increased noise produced by greater engine power is somewhat offset by the greater efficiency of the silencer, but unfortunately not enough to lower the noise level.

Also, unless replacement silencers are subjected to regulation, any benefits gained from better standards in factory-installed units will quickly be lost. Truck silencers must be replaced about every 50,000 miles; therefore, better silencers could represent an increase in the repairs and replacement overhead for a trucking firm. An additional goal for silencer design could be to produce a longer-lasting as well as a quieter unit.

It should be noted that turbocharging as compared to natural aspiration undoubtedly reduces noise at high power (by lowering the exhaust back pressure), however it changes the frequency content of the noise especially at lower levels. Turbocharging softens the low frequency high energy engine noise while the high frequency components remain.

Motorcycles

The weight of an adequate silencer or of a cooling fan for an enclosed engine may reduce the performance of a motorcycle but neither this nor the cost of an effective silencer, should be considered a valid excuse for failure to use them. Even with silencer redesign, the degree to which more effective silencing can be employed is limited by several other factors: the mechanical noise generated by brakes, gears, and the internal combustion engine, and the noise from tyre/roadway interaction.

3.1.2. *BRAKES AND GEAR BOXES*

Little applicable experimentation has been done on either gear or brake noise. The study of these automotive parts is certainly important in the prevention of traffic noise, since most urban traffic is stop-and-go and thus requires the most gear shifting and brake application of any phase of vehicle operation. As in other areas of automotive noise, old or faulty parts and improper use (e.g. poor shifting) produce the maximum amounts of noise.

3.1.3. *ENGINE NOISE*

When a piece of vibrating machinery (such as an automobile engine) is attached to a structure that radiates noise, redesign or isolation of the vibrating elements may be the suitable approach to noise control.

Airborne noise produced by engine vibration becomes more and more significant as better intake and exhaust silencing is realized. This also places a practical upper limit on intake and exhaust silencing, since further reduction would not be observable due to the predominance of engine noise.

The noise associated with combustion in an internal combustion engine can be modified considerably by changes in the cylinder pressure time pattern. Noise level changes of 5 dB(A) for diesel engines and 9 dB(A) for gasoline engines have been observed with cylinder pressure pattern changes [33]. These results suggest that further study could provide worthwhile reduction in engine noise.

There is an increasing tendency for diesel engines to displace gasoline engines – even in the smaller engine sizes – because of better fuel economy. Unfortunately, these diesel engines often produce much more noise than gasoline engines. Bruckmayer of the Vienna Technische Hochschule Graz concluded from his studies that a private car with a diesel engine produces 6 dB(A) more than one with a gasoline engine [7], [45]. These differences arise from differences in design (such as the self-ignition mechanism that produces the diesel's characteristic "knock") [33]. There is some possibility of reducing the noise of diesel engines through combustion control. Generally, the only ap-

proaches to obtain significant reductions would require the modification of the engine structure, isolation, or enclosure.

Diesel engine noise increases by 30 dB per tenfold increase in vehicle speed; gasoline engine noise increases by about 45 dB. At full load, the gasoline engine is quieter at low speeds than a corresponding diesel engine; but since the noise increases at a higher rate, the gasoline engine's higher speed noise is of the same order as that of the diesel engine.

Noise is also transmitted through the engine structure by vibrational energy transmitted through the engine mounts. In gasoline engines, this noise can overwhelm the airborne component [33]. Control of such noise may require that the engine be more tightly enclosed and separated acoustically from its surroundings.

A particular example of reducing engine noise in a bus by improving the enclosure occurred in London double-decker buses, for which lining and sealing the engine compartments achieved a reduction of 6 dB(A) [13]. With time, however, seals tend to weaken and the engine to become more noisy.

3.1.4. *TYRE/ROADWAY INTERACTION*

Relatively little research has been done on the other factors in urban traffic noise – specifically tyre/roadway interaction and aerodynamic noise. The National Research Council of Canada reports that, for about 50 % of the medium and large-sized passenger cars, tyre noise predominates at speeds over 30 mph [12].

A common method of urban noise abatement is to lessen stop-and-go traffic and, hence, the accompanying noise; but this has the effect of raising the average speed of all traffic and increasing noise from tyre/roadway interaction. According to a study conducted in the United States, modern cars, under normal operating conditions, generate as much noise by tyre/roadway interaction as by engine/exhaust conditions [1]. Under extreme conditions, a very rough highway surface can produce significantly greater noise from tyre/roadway interaction – and high speed or acceleration increases that noise.

Many characteristics of the tyre, the roadway, and the vehicle suspension are important in noise production. Tyre manufacturers have developed less noisy tread compounds and patterns, such as variations in patterns at points around the tyre to break up sound harmonies and frequencies. The "singing" of tyres on fast-moving trucks is usually caused by tread wear that leaves a pattern of small holes, "suction cups" that pop as the tyre rolls [34]. Manufacturers might develop tread designs that do not wear in such a way.

A change in road surface from rough to smooth asphalt can lower the noise level from tyre/roadway interaction by about 5 dB(A) [13]. Unfortunately, smooth asphalt provides substantially lower traction in wet weather. Figure 9 compares the octave band noise spectra of

passenger cars driving on various road surfaces: rough asphalt, concrete, and very smooth asphalt. It would be difficult to determine the relationship between the type of road surface and truck noise because of the predominant engine and exhaust noise.

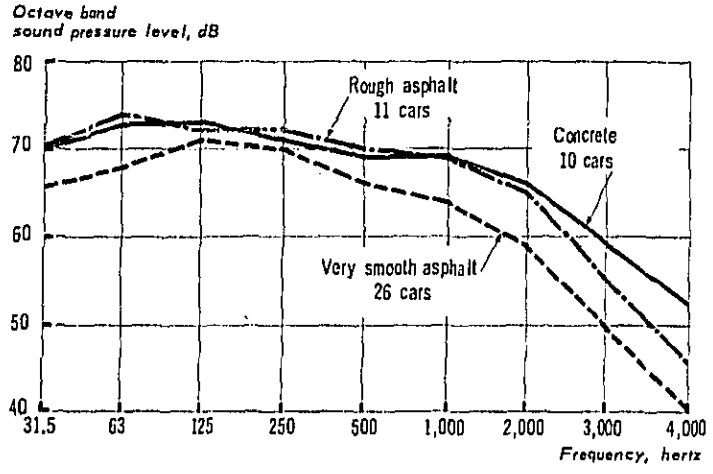


Figure 9. Noise spectra for passenger cars on three roadway surfaces, (at 25-foot distance, 43-57 mph speed range.)

Source : adapted from Fig. B-9 in Ref. [1].

Assuming maximum exhaust silencing, moderate control of the mechanical noise, and normal tyre tread designs, a large diesel tractor-trailer combination can be expected to produce 10 to 15 dB higher noise levels than a passenger car at the same speed – due to the relative contact areas of the tyres with the road.

The amount of tread and the pattern of a tyre, the condition of the road (wet or dry), the stiffness of the tyre casing, the loading of the tyres, and the coupling between the tyre and the vehicle body are all factors that must be better understood for better control of source noise.

3.1.5. *AERODYNAMIC DESIGN*

The other possible source of vehicle noise is that caused by the rush of air across a moving body. Unfortunately, the common method of research on this effect has been to put the vehicle engine in idle

and lock the gears in neutral; this method determines the noise produced as a result of tyres and mechanical "clatter" as well as aerodynamic noise. Certainly further specific research is needed, but it appears likely that aerodynamic noise outside the vehicle will be of importance only at extremely high speeds, if at all.

It should be noted that the engine cooling fan arrangement can be tailored to minimize noise due to excessive air turbulence. Attention should be paid to both the aerodynamic design of the fan and its proximity to the radiator.

3.1.6. *AGE OF VEHICLES*

Age rapidly deteriorates the normal automobile. In a study of Braunschweig (Germany) Martin (cited in ref. [7]) found that noise levels reached during 50% of the time were 77 dB(A) for vehicles manufactured between 1961 and 1963 and 79 dB(A) for vehicles manufactured between 1958 and 1960.

For certain types of vehicles, Bruckmayer (cited in ref. [7]) found that there is a difference of 2 to 3 dB(A) between cars 1 to 3 years old and the same type of cars 4 to 6 years old. Large differences were stated to occur with increasing use: 4 dB(A) difference between trucks with mileage of 8,000 km and 25,000 km. An average difference of at least 5 dB(A) has been recorded between the noise made by new vehicles (1962) and that made by older vehicles, the differences in some cases exceeding 10 dB(A) [11].

3.2. OPERATIONAL MODIFICATION

3.2.1. *REROUTING*

Since much urban housing is in the form of apartment buildings or complexes, rerouting heavy traffic away from predominantly residential areas would help to alleviate the discomfort and annoyance of a great number of people in a short period of time. In many large cities, there are few belts or sections that do not contain some residential buildings. In addition, many of a city's hotels are located within what are predominantly "business" districts. It would be difficult to build an urban expressway that would not affect *some* people in their homes or hotel rooms.

If it is at all possible, through traffic should be rerouted before it enters a town. Although a city bypass may be the longest route, it should be the quickest way to get to the other side of town. Within a city, strict rulings on commercial traffic, such as limits on the hours of deliveries or the unloading of large vans, can lessen to some extent the intrusion on the audio privacy of urban residents.

The Wilson Report [4] suggests that limiting the numbers of vehicles that pass through a particular district can be done by constructing bypasses and "ring-roads". Such rerouting reduces the traffic through the centre of towns, since they rarely have street patterns conducive to the efficient flow of heavy traffic. Obviously, well-planned road construction would be an effective solution to the problem at hand, but such activities require much money and years of planning and construction.

In the past, construction of bypasses and ring-roads has not kept up with the increase in the amount of traffic; an adequate road building programme could greatly relieve the congestion and noise in many of the supporting towns to large urban areas. "Such measures, however, would still leave untouched the problems caused by internal traffic... The local rerouting of traffic... is at most a palliative which will be effective for a few years only, and much more drastic measures will be necessary in the long run". [4].

3.2.2. *NIGHT OPERATION*

As previously stated, the lull in traffic noise levels at night is becoming shorter and shorter – due to the increase in night traffic. Soon night noise levels will approach those of the day. As Chapter 2 shows, sleep interference is a major reason for annoyance with noise.

Practical limitations on night operation can be made through lowered speed limits and stricter control on violations of the existing noise codes. A vigorous public information campaign for driver courtesy might increase driver awareness and thus effect a quieter city night.

3.2.3. *TRAFFIC FLOW*

Many of the traffic studies that have been mentioned in this report [1], [4], [11] concur that the noise from stop-and-go traffic (i.e., the noise of deceleration, braking, or acceleration), whether at night or during the rush hour, is the significant element in the urban noise situation. The wide difference between noise produced during maximum acceleration conditions and cruise conditions [1] (also see Figure 8) suggests that the major fluctuations in noise produced by individual vehicles occur in situations of stop-and-go driving, such as at intersections, rather than on the open road.

A ten-minute sample of noise from heavy daytime (stop-and-go) traffic in New York City showed a mean value of 81 dB(A), and standard deviation of 4 decibels, at 15 feet from the traffic [16]. Other data taken in the United States show motorcycles about 15 dB(A) noisier during acceleration than passenger cars [11].

There are several approaches to reducing the stop-and-go of traffic flow. These include the use of synchronized traffic lights and the creation of one-way streets. It is possible, however, that the creation

of one-way streets may lessen congestion at the expense of increasing the traffic and noise in side streets that were previously lightly travelled.

The influence of permanent braking and accelerating noise has been studied by the Federal Institute for Roads and Highways, (BAST), FRG, Cologne, for a light signal-controlled pedestrian crossing in the course of a major street. The results can be summarized as follows:

1. During the acceleration phases (the first 15 seconds after "Red"), it is mainly the L95-value (background noise) which rises.
2. Noise level values during the "Stop" phases (signal showing "Red", are markedly different; even at greater distances the mean value L50 in such cases is approximately 5 dB(A) lower than the average value.
3. During the change from "Red" to "Green" the noise level rises up to 18 dB(A). The mean level fluctuation amounts to more than 20 dB(A).
4. Mean values, i.e. average values through all phases of the signal are only slightly higher than the values obtained for freely flowing traffic.

3.2.4. *RECKLESS OPERATION*

A similar problem involves the reckless, thoughtless (and concurrently noise-producing) operation of a motor vehicle. Most cities have existing ordinances against "public nuisances", but such laws are rarely enforced.

Merely reminding the public of the existence (and interpretation) of existing ordinances could increase individual awareness of noise-producing activities. The National Research Council of Canada, in justifying in-the-field noise level measurements with a simple A-weighted sound level meter, commented that such an enforcement concept aims at controlling the operator-machine combination, rather than punishing the machine [12]. The method puts a premium on "considerate habits that may hopefully be carried over the various situations where legal enforcement may be difficult or impossible", (e.g., slamming car doors late at night). Little is gained by regarding all drivers as inconsiderate or by penalizing all infractions of a noise code. Most drivers are probably unaware of the amount of noise that they make. A vigorous public information campaign might increase driver awareness.

3.2.5. *HORNS, BELLS AND SIRENS*

Other frequent noise nuisances producing peak noises in the urban environment are the blowing of car horns, the sound of emergency bells and sirens. In some countries, rush-hour traffic jams may be particularly characterized by an enormous amount of irritated horn blowing.

In Paris and Vienna, for example, horn blowing has been completely prohibited unless it is the only means of avoiding danger or injury to persons. A somewhat flexible interpretation of the meaning of "injury" has made this law effective and acceptable. In Norway, only acoustic warning devices approved by Norwegian authorities may be used. In Belgium, horns must not be used between sunset and sunrise (cited in ref. [7]). Regulations suggest the substitution of flashing lights or headlights as warning signals. Limiting the use of horns, bells, or sirens to emergency situations would be a sensible way to eliminate one particularly annoying noise source.

3.3. TRANSMISSION PATH MODIFICATION

When a high-speed, controlled access road must be built within a city, it is important to know during initial planning what effects various road designs and barriers will have on the inevitable noise from the road. If, after these methods have been employed to achieve the maximum noise reduction, the noise levels are still not lowered to standards recommended for dwelling areas, then consideration must given to replacing the existing activities by others that are more compatible with the noise level.

3.3.1. *BUILDING LOCATION*

Traffic noise generally decreases with increasing distance, but the amount of the decrease depends on the nature of the source. Figure 10 shows the idealized relative behaviour of the noise produced by a composite of freely flowing vehicles, which acts as a line acoustic source, and by individual vehicles, which act as point sources.

The figure illustrates a situation with the sources and observation points on grade, with no shielding structures or barriers, and with average atmospheric attenuation included. Note that the noise "peaks" due to individual sources decrease more rapidly with distance than does the noise "background" due to a composite of many sources.

Measurements made in Switzerland show that there is a "fore area" near a road, in which the background noise level is practically constant. The width of this area is of the order of a few metres only when the traffic is dense and can increase to 100 metres with less dense traffic. Beyond this "fore area" lies a "rear area" in which the intensity of the noise decreases as one moves away from the road. The noise peaks are cut out more rapidly than the background noise so that at a distance of about 200 metres from the road the background noise alone prevails [43].

A committee of Scandinavian building authorities has used information on the propagation of traffic noise to develop rules for a minimum distance between highways and residential buildings [8], [9].

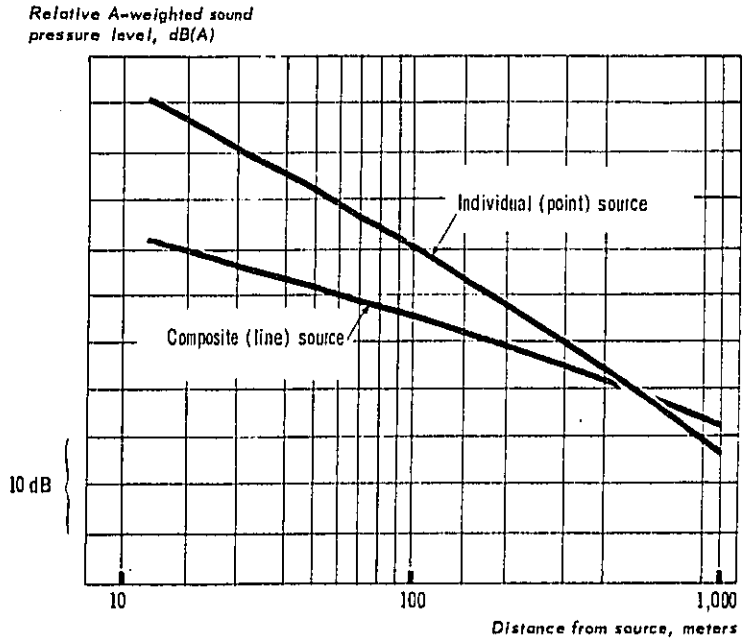


Figure 10. Relative decrease with distance of the noise levels from freely flowing traffic. Sources and observation points on grade, no shielding and in the absence of wind and ground effects.

Source: adapted from Fig. 3-3 of Ref. [16].

The committee has chosen 59 dB(A) as the permissible average noise level outside the buildings. (This corresponds to 35 dB(A) inside the buildings, which are assumed to have closed double-glazed windows). Figure 11 is the resulting design curve. Correction curves have been prepared for cases when the residences are not on the ground floor or when there are barriers or trees between the highway and the residences. Recent work by Lindblad [40] indicates that the values of sound attenuation used to develop Figure 11 may be over conservative and that the minimum distance can be somewhat smaller than shown in Figure 11.

Many large urban governments are redesigning entire sections of their cities to provide more pleasant environments and, in some ways, to attempt to alleviate the problems of servicing, safety, and health that breed in congested areas.

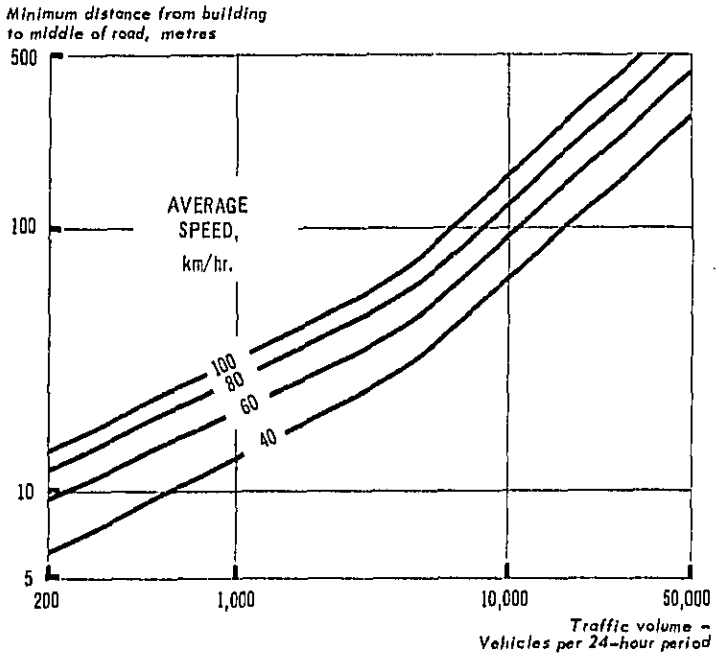


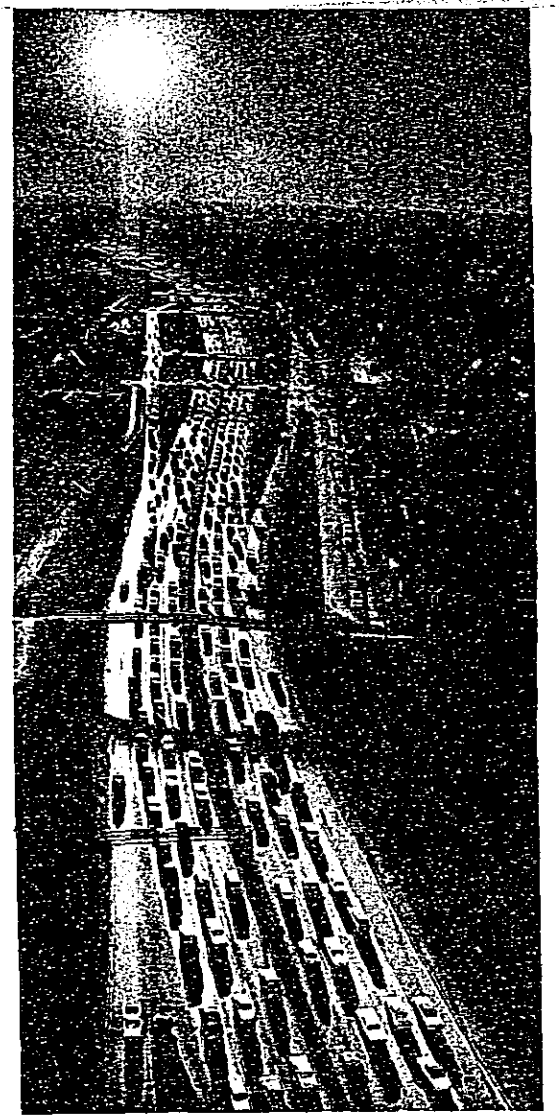
Figure 11. Minimum distance between road and built-up areas, as a function of traffic volume and average speed.

Source : adapted from Ref. [47].

These restructured environments offer the opportunity for innovation in civic design in regard to noise abatement. In the "Bijlmermeer" district project in Amsterdam [7], only low non-residential buildings will be allowed along the motorway. In most cases these buildings will form a screen between the motorway and the dwellings. Wide spaces planted with trees and shrubs will be left between the motorway and the dwellings to provide visual and some acoustic screening.

3.3.2. *STREET WIDTHS*

Since a large percentage of the world's major cities were built (and often rebuilt) a long time before the coming of the automobile, most of their streets are too narrow to accommodate more than two



An estimated 250 square miles adjacent to freeways or highways have a noise impact affecting about 2.5 million Americans. Of the 3 billion total highway vehicular miles traveled in 1970, better than half were within town or city limits. In addition, traffic over the 96,000 miles of major arterial roads in suburban communities exposes between 7 and 14 million persons to objectionable noise levels.

Other transportation modes, including railways, ships and special purpose or recreational vehicles, also contribute their share to the total noise impact from the transport system. Each of these presents its own peculiar problems to persons they affect and special challenges in the area of noise control.

Improved engineering design may be expected to bring decreases in noise from all types of vehicles. However, the most effective noise prevention measures will only be achieved by the use of a balanced transportation system, designed to move people and cargo economically, while minimizing total environmental impact. Planning and implementation of land use designs which minimize future noise impacts and gradually resolve existing ones, must be a key feature of any solution to problems of community noise.

Reprinted from EPA Bulletin - January 1972

U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

GPO : 1972 O - 461-854

Salvage Markets Co.
[illegible] 1972 USEPA

Noise and TRANSPORTATION

NOISE AND TRANSPORTATION

Noise is commonly defined as "unwanted sound"; this phenomenon may also be defined in terms of an environmental pollutant---a waste product often associated with some desirable activity.

The general public is well aware of the class of pollutants which may be termed "mass residuals". These include particulates and certain unwanted gases in the air, or undesirable chemical and biological substances that enter ground and surface waters, and the ocean.

Noise belongs to a second general type of pollution which may be termed "energy residuals." The waste heat from manufacturing processes is one example of an energy residual that can result in thermal pollution of streams. Noise---waste energy in the form of sound waves---is an unfortunate by-product of the transportation industry.

Although the total amount of energy dissipated as sound is not large in comparison with other forms of energy, the extraordinary sensitivity of the ear permits such relatively small energy to adversely affect man and other animal species.

In order to help determine the magnitude of the noise problem EPA sponsored a series of public hearings which were held last year in cities throughout the country. From comments and complaints registered at the public hearings, airport jet noise emerged as the single most important problem, if not in total number of citizens affected, at least in the intensity of feelings expressed. Some indication of the strength of this reaction may be reflected in the estimate of $3.8 billion in noise claims now pending against public airport operators.

Within the past year the Los Angeles Department of Airports found it necessary to adopt a most radical solution to its problem of noise complaints: a 600-acre subdivision adjacent to the Los Angeles International Airport was acquired by the Department and the 2,560 homes in the tract were demolished. The cost for this solution was $108 million.

The noise associated with jet aircraft is primarily due to the turbulent mixing of the high velocity exhaust jet and the surrounding air. Newer turbofan engines, that have largely replaced earlier turbojet models, offer reduced noise levels because they take in larger quantities of air and expel this air at lower jet velocities. The newest widebody aircraft, including the Boeing 747, DC-10 and L-1011, are all powered by improved engines that allow a 10 to 15 decibel reduction in noise over earlier turbofan aircraft.

Although the number of major airports has increased only slightly since the late 1950's, the frequency of flights has grown many times over. This factor, combined with vast new residential growth in the vicinity of nearly all busy airports, has resulted in growing airport-community antagonism that has not been totally offset by technical successes in reducing engine noise.

Improved technology and changes in operational procedures, may reduce noise levels still further, despite projected increases in air traffic. However, ultimate noise reduction goals may necessarily involve changes in land use requirements, zoning regulations and similar restrictions.

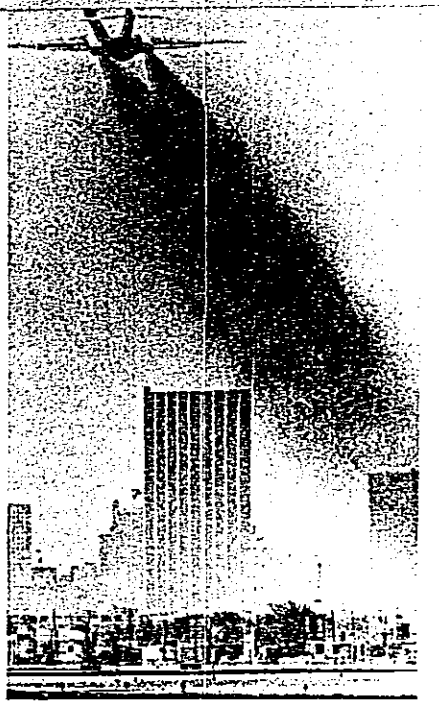
If aircraft noise evokes the most vigorous citizen complaints, the noise from highways affects a larger percentage of the population. Although the highest noise levels from vehicular traffic are experienced in immediate proximity to the highway--typically 75-80 decibels at 100 feet, and 60-65 decibels at 1,000 feet from the curb or shoulder-motor vehicles are also the major contributor to the residual noise level in urban and suburban communities.

Automobiles constitute the largest number of highway vehicles. While not as noisy as trucks, buses and motorcycles, their total contribution to the noise environment is significant due to the number in operation--87 million in 1970. Of the 19 million trucks in operation only 2 to 3 percent are powered by diesel engines. However, these vehicles are generally 8 to 10 decibels noisier than gasoline powered trucks, and 12 to 18 decibels noisier than automobiles.

Tires are the dominant noise source at speeds greater than 50 mph; in addition to speed, the amount of tire noise is a function of the road surface, axle loading, tread design and wear condition. Truck tires are generally noisier than automobile tires.

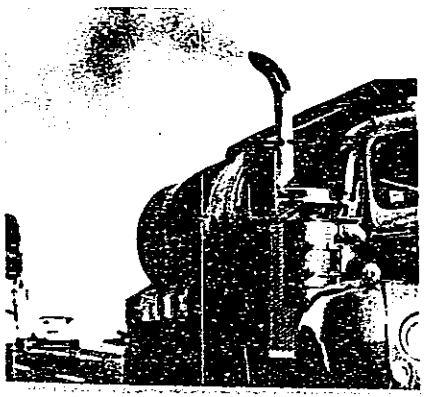
Engine-generated noise is normally dominant for trucks and automobiles at speeds below 35 and 45 mph, respectively. This noise is radiated directly from the engine exhaust and intake openings and from the vibrating engine casing.

A third source of highway noise includes that produced by turbulent aerodynamic flow over the vehicle body and rattling of loose mechanical parts.



Fifteen hundred square miles of urban area in the United States, adjacent to airports, are exposed to various levels of aircraft noise. As a result, some six million persons who reside or work in these areas are daily exposed to annoying, irritating and sometimes dangerous aircraft noise.

Trucks are the largest single source of highway noise, and of these the large diesel truck is most noisy in operation. In addition to the louder diesel exhaust, the sharp pressure rise in the combustion chamber results in noise radiated from the engine itself.



lanes of traffic. The narrowness of these streets also creates a special noise problem that results from amplification and reverberation. When streets are 12 metres wide between the fronts of buildings, a sound source of 95 dB is amplified to about 100 dB; for streets 6 metres wide, 95 dB becomes 105 dB. In addition, most narrow streets are also faced by a continuous line of adjacent buildings – a situation that further increases amplification. When street widths exceed 24 metres, no appreciable amplification occurs [7].

3.3.3. *NOISE SCREENS*

Several types of noise screens can act as adequate shields against traffic noise. Existing buildings in urban areas naturally provide some noise reduction. The presence of shielding buildings introduces a level reduction of about 10 to 20 decibels, essentially independent of the number of intervening structures [16]. However, few urban buildings were designed as noise screens; in fact most buildings reflect sound waves in another direction.

In a study of the noise levels in London, the Greater London Council [7] made theoretical calculations of the noise reduction effect of screens of varying height. For a protective barrier 3 metres from the edge of a road 30 metres wide, some of the findings were that:

- 30 metres from the screen, the total noise reduction varies from 9 to 15 dB(A) for a 1.5-metre barrier; from 17 to 22 dB(A) for a 5-metre barrier; and 22 to 25 dB(A) for a 10-metre barrier. Noise reduction due solely to distance is about 9 dB(A).
- 70 metres from the barrier, the total noise reduction varies from 14 to 20 dB(A) for a 1.5-metre barrier; from 20 to 27 dB(A) for a 5-metre barrier; and from 26 to 31 dB(A) for a 10-metre barrier. Reduction due solely to distance is about 14 dB(A).

Rücker and Glück (Germany) have studied experimentally the sound attenuation of 16 different screening systems for reducing traffic noise [35]. The best results were obtained when the screen surfaces consisted of impervious sound-absorbing elements. The noise reductions achieved ranged between 15 and 26 dB for such optimum systems. Good performance was also obtained from systems consisting of overlapping sound-absorbing slats, similar to venetian blinds. Such systems appear appropriate for use as roofs.

Grass, trees, or shrubbery would certainly be visually pleasant and acceptable noise screens for urban areas. Unfortunately, they are acoustically not very effective. Swiss and Scandinavian studies indicate typical attenuation values of 5 dB/100 metres for dense plantings of trees [7], [36].

Josse, Rapin and Gilbert (France) using a 1:20 model have simulated the acoustic efficiency of 90 different arrangements of screen along a rectilinear motorway [44]. The results obtained for frequencies of between 500 and 1,000 Hz, representing, for a given traffic situation, a noise level exceeded for 50% of the time, showed that the

noise attenuation achieved by means of screens was in all cases not more than 15 to 20 dB(A). A list of values which can be applied directly by urban planners shows that the case using two vertical screens is the least favourable and that it appears more economical to use higher and inclined screens rather than vertical screens covered with an absorbing material. The introduction of elevated expressways in urban areas would call for a redesign of the guardrails, and the use of screens or banks so as to permit construction on areas of land which might otherwise be condemned if the recommended environmental standards were to be observed.

3.3.4. *ROAD DESIGN*

Glück has studied the effects of road design on noise and has found that cuts are an effective way of reducing the noise exposure in adjacent areas [37].

Tunnels would be an effective way to remove the noise source entirely from the hearing range of the receiver and yet maintain existing traffic routes within and across cities. Since tunnels have been in use for many years to provide alternate transportation routes across rivers or bays, the technology need only be refined for use on major arteries. Furthermore, a significant contribution to noise reduction could be attained by diverting passengers from buses and cars on to subway systems.

Among many of the problems involved in the operation of tunnels would be that ventilation systems must not pollute the environment with channelled noise and exhaust fumes; vents would have to contain adequate baffling and, in some manner, filter harmful fumes or pollutants from the exhaust. Tunnels would also have to be treated acoustically, so that the noise levels *within* would not be beyond reasonable limits for the comfort of passing motorists. The effect of vibration on overhead buildings would also have to be studied. The resolution of one problem should not merely create a new inconvenience.

3.3.5. *ZONING*

An administrative approach to urban noise control involves establishing specific zones with maximum permissible noise limits. A government would define the quality of the noise environment in each zone and allow individuals to choose the zone that best suits their sensitivities and resources. It may then be possible to familiarize the public with the meaning of the zones, so that noise can be considered in purchasing real estate.

The authorities in the Paris region have investigated the possible use of noise zoning, based on a combination of the sound level and duration of the noise [7]. In Group I of the proposed zoning system, no residential building would be allowed. In Group II, residential building would be allowed only if the outer walls and windows give adequate

sound insulation. In Group III, all residential building would be permitted but schools and hospitals would require special sound insulation. In Group IV, all building would be permitted (see Annex 1 – Chapter on France).

Table 3 hereunder defines the basic (background) noise levels and levels of frequent and infrequent peaks for specific zones set by the Swiss in 1963. Districts in Tokyo are classified into five zones, in which maximum noise levels are specified. Austria also has set noise standards for living spaces in different areas cited in ref. [7].

Table 3. TOLERATED NOISE LEVELS IN dB(A) SET BY SWITZERLAND IN 1963

Zone	Background noise level[1]		Frequent peaks[2]		Infrequent peaks[3]	
	Night[4]	Day	Night[4]	Day	Night[4]	Day
Hospital and convalescent	35	45	45	50	55	55
Quiet residential	45	55	55	65	65	70
Mixed	45	60	55	70	65	75
Commercial	50	60	60	70	65	75
Industrial	55	65	60	75	70	80
Main arterial road	65	70	70	80	80	90

1. Background noise level: average value (mean level without peaks).
2. Frequent peaks: 7-60 peaks per hour.
3. Infrequent peaks: 1-6 peaks per hour.
4. "Night" is considered to be from 10.00 p.m. to 6.30 a.m.

Source: Adapted from reference [7].

3.4. ARCHITECTURAL MODIFICATIONS

If individual vehicles cannot be sufficiently silenced, nor their operation successfully controlled, and if modification of the transmission path is impossible or unfeasible to achieve, then the remaining control approach is through architectural modifications.

3.4.1. *WINDOWS*

Windows are usually the weakest acoustic link in insulating occupants from outside noise, and studies conducted have shown varying results. The Building Research Station (United Kingdom) [4], [41] shows that when windows are open the difference between noise levels outdoors and indoors will be about 14 dB on average; with closed windows the difference is about 25 dB, whilst in dwellings having double windows intruding noise may be reduced by as much as 45 dB

when the windows are closed. A similar study [43] conducted by the Swiss Federal Materials Testing Laboratory arrives at the following results: 5-10 dB for open windows, 15-25 dB for closed windows and 20-35 dB for closed double windows.

To achieve maximum reduction, the double windows have to be sealed and fitted with panes of different thickness (e.g. 3 mm and 5 mm to 6 mm) with 8 inches or more between the leaves and lined with a sound absorbing material. Sealed windows necessitate the provision of some sort of mechanical ventilation or air conditioning. When windows are to be opened they have to be very closely fitted. Reducing the size of windows will improve insulation to some extent; halving the size of windows will give a 3 dB improvement.

For many house windows, the lessening of noise reduction is governed by the cracks or leaks around the glass panels, rather than by the panels themselves. Tightly sealed storm windows or double-glazed windows can easily reduce sound if conventional windows must be used.

Appendix XIII of the Wilson Report, for example, describes in detail one of many possible window designs that could reduce noise yet still provide light, visibility, and ventilation [4].

3.4.2. *INTERIOR BUILDING LAYOUT*

Much can be done to reduce the ill effects of noise by putting the most vulnerable parts of a building as far as possible from the main source of noise, or by turning them away from it. With careful planning, the working or living areas that are most sensitive to noise could be shielded by less sensitive areas. Offices, studies, and bedrooms could be placed as far away as possible from the exterior walls exposed to the traffic noise.

REFERENCES

1. Galloway, W.J. Clark, W.E., and Kerrick, J.S., *Urban Highway Noise – Measurement, Simulation, and Mixed Reaction*, Bolt Beranek and Newman Inc., Technical Report No. 1505 (November 1968).
2. Bolt Beranek and Newman Inc., *Noise in Urban and Suburban Areas: Literature Search*, Report No. 1460 (January 1967).
3. Bonvallet, G.L., "Level and Spectra of Traffic, Industrial, and Residential Area Noise", *The Journal of the Acoustical Society of America*, Vol. 23: No. 4 (July 1951).
4. Wilson, A., *Noise*, Her Majesty's Stationery Office, London (1963).
5. *Aftenposten*, Oslo (22nd July, 1968).
6. Donley, R., "Community Noise Regulation" *Sound and Vibration*, Vol. 3: No. 2 (February 1969).
7. *Urban Traffic Noise: Status of Research and Legislation in Different Countries*, OECD, Paris (January 1969).
8. *Trafikbuller i Bostadsomraden*, Report No. 36, National Swedish Institute for Building Research and the National Swedish Institute for Public Health, Stockholm (1968).
9. *Stöj og Byplan*, Den Nordiske Komite For Bygningsbestemmelser, Copenhagen (1963).
10. Lamure, C., and Auzou, S., "Les niveaux de bruit au voisinage des autoroutes dégagées". *Cahiers du Centre scientifique et technique du bâtiment*, No. 71 (1964).
11. Bolt Beranek and Newman Inc., *Objective Limits for Motor Vehicle Noise*, Report No. 824 (December 1962).
12. *A Brief Study of a Rational Approach to Legislative Control of Noise*, The Acoustics Section, Division of Applied Physics, National Research Council of Canada, Ottawa (1968).
13. Thiessen, G.J., and Olson, N., "Community Noise – Surface Transportation", *Sound and Vibration*, Vol. 2: No. 4 (April 1968).
14. Olson, N., "Statistical Study of Traffic Noise", *The Journal of the Acoustical Society of America*, 1969.
15. Wiener, F.M., "Sound Propagation Outdoors", Chapter 9 in *Noise Reduction*, L.L. Beranek (ed.). New York: McGraw-Hill Book Co., Inc. (1960).
16. Bolt Beranek and Newman Inc., *Noise in Urban and Suburban Areas: Results of Field Studies*. Report No. 1395 (January 1967).
17. Wiener, F.M., Malme, C.I., and Gogos, C.M., "Sound Propagation in Urban Areas", *The Journal of the Acoustical Society of America*, Vol. 37: No. 4, pp. 738-747 (April 1965).
18. Johnson, D.R., and Saunders, E.D., "The Evaluation of Noise from Freely-Flowing Road Traffic". *Journal of Sound and Vibration*, Vol. 7: pp. 287-309 (1968).
19. Griffiths, I.D., and Langdon, F.J., "Subjective Response to Traffic Noise". *Journal of Sound and Vibration*, Vol. 8: pp. 16-32 (1968).

20. Robinson, D.W., *The Concept of Noise Pollution Level*, National Physical Laboratory (United Kingdom). Aerodynamics Division Report Ac 38 (March 1969).
21. Cavanaugh, W.J., Farrell, W.R., Hirtle, P.W., and Watters, B.G., "Speech Privacy in Buildings", *The Journal of the Acoustical Society of America*, Vol. 34: pp. 475-492 (1962).
22. Bruckmayer and Lang, *Störung der Bevölkerung durch Verkehrslärm*, pp. 382-385, Vol. 10, Österreichische Ingenieur-Zeitschrift.
23. Beranek, L.L., *Acoustics*, New York: McGraw-Hill Book Co., Inc. (1954).
24. Thiessen, G.J. *Effects of Noise from Passing Trucks on Sleep*. Paper Q1 presented in Philadelphia, Pennsylvania, at the 77th meeting of the Acoustical Society of America (April 1969).
25. Lang, J., and Jansen, G., *Report on the Environmental Health Aspects of Noise Research and Noise Control*, United Nations, World Health Organisation Report (May 1967).
26. Teichner, W.H., Arees, E., and Reilly, R., "Noise and Human Performance, A Psychophysiological Approach", *Ergonomics*, Vol. 6: pp. 83-97 (1963).
27. Leo, J., "Tests Show Noise Causing Tension", *The New York Times* (11th September, 1968).
28. Broadbent, D.E., "Effects of Noise on Behaviour". Chapter 10 in *Hand-book of Noise Control*, C.M. Harris (ed.). New York: McGraw-Hill Book Co., Inc. (1957).
29. Hoffman, H.S., and Flesher, M., "Startle Reactions: Modifications by Background Noise Stimulation", *Science*, Vol. 141: No. 3584, pp. 928-930 (1963).
30. Wakstein, C., *The Noise Problem in the United States*. Presented at the Fifth International Congress for Noise Abatement, London (13-18th May, 1968).
31. Jansen, G., Rosen, S., Schultze, J., Plester, D., and El-Mofty, A., "Vegetative Reactions to Auditory Stimuli", *Transactions of the American Academy of Ophthalmology and Otolaryngology* (May-June 1964).
32. *Motor Trend*, pp. 29-30 (January 1969).
33. National Physical Laboratory, Symposium No. 12, *The Control of Noise*. London: Her Majesty's Stationery Office (1962).
34. "City Noise: Designers Can Restore Quiet at a Price", *Product Engineering*, Vol. 39: No. 24 (18th November, 1968).
35. Rücker, A., and Glück, K., "Bauliche Schutzmassnahmen für Minderung des Strassenverkehrslärms", *Strassenbau und Strassenverkehrstechnik*, Vol. 47 (1966).
36. *Støj og Byplan-Praktiske Anvisninger*, Den Nordiske Komite for Bygningsbestemmelser, Copenhagen (1966).
37. Glück, K., "Die Schallentwicklung des ungebundenen Stadtverkehrs, die Ausbreitung und deren Beeinflussung durch die Bebauung", *Strassenbau und Strassenverkehrstechnik*, Vol. 32 (1964).
38. Jonsson, E. and Sorensen, S., "On the Influence of Attitudes to the Source of Annoyance Reactions to Noise", Nordisk Hygienisk Tidskrift, Vol. 48, pp. 35-45 (1967).
39. Robinson, D.W., "An Outline Guide to Criteria for the Limitation of Urban Noise", National Physical Laboratory, Aero Report Ac 39, (March 1969).
40. Lindblad, S., and Jonsson, H., *Metod for Beräkning av trafikbuller*. Available from Statens Planverk, Stockholm.
41. Scholes, W.E., and Parkin, P.H., "The Insulation of Houses against Noise from Aircraft in Flight", *Applied Acoustics*, 1968, 1, 37-46.
42. *Schalluntersuchung von Normfenstern*, Eidg. Materialprüfungs - und Versuchsanstalt sowie Architekbüro V. Wörgler, Zurich, im Auftrag der Forschungskommission Wohnungsbau (F.K.W.).
43. Furrer, W., "Der Lärm von Autobahnen und Überlandstrassen", Sonderdruck aus der Zeitschrift, *Lärmbekämpfung*, Jahrgang 10, Heft 3/4, Verlag für angewandte Wissenschaften GmbH, Baden-Baden.
44. Josse, Rapin and Gilbert, *Etude des Modes de Protection Phonique aux abords des Voies Rapides Urbaines*, C.S.T.B. (France) on behalf of the I.R.T. (1969).

45. Bruckmayer, F., *The problems of fixing and gradually reducing the maximum permissible levels of noise from motor vehicles*, Paper for the International Association against Noise, (1964).
46. *Snowmobile Noise, its Source, Hazards and Control*, National Research Council of Canada, (1970).
47. *Build International*, September/October 1968, pp. 55-57, an article that discusses the findings of reference [8].

ANNEXES

Annex I

CURRENT ADMINISTRATIVE AND LEGISLATIVE PRACTICES IN MEMBER COUNTRIES

This Annex contains the results of enquiries conducted by the Secretariat in support of the Report on Urban Traffic Noise. It covers the following countries: Canada, France, Italy, Japan, Netherlands, Scandinavia (Denmark, Norway and Sweden), Switzerland, United Kingdom

CANADA [1]

INTRODUCTION

Public interest in the subject of urban traffic noise is rapidly developing in Canada. News reports of activity and concern are almost daily occurrences and committees of citizens and officials have been set up in many places. This interest is often focused on specific noise problems such as motorcycle noise, particularly at night, in otherwise quiet residential areas, aircraft noise, heavy motor-vehicle noise and, most recently, snowmobile noise. The standard North American automobile, properly used, is a relatively quiet vehicle and is, therefore, rarely a direct cause of concern. Nevertheless, there is general concern about noise pollution as one of several factors contributing to a general deterioration of the environment.

Despite these encouraging signs of activity related to noise abatement, it must be said that specific legislation in this field is at the embryonic stage in Canada. Furthermore, since Canada is a federal state, legislative responsibility is distributed over three levels of government, federal, provincial and municipal, which makes it difficult to assemble a comprehensive and up-to-date review of the situation in Canada. Nevertheless, it is hoped that the following report will serve as a reasonable guide to the present situation.

1. FEDERAL GOVERNMENT ACTIVITY

No *central* body has responsibility for motor vehicle noise control measures. (Note that civil aviation and airports are regulated by the Government of Canada Transport Department which deals with noise abatement measures associated with aircraft certification and operation). However, Bill C-137, passed by the House of Commons in March 1970, makes provision for future action in this field. A new law

1. We are grateful to Dr. E. Shaw of the National Research Council of Canada who has very kindly drafted the chapter on Canada.

known as the Motor Vehicle Safety Act (S.C. 1970) came into effect during 1970 and is so defined as to permit action to deal with impairment of health. More explicitly, the Minister of Transport has stated that "we shall also study the relationship between motor vehicle noise and the impairment of health. Should the evidence indicate a need to control noise pollution from this source, regulations will be issued under this act". It should be noted that agreement has been reached for a sharing of responsibility with the provinces. The Federal Government would deal with new motor vehicles while the provinces would deal with motor vehicles in use and replacement and additional parts for motor vehicles.

In a federal state, co-ordinated government action may be engendered by advisory documents such as the National Building Code of Canada, which in 1966 had been adopted in whole or in part by more than 90% of the cities of Canada. In 1968, to meet requests for information from municipal officials, the Division of Applied Physics of the National Research Council of Canada prepared a short report entitled "A Brief Study of a Rational Approach to Legislative Control of Noise" (APS-467). This report reviewed the legal and administrative measures taken in Canada and in other countries, summarized the technical information then available and recommended specific means of controlling the noise levels due to motor vehicles, power lawnmowers, air conditioning systems, industrial operations, etc. The report suggested, as a guide, maximum decibel [db(A)] levels for the various types of noise and also recommended noise zoning. The recommended noise limits, as from 1969, are as follows:

Passenger Vehicles – Small Trucks

At a distance of 15 feet :

– in 30 mph zones	80 dB(A)
– in higher speed zones	88 dB(A)

Motorcycles

At a distance of 15 feet:

– in 30 mph zones daytime	85 dB(A)
– in 30 mph zones at night	82 dB(A)
– in higher speed zones	90 dB(A)

Trucks > 3 tons

At a distance of 15 feet:

– in 30 mph zones	87 dB(A)
– in higher speed zones	92 dB(A)

Tractor Trailers

At a distance of 15 feet:

– in 30 mph zones	87 dB(A)
– in higher speed zones	95 dB(A)

Skidoos and Similar Snow Vehicles

At a distance of 15 feet:

- in 30 mph zones ..... 85 dB(A)
- In higher speed zones ..... 90 dB(A)

It should be noted that the noise limits for motor vehicles recommended by the National Research Council are supported by measurements of noise level and spectrum for more than 4,000 cruising vehicles. Furthermore, where the recommended limits might be considered stringent in relation to current practice (e.g. for air-conditioning systems and snowmobiles), technical feasibility studies have also been carried out.

Hundreds of copies of the National Research Council report have been sent, on request, to elected and appointed officials, consultants and members of the public. Legislative action based on the report has already been taken by the city of Ottawa (Appendix 1) and is under discussion in several other places.

2. PROVINCIAL STATUTES RELATING TO HIGHWAY TRAFFIC

Highway traffic is regulated by provincial statutes. Each province has a statute section or regulation requiring that all motor vehicles be equipped with an exhaust muffler in good condition to prevent excessive or unusual noise. In some provinces, the use of a muffler cut-out, straight exhaust, gutted muffler, hollywood muffler, by-pass or similar device, is expressly forbidden. Two provinces, Alberta and British Columbia, have clauses which deal explicitly with loud and unnecessary noise due to improper use of the motor vehicle (e.g. tyre noise due to wheel spinning). The Province of Alberta has a section regulating the night-time operation of motor vehicles on residential streets within urban areas.

The effectiveness of these measures is not easy to determine but the numbers of court convictions registered in two provinces are indicative. In the Province of Ontario, which has more than 2,000,000 motor vehicles, it is reported that 26,538 convictions were registered in 1968 under Section 42 which covers noise, faulty mufflers, fumes, smoke and alarm devices (horns). It is not known how many cases related to noise offences. It is also noteworthy that 1,397 convictions were registered in the Province of British Columbia in 1968 under Section 7A.01 which deals with loud noise due to spinning tyres and similar improper use of the motor vehicle.

Elsewhere, it is recognized that statutes containing verbal descriptions of noise are not entirely satisfactory since it is left to the judge-

ment of the police officer whether a particular noise is excessive or unnecessary.

All provinces impose speed limits of 30 miles per hour in cities, towns and villages except on designated arterial roads and freeways where higher speed limits may be set. These speed limits are imposed for safety purposes and generally enforced. It is recognized that noise emission is related to vehicle speed, but there is no evidence that noise levels have ever been considered in setting speed limits.

In the Province of Alberta, the recently appointed Alberta Advisory Committee on Pollution Control has formed a sub-committee on noise which is particularly interested in urban traffic noise control.

3. MUNICIPAL ANTI-NOISE BY-LAWS

Local municipalities in Canada are entities created by the provincial governments with limited powers to prohibit or regulate "unusual noises or noises likely to disturb the inhabitants".

In 1958, the Municipality of Metropolitan Toronto passed a special By-law No. 835, which was slightly amended by By-law 1790 in 1962 and approved by the Ontario Department of Transport in 1963, 1964 and 1965. This by-law defined undue noise (from a motor vehicle) as "any sound, the overall sound pressure level of which exceeds 94 decibels when measured at a distance of 15 feet or more from its source by use of the C-weighting scale and the slow setting of a sound level meter". In 1963, a summons issued under this by-law was dismissed by the magistrate but his decision was appealed and was reversed in County Court on 2nd November, 1964. The driver of the vehicle was fined $25. Despite this initial success, it would appear that no further charges have been laid under this by-law since that time.

In 1968, the City of Ottawa sought special legislation in the Ontario Legislature to enable it to deal more effectively with motor vehicle noise and other problems. This legislation was approved with amendments and received assent on 11th April, 1968. The City of Ottawa was then able to prepare a by-law based upon the recommendations contained in the National Research Council of Canada Report. This most recent By-law No. 163-69, was passed by City Council on 2nd September, 1969 and approved by the Ontario Department of Transport on 22nd October, 1969. In connection with the enforcement of this by-law two police officers have received special training in the use of a sound level meter. In this connection also, one may refer to an outdoor noise "thermometer" built by the Canadian Research Council which displays the dBA sound level of passing vehicles for the benefit of the drivers. This "thermometer" is available to cities on

loan for educational purposes and was used by the City of Ottawa in Spring 1970, in connection with the enforcement of the new by-law.

In the city of Edmonton, Alberta, an *ad hoc* committee of experts surveyed the noise levels in eight areas of the city and prepared a draft by-law similar to that of Ottawa which is now awaiting final approval by the City Council. When the by-law is passed it is expected that a 3-month introductory period will precede legal enforcement.[1]

4. TRAFFIC FLOW

In Canadian cities, it is the general practice to minimize the movement of heavy motor vehicles on residential streets. This is accomplished either by designating mandatory "truck routes" or by prohibiting through traffic in residential areas. The purpose of these measures is to preserve the aesthetic values of residential neighbourhoods, to minimize noise and nuisance and to preserve property values.

In recent years, systems of one-way streets have been established in most Canadian cities, particularly in congested downtown areas, for the purpose of increasing the traffic carrying capacity of these streets. For the same reason, sophisticated traffic flow control devices have been installed in many places in recent years (e.g. computer-controlled traffic signals). There is no evidence that possible noise control benefits have ever been considered in making decisions about such matters.

5. URBAN PLANNING AND HIGHWAY LAYOUT

The cities of Canada have, in recent years, prepared and adopted overall plans which include industrial, commercial and residential zoning. While it has been recognized that industrial-commercial zones provide effective acoustic and aesthetic barriers between major traffic arteries and residential areas, many new traffic arteries and freeways do pass through residential areas, particularly in older parts of the cities.

In the past year or two, there has been evidence of changing attitudes, however. In Ottawa, for example, a proposal to route major traffic arteries through the "Glebe" area has been strongly contested by the residents and various alternative proposals are now under study

1. The City of Calgary, Alberta, recently approved an antinoise by-law which took effect on 31st October, 1970 (see Appendix 2).

by a committee of citizens and officials. The citizens have argued that the proposed traffic route would destroy a desirable residential area by splitting it in two, create excessive noise, reduce aesthetic values and lower the value of property.

On a much larger scale, the proposed extension of the Spadina expressway (a depressed freeway to the centre of Toronto) has been strongly opposed by many people. In this case it has been argued that the number of motor vehicles in the central area must be limited if essential environmental qualities are to be preserved, and that this requires investment in public transportation systems rather than expressways.

It should be noted that grade separation is generally considered essential for downtown expressways. Moreover, elevated highways have generally proved very costly so there is a strong tendency to build depressed expressways for reasons of cost alone, though it is recognized that there are acoustic benefits. Hence, depressed expressways *are* being built in Canadian cities but, in most cases for reasons other than noise abatement.

This trend is confirmed very cogently by two case histories in Montreal. In the first of these, it was necessary for l'autoroute Décarie, which is 3.3 miles in length, to pass through several municipalities in the west end of Montreal. For aesthetic reasons, not for noise abatement purposes, it was decided to build this expressway in cutting. The National Research Council was, however, consulted about the acoustic design of the cutting. In the second case, hospital authorities asked that a section of expressway be depressed. This was in fact done but it is probable that a cutting would, in any event, have been chosen as the best means of crossing an important railway and a major traffic artery.

Recent practice in British Columbia with regard to freeway design in urban areas included noise pollution as one of the factors assessed in selecting an optimum solution.

6. SOUND INSULATION OF RESIDENTIAL BUILDINGS

Superior sound insulation against external noise has been required for apartment buildings erected in the vicinity of an airport in Canada, but no case is known where sound insulation has been required for residences built near traffic arteries.

Double glazing to provide adequate thermal insulation against the severe winter climate is normal in Canada except in the warmer coastal regions. This also provides substantial sound insulation against traffic noise but is, of course, of no avail when the windows are open in the summer. Year-round air-conditioning with permanent double glazing has become fairly common in commercial and industrial buildings and is also found in a small percentage of residences.

Appendix 1

CITY OF OTTAWA BY-LAW 163-69[1]

A by-law of the Corporation of the City of Ottawa prohibiting noise in the operation of motor vehicles on the streets and public ways.

The Council of the Corporation of the City of Ottawa enacts as follows:

1. In this by-law:

   a) "vehicle" shall mean a vehicle as defined in Sub-section 29 of Section 1 of the Highway Traffic Act, R.S.O. 1960, Chapter 172;

   b) "noise level in dBA units" shall mean the reading of any sound level meter which meets the International Electro-technical Commission Standard No. 123 or the British Standard No. 3539, Part 1, or the United States of America Standard S1. 4-1961, when such meter is set on the A-weighting network and the fast response;

   c) "night" shall mean the period between 9.00 o'clock in the afternoon and 6.00 o'clock in the forenoon of the following day.

2. No person shall operate or cause to be operated a passenger vehicle or truck with rated gross vehicle weight of less than 6,000 lbs., the noise from which vehicle at a distance of 15 feet or more has a level greater than 83 dBA.

3. No person shall operate or cause to be operated a motorcycle, the noise from which motorcycle at a distance of 15 feet or more has a level greater than 88 dBA in the daytime and 83 dBA at night.

4. No person shall operate or cause to be operated a passenger vehicle or truck with rated gross vehicle weight of 6,000 lbs. or more, the noise from which truck or passenger vehicle at a distance of 15 feet or more has a level greater than 90 dBA.

5. No person shall operate or cause to be operated a tractor trailer, the noise from which tractor trailer at a distance of 15 feet or more has a level greater than 90 dBA.

6. Every person who contravenes any of the provisions of this by-law shall, upon conviction thereof, forfeit and pay at the discretion of the convicting magistrate, a penalty not exceeding the sum of $300.00, exclusive of costs, for each offence.

7. Sections 9 and 20 of By-law No. 268-56 are hereby repealed.

GIVEN under the corporate seal of the City of Ottawa this day of , 1969.

1. This by-law was approved by Board of Control on 19th August, 1969, passed by City Council on 2nd September, 1969 and approved by the Ontario Department of Transport on 22nd October, 1969.

CANADA

Appendix 2

CITY OF CALGARY

Anti-Noise By-Law
to take effect as from 31st October, 1970

LIMITS FOR MOTOR VEHICLE NOISE AT A DISTANCE OF 15 FEET

	Speed less than 30 mph	Speed 30–45 mph	Speed greater than 45 mph
Light motor vehicles, cars, motor-cycles, light trucks	80 dB(A)	85 dB(A)	88 dB(A)
Heavy trucks	87 dB(A)	91 dB(A)	95 dB(A)
Tractor trailers	88 dB(A)	94 dB(A)	98 dB(A)

FRANCE

1. ORGANISATION OF MEASURES FOR THE CONTROL AND ABATEMENT OF URBAN TRAFFIC NOISE

In France, there is no central body responsible for the overall co-ordination of the noise abatement activities of the public authorities, and the creation of such a body is not planned for the immediate future.

A number of government departments, however, each in its own field, have responsibilities in this connection:

- the Ministry of Equipment, responsible for laying down noise level standards for vehicles and for defining the conditions of sale of vehicles and new exhaust systems;
- the Ministry of Health, responsible – in particular, through the agency of the Noise Commission – for assisting in the definition of desirable noise levels;
- the Ministry of the Interior and the Ministry of the Armed Forces, responsible, by means of the police force and gendarmerie, for the enforcement of approved legislation and regulations.

It is interesting to note that the French Anti-Noise League was declared to be "in the public interest" in 1963 and from that time its activities have been subsidized.

In addition, at the end of 1969, an Inter-Ministerial Committee was set up by the Prime Minister to study the nuisance problem. This Committee's report contains proposals for dealing with water and air pollution and for reducing annoyance caused by noise.

FRANCE

2. REGULATIONS AND PRACTICAL MEASURES FOR LIMITING VEHICLE NOISE

2.1. *VEHICLES AND THEIR USE*

The noise produced by motor vehicles is the subject of detailed regulations[1] which lay down noise limits, varying with vehicle category, that must not be exceeded.

The main principles of these regulations are as follows:

– The noise produced by a motor vehicle and measured during approval testing, by type or singly, for the vehicles of the category concerned, must not exceed the figures shown in the following table, *a one decibel tolerance being allowed:*

Vehicle category	Maximum noise level dB(A)
Mopeds	76
Light motor cycles	80
Motor cycles and market garden tractors	86
Commercial vehicles of up to 3.5 tons laden weight	83
Private cars	83
Public transport vehicles	90
Commercial vehicles of over 3.5 tons laden weight, agricultural tractors and self-propelled agricultural machines	90

– The parts of the vehicle and in particular the exhaust system should be kept in good condition or replaced as necessary so that the noise produced by the vehicle does not exceed the levels laid down.

– Any change whatsoever to the exhaust system likely to increase the noise emitted by the vehicle is prohibited.

– In built-up areas, the use of excessively high engine speeds, particularly when starting or when stationary, and repeated "revving" of the engine, are prohibited.

Additionally, there is a limitation on the use and type of audible warning devices.

1. Ministerial Order of 25th October, 1962 concerning the measurement of noise produced by motor vehicles (the full text of this Order is reproduced in Appendix 1, page 91).

The use of multi-tone horns, sirens and whistles is prohibited. Between nightfall and daybreak, warning signals must be visual by means of headlamps, audible signals not being allowed except in cases of absolute necessity. In built-up areas the horn must not be used except in cases of immediate danger, and the signals given must be short and great moderation must be exercised.[1]

Should the devices intended to prevent a vehicle from being excessively noisy have been modified or removed the police or gendarmerie have the right to require the vehicle to be taken off the road until the owner has restored it to its proper condition.[2]

Additionally, any person contravening the provisions concerning noise produced by motor vehicles can be fined Frs. 40 to Frs. 60 and, for a repeated offence, can be sentenced to eight days or more imprisonment.[3]

When the police or gendarmerie officers stop the driver of an excessively noisy vehicle, they not only charge him with an offence but also issue a summons to him to bring the noisy vehicle to the test centre nearest to where he lives.[4]

In the noise testing centres, the vehicles are examined by means of a sound-level meter as laid down in the specifications attached to the Order of 25th October, 1962. This measure is designed to bring pressure on the offender to have his vehicle repaired before presenting it at the test centre. If the vehicle is not brought within a period of one month from the date of the offence, a fine of Frs. 60 to Frs. 360 can be imposed.[5]

In principle, each county (Département) has its test centre, generally in the vicinity of the main town and equipped either with portable sound-level meters or laboratory vans. Testing takes place on set days each month.

In practice, police officers may stop all vehicles making what seems to them to be excessive noise. They fine on the spot if the cause of the noise is apparent: damaged or obviously modified silencer, unnecessary "revving" of the engine when stationary or excessive acceleration etc. If the cause of the noise is not visible (where, for example, the baffles have been removed from the silencer), or where doubt exists, the penalty is not imposed until after inspection in a test centre.

Police officers on normal duty are not equipped with noise measuring instruments but directives are given to them from time to time, and they are given instruction on how to locate those parts of vehicles that are sometimes modified in order to make them noisier.

1. Articles 31 to 35 of the French "Code de la Route".
2. Article R 278 of the "Code de la Route".
3. Article R 239 of the "Code de la Route".
4. See Section 4: Annual statistics on the number of vehicles checked in Paris at the Noise Testing Centre and results of the 1968 anti-noise campaign.
5. Article R 242 of the "Code de la Route".

2.2. *TRAFFIC*

Very many traffic bans have been decided at local level on certain roads, mostly for heavy load-carrying vehicles but sometimes for all vehicles. These bans may be continuous and total, or limited to certain hours or a certain period of the year. Diversions by-passing the centre of built-up areas are a feature of practically all main arterial routes. They have many purposes: lightening traffic in town, easing pedestrian movement, protecting places of tourist interest and safeguarding the peace of those living near the roads.

These bans or limitations are so numerous that it is impossible to list them here. The following two examples, however, are interesting:

i) In Paris, the island of Saint-Louis has been put out of bounds to motor traffic from 6.00 p.m. to 2.00 a.m. as from 1st September, 1969, apart from the two main roads joining the two banks of the Seine.

ii) By inter-prefectoral Order, commercial vehicles are prohibited from going through the towns of Anse and Villefranche – near Lyons – as from the month of August, 1969. This measure was taken as the result of trouble between inhabitants and vehicle operators. Many trucks were no longer using the Anse-Villefranche diversion after this was made part of the toll motorway section. The inhabitants had then protested against the noisy traffic jams caused by commercial vehicles in the main street of the town.[1]

Moreover, a number of spas and health resorts – Vittel in particular – have created "silence zones" where motor traffic is controlled and where efforts are made to reduce the generation of noise.

In Vittel, the main hotels and buildings used for conferences are located in the "Parc Thermal" green zone, an area closed to traffic from 10.00 p.m. to 7.00 a.m. Traffic barriers are placed in position every evening by the municipal police and signboards indicate alternative routes.

In all built-up areas, speed is restricted. This limit is generally set at 60 km/h, but at local level it may be reduced for a particularly dangerous road or raised to 80 km/h in the case of a road that is part of a main traffic route. Very often, different speed limits apply to different types of vehicle (cars, heavy load-carrying vehicles, motor cycles).

It should be noted that these measures are primarily taken because of the danger of accident and not because of noise.

Various other measures are taken at local level to ease the traffic flow: one-way streets, temporary diversions, recommended routes.

1. It should be noted that at the beginning of 1970, the toll on the motorway was lowered for commercial vehicles so as to dissuade their drivers from crossing Anse and Villefranche by the main road.

The main purpose of these measures is to improve traffic flow but in some cases they have a not insignificant secondary effect, the acoustic environment ceasing to be made up of a succession of peak noises and becoming a continuous background noise.

3. LOCATION AND CONSTRUCTION OF THROUGH ROADS AND BUILDINGS: SOUND INSULATION OF DWELLINGS

In some cities (Paris, Lyons and Marseilles in particular) roads have been built or are being built in cuttings or in tunnels. The design and choice of motorway layout are very often guided by traffic flow and cost considerations, more rarely by esthetic factors and very seldom by noise considerations.

Nevertheless, research is underway on acoustic barriers designed to protect the inhabitants living in the vicinity of urban expressways. A study by the Centre Scientifique et Technique du Bâtiment (CSTB) conducted for the Transport Research Institute (IRT) has resulted in a list of noise reduction values for various types of barriers, which can be used directly by urban planners. Furthermore, full-scale tests using a 300-metre-long screen will be performed jointly by the Paris region authorities and the CSTB (see also para. 3.3.3. of the main report).

The town planning authorities for the Paris area have suggested that in order to prevent the average noise-level exceeding 60 dB(A) in front of dwellings – this is the acoustic threshold that, according to the results of surveys should not be exceeded – three different types of regulations would need to be adopted, depending on the local situation.

Assuming that the motorway takes the form of an approximately 50-metre-wide platform, the rules would be as follows:

A. Optimum clearance of the areas on either side of the motorway whenever land utilization requirements are not such as to justify the employment of less effective protection. This rule, which must be systematically applied in rural areas, includes a 100-metre building line necessary to provide an adequate margin for the future and an extension of further 50 metres for private houses (which may thus not be built closer than 150 metres from the edge of the motorway) and 100 metres for higher buildings (which may therefore not be situated at less than 200 metres from the edge of the motorway).

B. This rule is for general application in urban areas. It features a 50-metre building line (which can be reduced to 25 metres for second-class expressways), and the possible presence of buildings other than residential up to a further 50-metre line.

Dwelling houses may be built between 100 and 150-metres from the edge of the carriage way if they are no more than 12 metres in height (groundfloor plus 3 storeys). Between 150 and 200 metres, residential buildings may not exceed 37 metres in height.

C. The application of this rule should be preserved for the exceptional case represented by the densest parts of the built-up area. Its principle is to allow a choice between protection by distance and protection by screen. Under this rule the building line can vary from 10 to 25 metres from the road. Only sound-insulated dwellings or buildings other than living accommodation may be authorized in the area between this building line and a distance of 100 metres from the carriageway. Within the area lying between 100 and 150 metres from the edge of the carriageway, the height of residential buildings must not exceed 15 metres. The foregoing provisions could be modified if the buildings were separated from the expressway by a screen.[1]

It should be noted that these draft regulations are still under examination. The adoption of urban regulations relative to traffic noise is difficult in view of the presently available information on the economic aspect of external costs and the validity of annoyance thresholds. It may well be that by developing regulations based on a functional classification of highways and a too normative definition of zoning and annoyance the regulation will be too rigid in relation to the inherent limits of urban planning.

The success of such regulations will probably rest with the variety of development strategies chosen by cities, taking into account the various protective methods available and their efficiency.

As regards the acoustic insulation of buildings, and in order to help architects and town planners to allow for noise problems in their projects, the CSTB organises regular courses of instruction in acoustics and visits to the experimental station at Champs-sur-Marne, where practical examples of high-quality acoustic insulation are on display. Reference might also be made to an interesting project – the creation of a new town, Vaudreuil, which is being studied in detail by environmental experts with the aim of making this experimental town a silent one.

4. NOISE ABATEMENT IN PARIS

Although noise abatement is now organised at national level by the ministries concerned, it originated in Paris, the first step coming

1. By a screen is meant a barrier through which sound cannot pass, at least 1,5 m above the level of the carriageway along the edge of the road and in continuous sections of at least 100 metres in length.

from the Préfecture de Police: On 20th July, 1954 the Préfet de Police signed an Order prohibiting the use of horns. On the 5th June, 1959, the Order on noise was issued (see Appendix 2, page 94), the main content of which was later used for the formulation of the National Ministerial Order of the 25th October, 1962. (See Section 2.1 above and Appendix 1).

Furthermore, since 1963, a vehicle noise control centre is in operation, and is located in the Bois de Vincennes. At this test centre the annual statistics provide the following figures:

Year	*Number of vehicles checked*
1963	2,544
1964	1,008
1965	2,084
1966	1,884
1967	822
1968	1,529
1969	2,501

Moreover, legal actions have been taken in a large number of cases for noisy exhaust systems or excessive use of the horn:

Year	*Noisy exhaust*	*Excessive use of horn*
1967	3,347	9,597
1968	983	5,831

The Paris police do not confine their action to traffic noise alone. Manufacturers and contractors causing undesirable noise may be made to take remedial measures, these being required by the Préfecture de Police when the complaints received are proved to be well-founded. Additionally, since March 1960 the operation of portable radio receivers in the streets of Paris is prohibited and the use of rubber or plastic dustbins has been made compulsory in order to reduce the annoyance of refuse collection in the early hours.

But it is mainly the anti-noise campaigns that have attracted public attention. The most recent anti-noise campaign was organised from 18th-30th November, 1968.

It was given publicity in all available media (posters, advertisements in newspapers and on radio and television, etc.) and comprised two stages. In the first, offences were not reported, the drivers of excessively noisy vehicles were simply asked to remove the cause of the noise and to visit the test centre. In the second stage, legal action was taken and the offending drivers taken to court.

FRANCE

Throughout this campaign and the week that followed, i.e. up to the 7th December, 1968, two test centres were operated by the technical department of the Préfecture de Police: one in the Bois de Vincennes for all vehicles (this centre incidentally is used throughout the year and not only during the anti-noise campaigns); the other was set up in the Place des Invalides in the 7th Arrondissement and reserved exclusively for motorcycles and mopeds.

These centres were open every day except Sunday, from 8.00 a.m. to 6.00 p.m. Attendance there was not restricted purely to drivers stopped by police officers and instructed to bring their vehicles along; any person wishing voluntarily to have his vehicle's noise level checked could go.

1,161 vehicles were tested as the result of their owners being instructed to attend and 173 vehicles were brought spontaneously during this campaign. This total of 1,334 vehicles was made up of 905 cars and trucks and 429 motor cycles and mopeds.

It was found that 18% of the cars and trucks tested and 24% of the motor cycles and mopeds were emitting noise of unacceptable level. It should be noted that in line with the spirit in which this campaign was conceived, the owners of the vehicles stopped were asked to have them repaired before they came to the test centre. It is clear that a larger number of them followed this advice, otherwise the proportion of vehicles with unacceptable noise level would have been very much higher, since only those vehicles were stopped which were audibly producing an abnormal amount of noise.

From the tables below, in which the results of the test have been reproduced, it can be seen that there are three basic reasons liable to cause vehicle noise to reach an unacceptable level:

- exhaust system worn due to age (silencer holed by rust) or accidentally damaged;

NUMBER OF TESTS CARRIED OUT
BETWEEN 18th NOVEMBER AND 7th DECEMBER 1968

	Motor cycles and mopeds		Cars	
Number of vehicules attending on instructions from the municipal police	333		828	
Number of vehicules brought voluntarily	96		77	
Total vehicles tested	429		905	
	Normal	Unaccept.	Normal	Unaccept.
Results by category	326 (76%)	103 (24%)	749 (82%)	161 (18%)

- exhaust system modified by vehicle owner;
- original exhaust system replaced by a so-called "sports" exhaust, supposedly intended to increase the power developed by the engine.

All vehicles tested whose exhaust system was defective or had been modified were without exception found to be unacceptable. As regards the category of vehicles whose original exhaust system had been replaced, 80 % were considered to be excessively noisy.

For the most part, those people who were called to the test centres showed, when they came, complete understanding of the reasons for the campaign and its usefulness.

RESULTS OF TESTS BY YEAR OF MANUFACTURE
(Motor vehicles only, the year of manufacture of motor cycles and mopeds being in general unknown)

Year	Total	Normal noise level	Unacceptable level
		%	%
Prior to 1959	174	134 (77)	40 (23)
1959	45	42 (93)	3 (7)
1960	42	39 (93)	3 (7)
1961	77	63 (82)	14 (18)
1962	86	76 (88)	10 (12)
1963	79	72 (91)	7 (9)
1964	95	84 (88)	11 (12)
1965	100	81 (81)	19 (19)
1966	74	55 (74)	19 (26)
1967	63	47 (75)	16 (25)
1968	70	51 (73)	19 (27)
Total	905	744	161

ANALYSIS OF CAUSES FOR WHICH THE NOISE LEVEL OF CERTAIN VEHICLES WAS FOUND TO BE UNACCEPTABLE WHEN TESTED

	Normal noise level	Unacceptable noise level
Vehicles with defective exhaust system	0	190 (100%)
Vehicles whose exhaust system had been modified by vehicle owner	0	43 (100%)
Vehicles whose exhaust system was different from that originally fitted	8	31 (80%)

FRANCE

5. SURVEYS OF URBAN TRAFFIC NOISE

The requirements of the authorities responsible for town planning and building have, for some years now, made it essential to conduct surveys designed to assess the annoyance caused by urban traffic noise.

At the request of the Paris District authorities and the Ministry of Equipment, the Scientific and Technical Centre of the Building Industry (CSTB) carried out:

a) in 1965, a survey among people living alongside the south motorway and the Paris ring motorway; and

b) towards the end of 1968, a large-scale survey based on a sample of 2,000 people living in the Paris area;

a) 1965 survey

The sample of families involved in this survey (420 interviews) was based on acoustical considerations, the noise levels used being the average noise levels (exceeded for 50 % of the time) measured at the front of residential buildings.[1] It was considered that levels inside the dwellings are 10 to 15 dB lower than the measured level when the windows are closed, and 0 to 5 dB lower when the windows are open.

Nine residential communities alongside the south motorway and the ring motorway were selected: altogether 420 families were called on. The most distant dwellings were 150 metres from the side of the motorway and the closest 10 metres away. Noise levels recorded ranged from 53 to 81 dB(A).

The questionnaire contained 66 questions, 38 of them relating to motorway noise. Fifteen of these questions were designed to enable an annoyance scale to be constructed so that annoyance scores from 0 to 10 could be awarded, the value 10 corresponding to maximum annoyance. According to the authors a fairly high degree of correlation ($r = .61$) is shown to exist between annoyance scores and noise levels at least in so far as buildings parallel to the motorway are concerned. On the other hand, a faster increase in annoyance is observed once average external noise level reaches a point between 62 and 64 dB(A).

From the results they had obtained the CSTB research workers estimated that a critical annoyance level is reached when the noise level attains 60-65 dB(A) at the front of the buildings.

1. *La gêne due au bruit de la circulation automobile. Une enquête auprès des riverains d'autoroutes, (Annoyance caused by vehicular traffic noise. A survey among those living alongside motorways).* CSTB Publication No. 88-762 (October 1967).

b) 1968-1970 survey

The results of this survey are not yet analysed and discussion must therefore be restricted to its objectives and the method of approach adopted. [1]

The overall purpose of the survey is:

- research into physical parameters characterizing traffic noise and providing optimal correlation with claimed annoyance and disturbance of sleep in urban situations;
- the definition of maximum noise levels not to be exceeded at the front of residential buildings;
- the devising of a method enabling the characteristics of urban traffic noise to be worked out on the basis of the road cross-section and the intensity and type of traffic carried;
- the compilation of a catalogue of case studies: roads of various types with and without traffic lights.

The study is based upon a comparison between physical noise measurements and the results of the attitude survey.

The measurements relate to 100 points throughout Paris and its suburbs, 20 people being interviewed at each point.

The roads along which acoustic measurements are taken are of various types: one-way and two-way through traffic roads, local roads, cross-roads and internal net-works in housing complexes.

The noise readings are made at the front of buildings at different heights.

The psycho-sociological survey itself was preceded by a pilot survey the results of which were used to establish an annoyance scale. The replies to the questionnaire and the annoyance scores obtained by means of the annoyance scale will be cross-analysed with various physical parameters: noise level in dB(A) exceeded for 1%, 10%, 50% and 90% of the time and a coefficient combining into a single formula the noise level exceeded for 10% of the time and that exceeded for 90% of the time.

An attempt will also be made to differentiate annoyance in relation to the time of day at which exposure to the noise occurs (morning, day-time, evening, night-time), and taking into account the number of rooms per dwelling exposed to the noise, occupants' sensitivity to noise, etc.

Before terminating this report on the efforts being made in France to reduce noise due to traffic in towns, it is interesting to note that the

1. Information supplied by the Acoustics Division of the CSTB.

FRANCE

first legislation on noise abatement was formulated no less than 161 years ago. Thus the Penal Code of 12th February, 1810 includes the following provision:

> "Those causing or abetting the causing of offensive or nocturnal noise, uproar or assembly disturbing the peace of the neighbourhood will be liable to a fine of 40 to 50 francs".

Appendix 1

MINISTERIAL ORDER DATED 25th OCTOBER, 1962 CONCERNING THE MEASUREMENT OF NOISE PRODUCED BY MOTOR VEHICLES

Article 1

The noise produced by a motor vehicle and measured during type approval tests or singly shall, for vehicles of the category concerned and except as otherwise provided in Articles 3 and 6 of this Order, not exceed the figures shown in the following table, *a one decibel tolerance being applicable to these values:*

Vehicle category	Maximum noise level dB(A)
Mopeds	76
Light motor cycles	80
Motor cycles and market garden tractors	86
Commercial vehicles of up to 3,5 tons laden weight	83
Private cars	83
Public transport vehicles	90
Commercial vehicles of over 3,5 tons laden weight, agricultural tractors and self-propelled agricultural machines	90

Article 2

The measurements shall be taken by a laboratory approved by the Minister of Public Works and Transport in accordance with the method laid down in the attached specifications[1] for tests made on the vehicle and for replacement silencer tests.

Article 3

Every silencing system must be designed so as to maintain its effectiveness over time. Clearly visible on an outer wall or on one of its integral parts it must carry an irremovable marking affixed:

1. The text of these specifications is not reproduced in this report.

3.1 By the vehicle manufacturer in the case of a silencer fitted as original equipment or sold as a replacement part under the name of the vehicle manufacturer; this marking certifies the conformity of the silencer with that fitted to the vehicle at the time of the type approval test by the "Service des Mines" (French vehicle approval testing authority).

3.2 By the manufacturer of the system in the case of a replacement silencer of another make; this marking certifies that the device has an acoustic effectiveness at least equal to that of the silencer fitted when the vehicle was type-approved tested by the Service des Mines, the vehicle having satisfied the conditions laid down in this Order. In addition replacement silencers must, when they are sold, be accompanied by instructions prepared by the manufacturer on his own responsibility showing the type or types of vehicles to which the tests carried out by the approved laboratory entitle them to be fitted.

Article 4

The parts of a vehicle and in particular the exhaust system must be maintained in good condition or replaced where necessary so that the noise produced by the vehicle does not exceed the levels laid down by this Order.

Article 5

5.1 In built-up areas, the use of excessively high engine speed, particularly when starting or when stationary, and repeated "revving" of the engine are prohibited.

5.2 Any change whatsoever to the exhaust system that may increase the noise emitted by the vehicle is prohibited.

Article 6

6.1 The provisions of Article 1, 2, 3 and 4 shall apply as from 1st October, 1961 to type-approved vehicles or single vehicles after that date.

6.2 The provisions of Articles 1, 2 and 4 shall apply:

6.2.1. As from 1st April, 1962, to vehicles put into use for the first time after that date and conforming to a type approval, tested before 1st October, 1961, the provisions of Article 3 being applicable to such vehicles as from 1st January, 1963.

6.2.2 Except as otherwise provided in paragraphs 6.1 and 6.2.1 above, as from 1st October, 1963 to all mopeds, light motor-cycles and similar and motor-cycles in use, the provisions of Article 3 being applicable only to vehicles of a type not corresponding at that date to the conditions of Articles 1 and 4.

6.3 The provisions of Articles 1, 2, 3 and 4 shall apply as from 1st January, 1964 to the following vehicles for agricultural or civil engineering use taken into service for the first time after that date:

- crawler tractors and tractors driven by two-stroke diesel engine.

6.4 Vehicles in use belonging to the categories laid down in paragraphs 6.1, 6.2 and 6.3 of this Article shall be allowed an additional two decibel tolerance over and above the one decibel tolerance laid down in Article 1.

6.5 Vehicles not included in the categories referred to in paragraphs 6.1, 6.2 and 6.3 of this Article shall remain subject to the provisions of Articles 1 to 3 of the Order of 3rd August, 1957.

6.6 The provisions of Articles 2, 3 and 4 shall apply as from 1st October, 1963 to silencers sold as replacements for original equipment or as replacement silencers of other makes, which shall exhibit the markings laid down in Article 3.

6.7 The provisions of Article 5 shall apply forthwith.

FRANCE

Appendix 2

LOCAL ORDER REGARDING NOISE
DATED 5th JUNE, 1959
PARIS, PREFECTURE DE POLICE

Article 1

All noise caused either needlessly or due to lack of care is prohibited.

Article 2

1. Those noises are prohibited, in the conditions specified in Article 1, which arise, inter alia:

a) from work of whatever nature carried out on the public highway;

b) from a motor vehicle travelling at high speed;

c) from a vehicle's engine being accelerated;

d) from a vehicle's body-work or engine and its accessories in bad condition;

e) from badly installed or badly maintained brakes;

f) from the engine or a vehicle undergoing a test or being tuned;

g) from a vehicle travelling with a badly secured load;

h) from the handling, loading or unloading on the public highway of any noisy materials, equipment or objects whatsoever, such as metal plates and sheets, bars and rods, milk churns, refuse bins, cans and metal drums. These articles must be carried and not dragged, put down and not allowed to fall.

If these articles cannot be carried by reason of their size or weight, they must be fitted with a device enabling them to be moved noiselessly.

2. The following are also prohibited in the same conditions:

a) spoken or sung advertising announcements;

b) the beating of carpets, curtaining and materials.

The latter activity is absolutely prohibited before 7.00 a.m.

Article 3

The following are or remain prohibited in all circumstances:

a) the use of harsh, strident or multi-tone audible warning devices by the driver of a vehicle;

b) the use of a vehicle whose engine is not fitted with an effective silencer;

c) the use of whistles, and the like ("tierces"), sirens and similar instruments. However in industrial and commercial establishments, staff movements may be governed by means of bells and buzzers. Their use in that case must not exceed a period of 15 seconds;

d) the use on fairgrounds of "trumpet" or "swell" organs ("orgues à trompette, orgues expressifs"), big drums, bells, gongs, loudspeakers, sirens, whistles, horns and other particularly noisy instruments;

e) street parades and fairground music after 10.00 p.m. on week-days and after 11.00 p.m. on Saturdays, Sundays, the eves of public holidays and public holidays themselves;

f) all musical or vocal performances on the public highway, unless specially authorized;

g) the discharge of firearms, crackers or fireworks on the public highway except when authorized on the occasion of public holidays or festivities;

h) the use of loudspeakers on the public highway in the absence of special authority issued in the conditions laid down by the circular of the Minister of the Interior dated 21st September, 1949.

Article 4

Noise occasioned by an industrial, commercial or household activity and noise arising either from the discharge of fireworks, crackers and firearms or from the use of record players, loudspeakers, television and radio receivers and any musical instruments whatsoever is likewise prohibited, with due reference to the hour and the place, inside premises, dwellings or their outbuildings.

Article 5

All firms, craftsmen and workers using tools or appliances likely to produce a noise loud enough to sound outside the workshop must leave off work at all times of the year between 10.00 p.m. and 7.00 a.m.

The same requirement is binding on building contractors using road-breaking equipment, concrete mixers, reveting hammers and other noisy machinery.

Article 6

All motors or engines, whatever their nature, and all appliances, power-driven machinery and transmission systems used in plants or establishments not subject to the special legislation applicable to classified establishments must be installed and arranged in such a way that their operation can in no way disturb the rest and peace of the neighbourhood.

Article 7

The Orders dated 27th April, 1950, 20th July, 1954 and 21st August, 1954 are hereby revoked.

Article 8

Any breach of the provisions of this Order shall be reported by means of duly attested statements which will be submitted to the competent courts.

Article 9

The Director-General of the municipal police, the Director of traffic, transport and commerce, the Director of Technical Services, the Superintendents of police for the City of Paris and suburban districts, the Mayors of the Communes of the Seine Département, the Colonel commanding the Légion of the Garde Républicaine and the Colonel commanding the first Légion of the Gendarmerie Départementale are hereby instructed, each insofar as he is concerned, to ensure compliance with this Order.

ITALY

CENTRAL CO-ORDINATION

In Italy it is the General Road Transport Directorate of the Ministry of Transport and Civil Aviation which is responsible for vehicle noise control in that it conducts tests on motor vehicle silencers and is responsible for vehicle inspection.

VEHICLE NOISE EMISSION LEVELS

The administrative and legislative measures for limiting urban traffic noise are set out in the Highway Code and in its Rules of Application as well as in circulars drawn up by the Ministry of Transport and Civil Aviation. The maximum vehicle noise emission levels presently in force are laid down in Article 214 of the Rules of Application of the Highway Code, which stipulate that vehicles should not emit noise exceeding the following limits:

Vehicle Category	*Noise Level*
Mopeds	83 dB
Motorcycles with a two stroke engine and with an engine capacity not exceeding 200 cc	87 dB
Motorcycles with a 4 stroke engine and with an engine capacity not exceeding 200 cc	90 dB
All other motorcycles	92 dB
Motor vehicles with an internal combustion engine of a capacity not exceeding 1000 cc	88 dB

ITALY

Motor vehicles with an internal combustion engine of a capacity from 1000 cc-1500 cc	90 dB
All other motor vehicles (except agricultural vehicles)	93 dB
Agricultural vehicles on wheels with a multi-cylinder 4-stroke engine	94 dB
Agricultural vehicles on wheels with a two stroke engine or a 4-stroke cylinder	98 dB
Agricultural vehicles with crawler tracks	90 dB

These limits are reduced by 2 dB in the case of vehicle homologation, type certification of silencers and for tests on new silencers.

It should be noted that as of 10th August 1971, Italy will apply the directives of the European Economic Community given in Annex II of this report (see page 161).

Vehicles exceeding the authorized limits are not allowed on the road. The owners of vehicles found to exceed these limits are liable to be fined.

VEHICLE OPERATION

There are several articles in the Highway Code concerning vehicle noise:

Audible Warning Devices

All vehicles should be equipped with an audible warning device whose characteristics are laid out in the Rules of Application of the Highway Code; these characteristics are designed to avoid unnecessary and annoying noise. Police vehicles and ambulances may have supplementary audible warning devices. The driver of a vehicle not equipped with an authorized warning device may be fined from 4,000 to 10,000 lires (Article 46).

Silencers

Motor vehicles, motor cycles and mopeds must be equipped with an adequate silencer. The driver of a vehicle with a defective silencer may be fined from 4,000 to 10,000 lires (Article 47).

Vehicle Inspection

The Ministry of Transport may decide by a decree in the Official Bulletin on a general or partial inspection of private motor vehicles,

side-cars and motor cycles to ensure that they comply with safety and noise standards. General or partial inspection may take place once every five years.

All other motor vehicles notably public transport vehicles, vehicles for hire and trailers are inspected every year.

Private motor vehicles, motor cycles and mopeds may be subjected to a special inspection when such vehicles are believed not to comply with the regulations.

The Vehicle inspection authorities are empowered to inspect a vehicle at any time. Police authorities are also empowered to inspect vehicles on the road. Anyone found driving a vehicle which has not been inspected may be fined from 4,000 to 10,000 lires.

Offences against this Article may lead to the immediate withdrawal of the vehicle licence; in such cases the owner is obliged to present his vehicle to the Inspection authorities before the licence is given back (Article 55).

Avoiding unnecessary noise

All annoying noise caused by reckless driving, badly fastened loads, etc., must be avoided. Silencers must be kept in good working condition and should not be modified. Offences may lead to fines from 5,000 to 20,000 lires (Article 112).

Use of audible warning devices

Audible warning devices should be used with the utmost moderation. Their use is forbidden in built up areas except in emergency situations or for vehicles carrying injured or sick persons. At night the use of headlamps is to be preferred. Offences against this article may lead to fines of from 4,000 to 10,000 lires (Article 113).

The number of fines issued for offences against four of the above articles were as follows in 1966 and 1967.

	1966	1967
Article 46	16,037	14,743
Article 47	51,517	45,368
Article 112	36,099	41,116
Article 113	31,890	24,274

Speed limits

Speed limits have been imposed in built up areas and local authorities have been given the power to establish special speed limits in their respective localities, in part for reasons of noise.

ITALY

METHOD FOR MEASURING NOISE EMISSION

The method for measuring noise emission is laid down in Article 215 of the Rules of Application of the Highway Code. The measurement is made with a standard sound level meter. Measurements are made until 5 consecutive readings are identical within 3 dB; the final result is calculated on the basis of the average of the 5 readings.

Two types of measurement are made – one on a stationary vehicle and one on a moving vehicle.

a) *Stationary vehicle.* The readings are taken by means of a microphone placed at a distance of 7 metres directly to the rear of the exhaust pipe at a height of between 1 metre and 1.25 metres above the ground. There should be no obstacle between the vehicle and the microphone. The test is conducted with no load on the engine and at peak power r.p.m.

b) *Test on moving vehicle.* The vehicle moves along a straight line which coincides with a line 7 metres away from the microphone of the sound meter placed on the same side of the vehicle as its exhaust pipe at a height of between 1 to 1.25 metres. The vehicle is driven in its lowest gear ratio in such a way that when it is at a right angle to the microphone it is at its peak power r.p.m. and is developing maximum power. The reading to be applied during each test is the maximum noise level indicated by the instrument for a duration of a second.

The engine may be loaded in the following ways applied separately or in combination:

– using the inertia of the vehicle and its rotating assemblies (acceleration tests);

– using the gradient of the road (uphill tests).

The test may be conducted using a roller-type dynanometer – when such equipment is available.

In the case of agricultural vehicles with crawler tracks, only the stationary test is used.

JAPAN

1. CENTRAL CO-ORDINATION

In order to promote intensive and overall measures against environmental pollution, the Headquarters for Environmental Pollution Control Measures, headed by the Prime Minister, were established within the Prime Minister's Office in July, 1970. The Headquarters are empowered to co-ordinate environmental measures taken by the various Ministries concerned, and the same applies to noise regulations. Noise from automobiles, factories, and from construction works has been controlled in accordance with the respective noise standards under the Noise Regulation Law enacted in 1968. Furthermore, the introduction of environmental quality standards for noise is under study.

The Ministry of Transport regulates noise emission from motor vehicles, either through standard type approval tests of a production model or through checks on the condition of vehicles in use, according to the safety standards laid down in the Road Transportation Vehicle Law. The National Police Agency regulates road traffic and where necessary, may intervene with regard to noise control by inspecting vehicles on the road as a part of the general traffic control required by the "Road Traffic Law".

The Environmental Agency established on July 1st, 1971, is to play a central role in implementing various environmental measures. It is the Agency's task therefore to stipulate noise tolerance levels to comply with the "Noise Regulation Law".

2. CURRENT ADMINISTRATIVE AND LEGISLATIVE PRACTICES REGARDING VEHICLES, VEHICLE CONSTRUCTION AND MAINTENANCE

The Road Transportation Vehicle Law specifies that no motor vehicle shall be allowed on the road unless it meets the vehicle safety

standards laid down in the Ordinance of the Ministry of Transport. As from 1951 all vehicles have been prohibited from emitting noise exceeding:

i) 85 phons as measured 7 metres to the left of the longitudinal axis of the vehicle when a motor vehicle is running on a level road at a speed of 35 km/h (or in the case of a motor vehicle for which the maximum speed is less than 35 km/h, at 60% of its maximum power).

ii) 85 phons as measured at a point 20 metres to the rear of the exhaust pipe when a motor vehicle is running unloaded at 60% of its maximum power.

The Vehicle Safety standards specify that every motor vehicle must be equipped with a suitable device such as a silencer so that the noise emitted does not exceed the above limits.

The type approval test for a new car is conducted by the Research Institute of the Ministry of Transport before the vehicle is allowed for sale. The standards for a new type of vehicle are more stringent than for vehicles already on the road.

The standards shown below are applicable to new types of vehicles as from 1st April, 1971, and all other vehicles registered before the above date should conform to the standards by January 1st, 1972.

Category of vehicle	Constant speed 35 km/h (phon)	Acceleration (ISO method) (phon)
Truck and bus		
Gross weight of vehicle exceeding 3.5 tons Engine power: over 200 h.p.	80	92
Gross weight of vehicle exceeding 3.5 tons Engine power: 200 h.p. or less	78	89
Gross weight: 3.5 tons or less	74	85
Passenger car	70	84
Motorcycle		
Engine capacity over 250 cc	74	86
Engine capacity 250 cc or less and over 125 cc ..	74	84

Note: Motorcycles with an engine capacity of 125 cc or less 125 cc do not fall under this regulation.

The Road Transportation Vehicle Law also specifies that all users of motor vehicles shall maintain their vehicles in a condition conforming to the Safety Standards. The Ministry of Transport is responsible for

conducting vehicle inspection – once a year for motor vehicles other than passenger cars, and once every two years for passengers cars. Vehicles which conform to the specified requirements are given an inspection certificate showing the term of validity of the inspection – together with an inspection "sticker" stamp for the vehicle. No vehicle is considered suitable for operation unless it complies with the Safety standards. Offences against this regulation are penalized. There are 830 vehicle inspectors operating in 69 inspection stations throughout the country who are responsible for ensuring that vehicles comply with the safety standards, which includes noise emission.

The method for measuring the noise level at the 69 inspection station is as follows:

- Ordinarily the inspector examines the vehicle with regard to noise by ear alone; if he suspects that the noise emitted exceeds the limit allowed he makes a precise measurement with a sound level meter. Should the vehicle be defective, no immediate fine is imposed but the owner must repair the vehicle within a given period. Should he fail to do this and continue to drive, or allow a noisy vehicle to be driven, he may be fined a sum not exceeding 30,000 yen. In the case of repeated offences (for noise or other reasons) the driving licence or vehicle validity certificate may be withdrawn.

Car dealers and repair shops have been requested by the Ministry of Transport not to install noisy mufflers, not to remove mufflers from vehicles, and not to conduct inadequate repairs on a vehicle.

NETHERLANDS

INTRODUCTORY REMARKS

Urban traffic noise is not yet a problem of priority concern in the Netherlands; urban nuisances such as water pollution in the first instance, air pollution and more recently aircraft noise as well as the unintended effects of pesticides have received far more attention by public authorities and are problems of which the public is particularly conscious.

1. ORGANISATION: CENTRAL CO-ORDINATING BODY

There is no single body in the Netherlands which deals with noise problems in general and there are no plans to set up any such co-ordinating body. Laws concerning urban traffic noise (see below) have been set up by the Ministry of Transport, and their application is enforced by the police authorities under jurisdiction of the Ministry of Justice. There is, however, no direct liaison between the Ministries of Transport and Justice on such matters.

2. CURRENT PRACTICE REGARDING VEHICLES AND VEHICLE OPERATION

The following regulations were laid down in June 1966:

NETHERLANDS

Category of Vehicle	Maximum noise level as measured by ISO test	
	Type approval	Road Test
A. *Motor Vehicles*		
Motor cycles Tricycles Passenger cars Motor vans of 3,500 kg or less, gross vehicle weight	83 dB(A)	85 dB(A)
Trucks and Buses of 3,500 kg and over, gross vehicle weight of 200 h.p. (DIN) or less	88 dB(A)	90 dB(A)
Trucks and Buses of 3,500 kg and over gross vehicle weight of 200 h.p. (DIN) and over	92 dB(A)	94 dB(A)
Acoustical signal for all motor vehicles except mopeds	Max. 104 dB(A) Min. 70 dB(A)	
B. *Mopeds*		
These vehicles must be of an approved type (laid down in the Road Traffic Regulations). One of the conditions for such approval is that the vehicle must not produce noise louder than:	74 dB(A) 73 dB(A)	77 dB(A) 77 dB(A)

The Netherlands are considering adopting the ECE levels (see chapter on United Nations). However, as the Netherlands rely for the great part on imported vehicles they will probably not adopt more stringent levels than those recommended by the ECE.

Non-type certified vehicles are, in principle, controlled in a similar manner to type certified vehicles.

The regulations lay down that owners of vehicles causing excessive noise (i.e. 2 dB(A) over the accepted noise emission levels) will be fined if they do not repair the car adequately within a given period. However, due to lack of staff and facilities, this procedure is rarely applied, and car owners are very much more frequently fined for safety reasons. There are no noise spot-checks in the Netherlands. The police are not equipped with simple noise-measuring devices, but when complaints concerning a vehicle are received, the police may intervene.

There are no special regulations concerning the condition or replacement of exhaust systems of vehicles (except mopeds) other than that the vehicle should not exceed the above limits. In the case of mopeds, it is forbidden to change the type of muffler installed by the manufacturer or to tamper with it in order to produce more noise.

Private vehicles are not subject to compulsory inspection. Public service vehicles – taxis, buses, and trucks carrying dangerous goods – are liable to compulsory inspection – for buses, every six months; for taxis and trucks, once a year. These inspections are essentially for safety purposes and, in the case of buses, noise is also taken into account. If the vehicles are found to be defective, the owners have a given period in which to restore the satisfactory condition of the vehicle; failing this, they are fined. Consideration is presently being given to the possibility of inspecting all vehicles in the future. But here again this will be essentially for safety reasons.

It is forbidden to operate vehicles (including mopeds) in a manner which will produce excessive noise. The definition of excessive noise, however, is not precisely specified. There are specific regulations concerning motor-horns; the use of sound signals is permitted only in the case of imminent danger, and in non-built-up areas when overtaking. Sound signals are forbidden in all circumstances at night, and are to be replaced by "on and off" headlights. In the case of motor vehicles, only horns with a single tone are allowed; for mopeds, only a bell is allowed. Under the Road Traffic Regulations, the sound level of a horn may not be lower than 70dB(A) or higher than 104 dB(A), measured at a distance of 7 metres from the source.

3. CURRENT PRACTICE REGARDING TRAFFIC

In general, there are no restrictions on certain types of traffic in certain streets; when such restrictions are enforced, this is for reasons of traffic congestion and safety, and not for the purpose of reducing noise.

In Scheveningen, the seaside resort near the Hague, mopeds are forbidden in the summer months, but noise is only a minor reason for this. On the island of Texel, in the north, a popular holiday resort, mopeds are forbidden at night; in this case noise reduction is a major aim.

The following speed limits are enforced:

Motor vehicles	:	Built-up areas: 50 km/h Open road: none
Mopeds	:	Built-up areas: 30 km/h Open road: 40 km/h.

Furthermore, special vehicles are subjected to certain speed limits.

Fines for infringement are high; with the exception of mopeds, these limits are generally well observed.

4. HIGHWAY DESIGN AND BUILDINGS

There are no rules concerning the distance of motorways from residential buildings, only general guidelines. Consideration is given to the noise factor in designing motorways in the vicinity of dwellings and guidelines have been established which stipulate that it is desirable in open country and small villages for low buildings to be situated at least 100 metres, and high buildings at least 200 metres from the motorway. Adherence to these guidelines is not mandatory; although originally drawn up for aesthetic reasons and to avoid driver distraction, they are now also used for acoustic reasons.

When cuttings and tunnels are used on a motorway it is mainly for engineering purposes. One notable exception is a motorway to be constructed on an island in the south of the Netherlands which is a nature reserve; it will be flanked by sand-banks so as not to disturb the wild-life with the traffic noise.

Also, in the urban planning of Bijlmermeer, certain residential streets are forbidden to through-traffic, and are open only to vehicles going to houses in a given street.

As far as buildings are concerned, 80% are state-subsidized, and while there are standards for sound-proofing *between* apartments, there are not standards concerning noise from the street. Attention is given in designing new building to arrange for bedrooms to be on the non-street side of the residential building.

5. GOVERNMENT PURCHASED VEHICLES

Government-owned vehicles are subject to the same statutory regulations as any other vehicles of the corresponding category. There are no special noise standards as concerns Government-owned vehicles.

6. IMPORTANCE GIVEN TO TRAFFIC NOISE

As mentioned earlier, there is not yet an acute traffic noise consciousness in the Netherlands; the press and political circles have not yet given particular attention to the problem, and there have consequently been no anti-traffic noise campaigns. The Dutch authorities consulted in the course of this enquiry felt that the most useful measures to be taken in further reducing urban traffic noise would be:

a) to reduce the noise at its source, by more consultation between the smaller non-car-producing countries to arrive at harmonized regulations concerning noise emission standards, and so constitute sufficient incentive to be offered to car manufacturers;

b) to develop a simple device for measuring noise in real traffic conditions to facilitate the enforcement by police authorities of the current noise regulations in real traffic conditions;

c) to study whether the reduction of air pollution caused by cars, presently a problem of major concern, can be effected without increasing noise emission.

SCANDINAVIA

The reports on Denmark, Norway and Sweden refer to a joint body – The Nordic Committee for Building Regulations (Nordiske Komite för Bygningsbestemmelser – NKB) which through its different sub-committees co-ordinates building and planning regulations in the 4 countries. One of these sub-committees is working on noise within communities, and in December 1966 put forward a proposal with standards and rules for the measurement of noise from highways (Stoj og Byplan). Though these recommended standards are not mandatory, they are nevertheless widely accepted or at least taken into consideration in urban development plans, highway construction and building design throughout the Scandinavian countries.

As the norm for the maximum permissible noise reaching dwellings from highways, the Committee has recommended 59 dB(A) as the average 24-hour energy level immediately in front of the dwelling, which corresponds to 35 dB(A) indoors with double-glazed windows closed [i.e. the double-glazed window offers a noise attenuation of approximately 24 dB(A)]. At such a sound level indoors it is possible to carry on a conversation at normal pitch. The application of a noise limit of 35 dB(A) by no means implies an extremely low noise level. The Committee points out that it would be most desirable to lower this limit to such an extent that an acceptable low level of noise would be obtained indoors even with the windows open. However, stricter standards would necessitate such great distances between highways and dwellings that their adoption would be financially prohibitive.

Figure 12 illustrates the minimum distance in metres between the middle of the road and buildings, depending on traffic density (both directions) and average velocity; the curves in the figure correspond to speeds of 40, 60, 80 and 100 km/h. It is assumed that the building is one storey high, that it is built on the same level as the motorway and that it is not shielded by screens or other objects. This figure shows that a doubling of the average speed from 40 to 80 km/h corresponds approximately to a doubling of the minimum distance, while a further increase in speed to 100 km/h only corresponds to a 20%

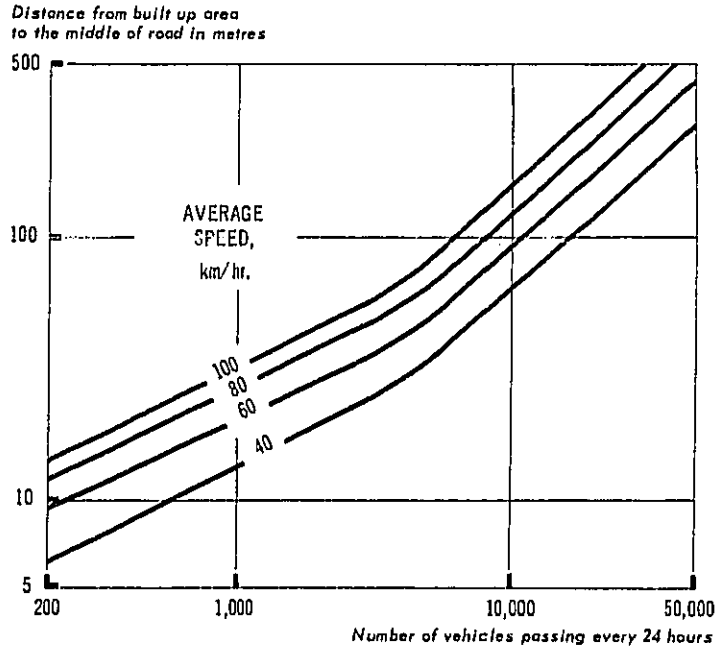


Figure 12. The minimum distance between the road and the housing area, depending on traffic density and average speed.

increase in the distance. This results from the fact that the noise emitted increases more slowly when speed is increased in the higher part of the speed scale than in the lower. [1]

It is reasonable to assume that the noise from a motor vehicle is emitted at a point 0.5-1.0 metre above the road. The component of the sound is directed downwards on to the road and is reflected, causing the sound to increase when travelling upwards. The volume of sound increases with height until the height is such that the distance takes over and muffles the sound. Figure 13 shows a number of curves plotted in a vertical section at right angles to the road. The heights

1. Recent work undertaken by S. Lindblad in Sweden indicates that the values of sound attenuation used to develop Figure 12 may be over conservative and that the minimum distance can be somewhat smaller than shown in this figure.

are shown in metres (one storey = three metres). The curves are based on measurements taken at distances of 15, 25, 50 and 100 metres from the road. Figure 13 clearly shows that if the same noise level is to be obtained in taller buildings as in one-storey buildings, then the distance between the building and the road must be increased to compensate. The greater the number of storeys, the greater must be the distance.

By placing a barrier between the road and the housing it is possible to reduce the minimum distances shown in Figure 12. The barrier may consist of belts of vegetation or permanent objects such as slopes, embankments, walls or buildings. The results of measurements recorded in thick, leafy vegetation shows that the muffling effect amounts to 2-3 dB per 100 metres and in thick plantation of coniferous trees to 5-10 dB per 100 metres. Belts of trees are not a satisfactory means in themselves for reducing the minimum distance between roads and buildings but they have a psychological damping effect in that attention is to a certain extent distracted from the disturbance (see also chapter on Switzerland). Planting of buffer zones with trees near roads with heavy traffic can bring about a reduction in the minimum distance which is not much less than the reduction achieved with other forms of shielding. By planting the whole length of buffer zones with trees giving a muffling effect of 3 dB, the minimum distance can be reduced as shown in Figure 14. The vegetation should consist of a closely planted mixture of deciduous and coniferous trees and should be thinned in good time so that the trees retain their lower leaves or alternatively low shrubs should be planted in the intervening spaces.

Building embankments, walls etc. make effective barriers on condition that they are located near to the source of noise and are sufficiently high. Where noise is to be muffled along a relatively short stretch of road, barriers parallel to the road should be of a certain length since some of the sound will pass around them and reduce the damping effect at either end of the barrier. The length of the barrier should therefore generally not be less than 100 metres. Substantial muffling of noise can often be achieved simply by taking noise control into account at the urban design and planning stages. The greater the attention paid to noise in the master plan of large areas, the fewer the subsequent noise problems. It is often possible in the master plan to locate noise-generating areas (industrial) far from sensitive (residential) areas. Areas in the master plan might be devised as follows:

1. Industrial estates: Little need of noise control, great need of road accessibility.
2. Service areas: (Commerce, administration, education entertainment and exhibitions). A certain need for noise control, but very great need of road accessibility.

SCANDINAVIA

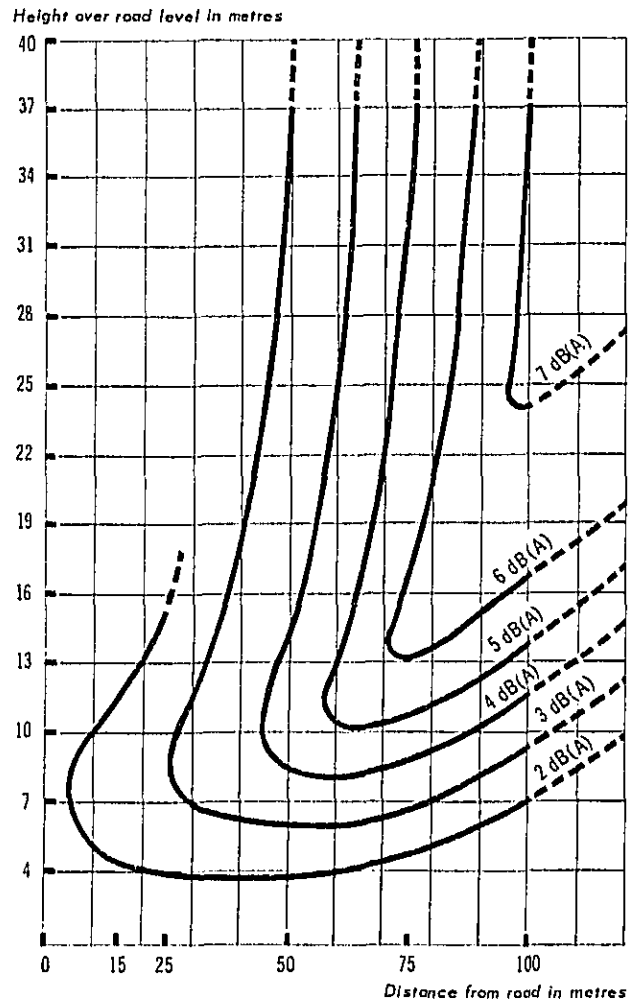


Figure 13. Increment to intensity of sound at road level, depending on the distance from the road and the height above the road surface (1 storey = 3 m).

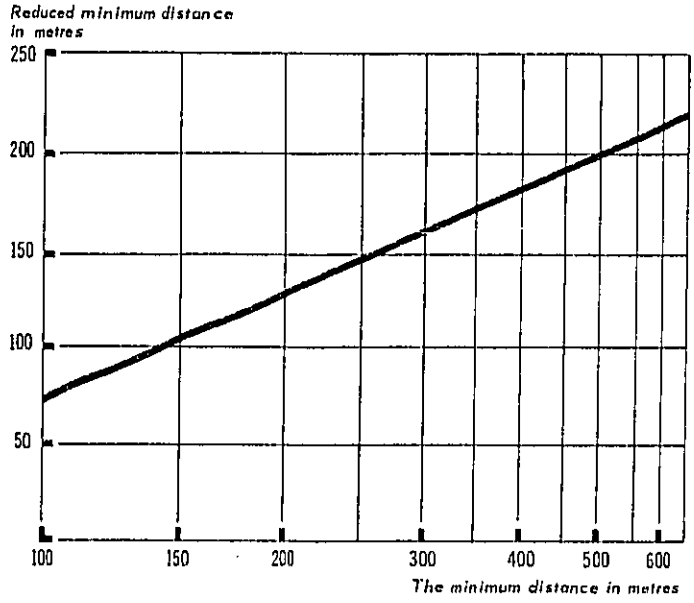


Figure 14. Reduction of minimum distance when planting over the full width with a muffling of 3 dB(A) per 100 m.

3. Residential areas: Great need for noise control, fairly small need of road accessibility.

4. Recreational areas: (Parks, woods, nature reserves). Very great need for noise control, fairly small need for road accessibility.

Thus the distribution of areas in relation to the main road network might be envisaged as follows:

Industrial estates:	Nearest the roads.
Residential areas:	Receded from roads.
Recreational areas: (in towns)	farthest from roads and surrounded by residential areas.
Service areas:	For the sake of accessibility, near to junctions in the road network.

The road network should be consistently differentiated and designed so that urban and recreational areas are not unnecessarily

divided. The design of the road network is also of importance to noise control; evenly flowing streams of vehicles will help to reduce the noise levels.

Further, the best control of traffic and noise can often be achieved during the detail planning of residential areas by spreading buildings around undeveloped central areas. The distributor roads are placed outermost with access roads to residential areas leading inwards to the housing. No road with dense traffic should be allowed into the central area.

The central area constitutes the common green space for the surrounding dwellings and in its position is best protected from traffic noise by both the muffling effect caused by distance and the shielding barrier of the buildings.

This central area is mainly intended for recreation purposes but certain common facilities serving the residents of the surrounding development can be considered so long as these entail only a small amount of motor traffic, e.g. schools. Traffic and noise control is increased even more if the individual buildings making up the area are situated beside the local distributor roads but are served by access roads which are used exclusively by vehicles with business in them. Access roads should therefore always be cul-de-sacs or be so placed that they do not form short cuts to the peripheral roads but rather entail a detour for unauthorized traffic. The segregation of buildings from distributor roads – necessary on account of the noise from these roads – need not mean an unreasonable loss of exploitable land since garages, parking spaces and certain common service facilities for the dwellings are best placed between the housing and the roads around the junctions with the access roads.

The distance between open parking and access facilities and the fronts of the buildings should not be less than 15 metres and residents should normally be prepared to accept a walking distance of 50-70 metres. Footways between parking spaces and dwellings may possibly be covered. Parking and access areas can often be located to advantage along the gable end of the blocks of dwellings where disturbance from noise is least.

If garages are provided, these may possibly be placed with their back towards the housing so that they form a barrier between access areas and the dwellings with their outdoor areas (balconies, terraces, etc.). Where there are enclosed courtyards with buildings on three or four sides, the location of garages, parking spaces and driveways may often cause noise problems on account of the tendencies of sound to reverberate, and in small courtyards this can cause considerable disturbance. It is therefore important from the point of view of noise control to keep hard courtyard areas down as far as possible. Elevations covered with ivy or other creepers may also hinder the spread of sound.

The best solution, however, to noise problems in residential areas is to have sunken, decked-over car parks. This is not the cheapest

solution but, for the same cost, in addition to providing an efficient degree of noise control, it increases the area available for other purposes and offers the possibility of an extremely short distance between the car and the dwelling, since the parking facilities can be located in the immediate vicinity of the housing or even in the basements. In some older residential areas which were not provided with parking grounds from the beginning, sunken and decked-over facilities are often the only practical solution to the problem of increasing the number of parking spaces if we are to avoid taking over the already relatively meagre open spaces for parking, thus depreciating the standard of the area. A compromise between surface parking spaces and underground facilities is the alternative for garages located on the ground floor of a block of flats with their entrances in the block's facade. This type of garage provides no clear segregation between cars and pedestrians and disturbances from noise can be considerable due to the fact that the cars pass so close to the dwellings. This type should therefore not normally be recommended.

In the case of terraced and patio houses it is in general doubtful whether individual parking spaces should be provided for each separate dwelling. Freedom from noise and safety for pedestrians argue against this. In this type of development garages and parking spaces can, with advantage, be assembled in a group at the entrance to the access roads so that arrivals and departures by car are outside the actual housing development.

In areas of fully detached houses parking facilities may usually be provided on the individual sites. The form of the road network is, however, of decisive importance. Unauthorized traffic should not travel through the area but should instead keep to its periphery. One should differentiate between access roads serving the individual properties and local branch roads which receive groups of access roads and continue on down to the distributors. In areas of one-storey housing, access roads should be given the character of minor roads and be either cul-de-sacs or in the form of loops. They should serve not more than about 20 houses. These can with advantage be laid out so that the dead end faces a common open space with the local branch roads as its outer limit. On account of traffic noise there should be not less than two site widths between two parallel roads. Turning bays should be made sufficiently large to be used without the need to reverse, which generates more noise than forward driving.

In general, town planning cannot be of help in the struggle against traffic noise in existing urban areas.

It is, however, possible to undertake a certain degree of traffic differentiation by closing numerous secondary streets to through traffic. Noise can thus be reduced in some places, but will become all the louder in others. Such steps should therefore be taken only after general discussions as to where residential areas should be preserved and commercial areas, which are more tolerant to noise, located.

Often, in order to relieve the old radial streets in towns of some of their traffic burden, new high-capacity road systems are planned to serve through radial traffic. These new roads often contribute, however, to a worsening of conditions from the point of view of noise in the already unfavourably situated older residential areas since the old radial streets will presumably continue to be used to the limit of their capacity, while the new roads, by cutting through building developments or by encroaching on existing open spaces, will expose a large number of other areas to serious noise disturbances. This type of system should therefore be carefully considered from the point of view of noise. Elevated motorways through existing urban areas are particularly troublesome from the noise point of view and would also prove to be financially disadvantageous, if burdened with the costs of devices for the control of disturbances from noise. Tunnel constructions involve no such costs.

Therefore, when implementing new major road systems in existing urban areas, it is important from the point of view of planning, to work simultaneously on the necessary alterations to the roads' surrounding areas, not only from the standpoint of road engineering, but also from that of the utility and well-being of the building development. If a reasonable standard for housing developments which border on roads cannot be established, demolition should be considered if the buildings cannot be reasonably converted to commercial purposes. In the development of vacant sites in older urban areas or the renovation of isolated developments ripe for clearance where the street system can be taken as an existing factor, traffic noise can be reduced by means of the buildings' locations.

If buildings are placed parallel to the street, they are exposed to the full range of disturbances from traffic noise on their main elevation, while the rear elevation achieves a relative maximum of quiet. If buildings are placed at right angles to the street, both these elevations are exposed to the same amount of disturbance but these disturbances decrease with distance from the street. If the flats in such buildings have rooms on both elevations, relatively quiet sleeping conditions can be achieved in rooms facing away from the street if the building is placed parallel to it. Living rooms tolerate a noisy orientation facing a street better. In principle the best solution is the orientation of only ancillary areas of the dwellings, i.e. kitchens, bathrooms and halls, facing the street, while the living rooms and bedrooms are situated on the quiet side. In some cases, it has been possible to implement this room arrangement, e.g. in blocks of flats with balcony access. If flats have their rooms on only one side of the block, the situation will be completely unacceptable in flats with all their rooms on the side exposed to noise. In such cases, buildings should be placed at right angles to the street.

Reverberation of sound from surrounding buildings which are so situated that they trap street noise can cause deviations in the distribution of noise. An unbroken row of buildings along a street shields

the rear side much better than a broken row of buildings which allows noise to force its way in between the buildings, and possibly even reverberate from the elevations of parallel blocks of buildings behind, thus damaging the shielding effect of the first row on their rear elevations.

Where it is a question of an isolated new building in an otherwise unbroken row development, the most advantageous solution from the point of view of noise is to re-establish the unbroken facade facing the road. A new building replacing one which had been demolished need not, however, as a rule be higher than one or two storeys to have a reasonable muffling effect on traffic noise. A building of moderate height such as this can as a rule be used for shops, offices and other similar purposes which are less sensitive to traffic noise than housing.

The form of housing where blocks are built around four sides to enclose a central courtyard is often the type that shields this open space best. However, for the sake of lighting and to ensure privacy, this type of housing block should be of considerable size, partly also because such court developments often provide excellent housing environments.

Where large areas are demolished at a time and the layout of the new development is not hampered by existing buildings, noise may effectively be reduced if the plan of the development is allowed to cover a whole square in the primary street network so that local streets can be planned as access roads to the development in a layout which protects them from unauthorized traffic. In this way the new development can be kept at a distance from the surrounding main streets or alternatively be shielded from them.

DENMARK

1. ORGANISATION: CENTRAL CO-ORDINATING BODY

City measures for the control and abatement of noise are part of the mandate of the Pollution Control Board set up by the Danish Government in November 1969. A technical pollution control committee composed of scientists and experts assists the Board and, with the aid of sub-committees for air, water, soil and noise, will prepare measures to be introduced by the end of 1971.

2. CURRENT PRACTICE REGARDING VEHICLES AND VEHICLE OPERATION

The Ministry of Justice is responsible for matters concerning road traffic rules, vehicle construction and equipment, driving licences, and police control. The Ministry of Justice has jurisdiction over the Motor Vehicle Inspectorate which deals with the application of regulations concerning vehicle construction and equipment. The inspectorate establishes regulations of a more technical nature, grants exemptions to technical regulations and undertakes standard-type approval of vehicles. Furthermore, it acts in a consultative capacity for the Ministry of Justice on all matters relating to road traffic legislation. The car inspectors responsible for local inspection of the technical condition of motor vehicles are under the direction of the Vehicle Inspectorate.

Until 1st July, 1969 there were no specific or quantitative regulations; it was merely stipulated that vehicles should be operated without making *unnecessary* noise. Police officers had been requested to be more alert to noisy vehicles, but lack of personnel – and, more particularly, lack of quantitative measures – meant that they could not be as severe as they might have been. As from 1st July, 1969, the situation has been considerably improved by the introduction of new legislation prepared by the Motor Vehicle Inspectorate concerning noise emission of vehicles (see Appendix 1). This legislation is a slightly

amended version of the ECE recommendations.[1] From now on all new vehicles will be subjected to noise emission certification which will provide the police with quantitative criteria for checking vehicles, and if necessary penalizing their owners, when such vehicles appear to be excessively noisy. The figures as stipulated in these laws are relatively high. The Danish authorities feel that it is wise, when introducing new regulations, to use lenient measures. These should be tightened as soon as the regulations have been accepted by the public and both measurement techniques and administrative procedure have been well established. This the Danish authorities intend to do progressively over 2-3 years. In 1968, prior to establishing the new noise emission levels mentioned above, 500 vehicles were "spot-checked" on a random basis to see how much noise they were emitting. Of the 500 vehicles tested only a small percentage of motorcycles were found to exceed the new noise limits. In other words, present vehicles running in Denmark do not, apart from a few rare exceptions, exceed the new noise limits.

The introduction of these limits, however, is the "thin edge of the wedge" leading to stricter measures.

When vehicles *over 5 years* old are re-sold they are submitted to a compulsory check, including a noise check. There are 50 such check points in Denmark equipped for safety inspections and noise inspection (ISO stationary method).[2] Commercial vehicles are checked every year when more than 5 years old; this safety check also includes a noise check.

Under the new rules mentioned above, a car noticed by a police officer to be making excessive noise may be directed to a check point. If the vehicle exceeds the accepted limits by more than 3dB(A), the owner will be obliged to have the car repaired within 14 days, after which time it is re-checked. If it is still not in a satisfactory condition the registration can be removed. No fines are imposed, but the vehicle's owner finds himself no longer in a position to operate the vehicle legally.

The use of motor horns is not forbidden in towns. Excessive use of motor horns can be penalized on the grounds of unnecessary noise, but in practice this rarely occurs.

Very frequent offenders as regards vehicle noise are teenagers who drive their motorcycles round the block or congregate around "pop shows" and rev up their engines; they may be requested to refrain from such behaviour when complaints are received by the police.

1. See chapter on the United Nations (page 163).
2. ISO Recommendation: R. 362, February 1964.

3. CURRENT PRACTICE REGARDING TRAFFIC OPERATION

There is no general speed limit for cars in Denmark; limits are established locally and at certain "danger" points, for safety reasons. Generally speaking there are no traffic restrictions on certain types of vehicles at certain hours. In some smaller towns, however, e.g. Nakskov (16,000 inhabitants), Naestved (22,000 inhabitants) and Vejle (32,000 inhabitants), motorcycles and mopeds are banned in the town centre between 10.00 p.m. and 6.00 a.m. On some roads, trucks are forbidden, but this is for congestion purposes and not primarily because of noise. It is common in Denmark to have traffic-free shopping streets, such as Strøget in Copenhagen.

4. HIGHWAY PLANNING AND BUILDINGS

There is no legislation in Denmark which stipulates a certain distance between residential or other buildings and roads, motorways, etc., on account of noise nuisance. Recommendations of the Nordic Committee (see chapter on Scandinavia) are taken into consideration but are not mandatory. An interesting case is under discussion in connection with a new motorway in Copenhagen. The initial plans for this motorway made it cut through a residential area and run close to a hospital. This gave rise to serious concern and discussion regarding the noise it would cause, and an alternative project is under preparation in which the motorway would run through a slum area and would provide an opportunity for urban renewal of this area.

5. GOVERNMENT INCENTIVES

There are no particular restrictions as regards noise or safety for government-owned vehicles. Furthermore, since Denmark is not a car-producing country, there is obviously no possibility of government incentive through R and D support to the car industry.

DENMARK

6. INFORMATION CAMPAIGNS

The press and Automobile Club journals have given wide and repeated publicity to the rules which came into force on 1st July, 1969.

Every autumn, there is a "lighting" campaign in Denmark during which motorists are encouraged to have their lamps checked free of charge. It is envisaged that in the future these voluntary checks might also include noise inspection.

Appendix 1

REGULATIONS CONCERNING VEHICLE NOISE EMISSION LIMITS IN FORCE IN DENMARK AS FROM 1st JULY, 1969

(Extract adapted from the regulations prepared by the Government Motor Vehicle Inspectorate, dated 20th February, 1969)

REGULATIONS ON NOISE EMISSION LEVELS

I. *Introduction*

By Regulations of 19th February, 1969 the Ministry of Justice amended Regulation 11 of the Regulations on the Construction and Equipment of Motor Vehicles.

The amendment empowers the Government Motor Vehicle Inspectorate to make detailed regulations on methods of measurement and limits concerning the emission of smoke and of noise from motor vehicles.

The Government Motor Vehicle Inspectorate has consequently laid down the following Regulations on the noise emission of motor vehicles:

II. *Non-Standard Type Approved Motor Vehicles*

a) First registration

1. For vehicles registered for the first time after 1st July, 1969 the noise level measured in the manner described below must not exceed the following values:

Motor vehicles whose permissible maximum weight does not exceed 3,500 kgs:

- with petrol or gas engine ..... 82 dB(A)
- with diesel engine ..... 86 dB(A)

Motor vehicles whose permissible maximum weight exceeds 3,500 kgs:

- with petrol or gas engine ..... 86 dB(A)
- with diesel engine ..... 88 dB(A)

Motor cycles:

- with two-stroke engine ..... 84 dB(A)
- with four-stroke engine ..... 88 dB(A)

2. *i*) The measurements shall be made on stationary vehicles at a distance of 7 metres measured from the mouth of the exhaust pipe in the direction of the pipe.

ii) For vehicles with engine and exhaust pipe fitted in the same part of the vehicles, measurements shall be made in each of the four main directions at a distance of 7 metres from rear end, front end, right and left side. The noise level shall be calculated as the average of these four measurements.

iii) For vehicles with exhaust pipe directed vertically upwards, the noise level shall, irrespective of the position of the engine in relation to the exhaust pipe, be measured at a distance of 7 metres from the vertical axle of the pipe backwards or diagonally backwards.

iv) The sound level shall be measured at a height of 1.2 metre above ground level.

v) Two measurements shall be made. Their average shall constitute the result of the measurement. The engine shall be brought to its normal operating regime before the measurements are started.

3. *i*) Any petrol or gas engine shall be run without load at three-quarters of the number of r.p.m. at which according to its manufacturer it develops its maximum power. That r.p.m. speed shall be adjusted by means of a revolution counter and shall be kept stable during the reading of the sonometer.

ii) Any diesel engine shall be run without load at the maximum governed r.p.m. speed.

4. Measurements shall be performed on level ground with a firm surface. There must be no sound-reflecting or acoustically disturbing objects such as buildings, trees, fences, etc., nearer than 20 metres from the sonometer. The noise level of the surroundings and the pointer deflections caused by the wind shall be at least 10 dB(A) lower than the sound levels measured.

5. Where it is not possible at the inspection site to procure requirements mentioned in 1 and 2, the Government Motor Vehicle Inspectorate may prescribe under what conditions noise measurements may be carried out.

b) Vehicles in use

For non-standard type certified vehicles already in use, the noise level must not exceed the above noise emission limits indicated there by more than 3 dB(A).

III. *Standard-Type Approved Vehicles*[1]

a) Standard-type approval

1. In the case of standard-type approval after 1st July, 1969, the noise level measured in the manner described below must not exceed the following values:

1. A standard-type approval is a homologation of a complete vehicle of the type in question. Standard-type approved vehicles can be registered without previous control by an authorized inspector.

Passenger cars for not more than nine persons, including the driver	84 dB(A)
Passenger cars for more than nine persons, including the driver as well as lorries and vans:	
– permissible maximum weight not exceeding 3,500 kgs.	85 dB(A)
– permissible maximum weight over 3,500 kgs	89 dB(A)
Motor vehicles with an engine of more than 200 h.p. DIN.	92 dB(A)
Motor cycles with a two-stroke engine:	
– not exceeding 125 cm3	82 dB(A)
– over 125 cm3	84 dB(A)
Motor cycles with a four-stroke engine:	
– not exceeding 125 cm3	82 dB(A)
– over 125 cm3 but not exceeding 500 cm3	84 dB(A)
– over 500 cm3	86 dB(A)

2. *i*) The noise shall be measured on both sides of the vehicles during acceleration. At the same time, the maximum value of the sound level shall be read. The arrangement of the runway and the position of the sonometer are shown in the sketch at the end of this Note.

ii) The acceleration of the vehicle shall start when its front end passes the line AA and terminate when its rear end has passed the line BB.

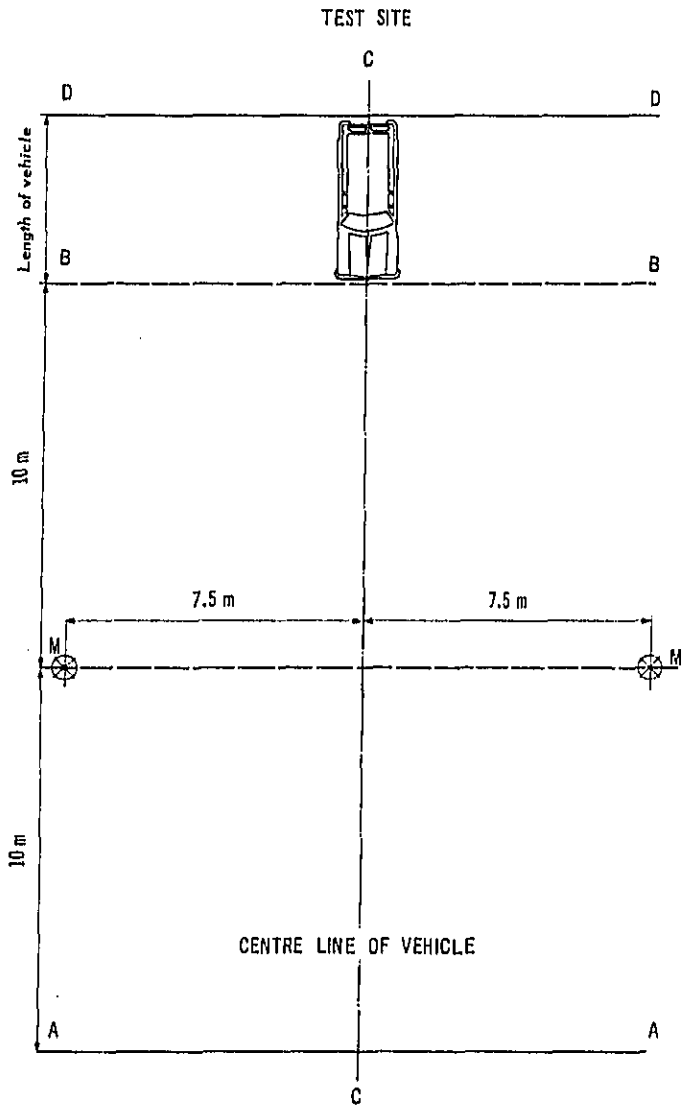
iii) The sonometer shall be placed in the measurement points MM on both sides of the centre line of the vehicle at a distance of 7.5 metres and at a height of 1.2 metre above ground level. At least two measurements shall be made on each side of the vehicle. The maximum sound level of those recorded on both sides of the vehicle shall constitute the result of the measurement. The engine shall be brought to its normal operating regime before the measurements are started.

3. If the vehicle is fitted with a two-, three- or four-speed gear box, the second gear shall be used. If the vehicle has more than four speeds, the third gear shall be used. For noise measurements, the vehicle shall approach the line AA at a steady speed (without braking) corresponding to three-quarters of the engine r.p.m. speed, at which the engine develops its maximum power, subject to a maximum of 50 km/h. When the front part of the vehicle passes the line AA, the throttle shall be fully opened rapidly. When the front part of the vehicle passes the line DD, the throttle shall be closed again as rapidly as possible.

4. The test conditions shall be similar to those stipulated in Regulation 4 of Part II(a) of these Regulations.

5. Furthermore, provided the noise level limits set out in Regulation 1 of this Part are observed, the noise of the vehicle when stationary shall be measured in the manner described in Part II(a) of these Regulations, provided that, for a vehicle, measurement of the vehicle when stationary shall be made at only 7 metres from the mouth of the exhaust pipe in the direction of the pipe. The result of the measurement shall be stated in the standard-type approval document.

DENMARK


TEST SITE
C
D
D
Length of vehicle
B
B
10 m
7.5 m
7.5 m
M
M
10 m
CENTRE LINE OF VEHICLE
A
A
C

b) First registration

For a vehicle registered for the first time after 1st July, 1969, the noise level for stationary vehicles stated in the standard-type approval document must not be exceeded. The measurement shall be made as described in Part II(a) of these Regulations, provided that, for a vehicle with engine and exhaust pipe fitted in the same part of the vehicle, measurement of the vehicle when stationary shall be made at only 7 metres from the mouth of the exhaust pipe in the direction of the pipe.

c) Vehicles in use

For a vehicle in use that is covered by these Regulations, the noise level must not exceed the level stated in the standard-type approval document for stationary vehicles with the addition of 3 dB(A). The measurement shall be made as described in Part II(a) of these Regulations provided that, for a vehicle with engine and exhaust pipe fitted in the same part of the vehicle, measurement of the vehicle when stationary shall be made at only 7 metres from the mouth of the exhaust pipe in the direction of the pipe.

IV. *Commencement*

1. (1) The Regulations shall come into force on 1st July, 1969.

(2) These Regulations shall not apply to vehicles registered for the first time before that date.

2. In a transitional period there may be standard-type approved vehicles whose noise level is not stated in the standard-type approval document. As far as noise levels are concerned, the regulations governing vehicles not standard-type approved shall apply to such vehicles.

NORWAY

1. ORGANISATION: CENTRAL CO-ORDINATION BODY

There is no central body in Norway which handles all aspects of the noise abatement problem.

These are dealt with by various administrative departments, each with its own specific field:

- Ministry of Justice and Police;
- Ministry of Communications;
- Ministry of Labour and Municipal Affairs;
- Ministry of Social Affairs.

The Royal Norwegian Council for Scientific and Industrial Research, which sponsors research, has a special advisory group on noise problems, called the Norwegian Committee for Acoustic Questions.

2. CURRENT PRACTICE
VEHICLES AND VEHICLE OPERATION

Limits on noise from motorcycles were laid down in 1959. They are as follows:

- 75 dB(B) for new motorcycles with a cylinder capacity of under 50 cc;
- 85 dB(B) for new motorcycles of over 50 cc.

To make sure that these limits are observed, each make and type of vehicle is acoustically measured: the whole series of vehicles of any given make and type sold in Norway is thus certified.

The relevant authorities point out, however, that these limits apply only to new motorcycles (with a tolerance of 5 dB for motorcycles in traffic), and that any vehicle submitted to them for testing is generally in very good condition and emits the lowest level of noise that can be expected from its particular category. In any event, the limits as prescribed apply only to motorcycles, no regulations having been promulgated as yet for other types of vehicles.

Nevertheless, it is planned to apply the noise limits proposed by the ECE-Geneva to all vehicles in the near future (see chapter on United Nations).

For the time being, the only mandatory measure taken in respect of all vehicles, whatever their nature, concerns horns. Compressor-type horns, as well as conventional horns that are overloud, are prohibited and vehicle importers are frequently obliged to change the original horns for ones of the approved variety before the vehicles can be put on sale.

It is the police who are responsible for taking practical measures to control noise in actual traffic conditions. In particular, they have the authority to stop motorcyclists whose machines are making too much noise and require that the vehicles undergo a test. If this test shows that the noise produced by a motorcycle is more than 5 dB over the aforementioned limits, the vehicle owner is obliged to repair it within a given time, failing which he is fined and the vehicle papers withdrawn.

But, here again, the really practical noise abatement measures apply only to motorcycles. If any action is to be taken in respect of other categories of vehicle, specific complaints must first have been received by the police. But quite obviously, such complaints can hold good only against vehicles that are very easy to locate, i.e. essentially vehicles habitually driven very noisily around a block of houses.

Just as it is planned to apply the standards proposed by the ECE to all vehicles sold in Norway, so it is intended to introduce periodical checks on the noise made by vehicles to coincide with the compulsory roadworthiness inspections, which have already taken place and which vehicles are required to undergo every three or four years.

Each of the 20 counties in Norway now has it own permanent inspection station. It would, therefore, not be too difficult to install noise-measuring apparatus in these stations, at any rate if the procedure were to be confined to measuring the level of noise made by stationary vehicles.

At present, particularly where the certification of motorcycles is concerned, the noise-measurement method used is that recommended by the ISO (see R. 362 – February 1964) but the Norwegian police would like to have a reliable method that is simpler and more rapid.

No concerted plan of procedure against improper use of vehicles exists, nor is there any legislation prohibiting the use of horns in built-up areas.

However, it has become common practice to use the horn only in cases of imminent danger and most Norwegian citizens comply spontaneously in this matter. In any case, as already mentioned, the sale of overloud horns is prohibited in Norway (see above).

3. CURRENT PRACTICE CONCERNING TRAFFIC

Speed limits are imposed throughout Norway (Norwegian laws for road traffic, April 1967). They are as follows:

- 50 km/h in built-up areas;
- 80 km/h outside built-up areas.

On certain stretches of road, higher or lower limits may be imposed, in which event they are indicated by sign-plates (90 km/h on certain motorways).

The above mentioned limits apply to all vehicles, except in the following special cases where stricter limits are imposed:

- trams: 40 km/h;
- lorries of over 7.5 tons laden weight: 70 km/h (outside built-up areas);
- vehicles with trailers: 70 km/h if the trailer is equipped with independent brakes and 60 km/h if not (outside built-up areas);
- tractors: 30 km/h (in and outside built-up areas).

Radar checks being frequent and the fines for infringement high, these limits are usually well observed. Although decided on for reasons of safety, they are clearly of help in maintaining a tolerable overall level of sound. In any case, they preclude the high noise levels produced by very fast-moving vehicles.

Other traffic control measures likely to have beneficial effects from the acoustical standpoint are very localized and do not form part of an overall plan, the most important of them being to bar private cars and lorries from certain streets in Oslo where only public transport vehicles and taxis are allowed. The aim of these measures is to enable pedestrians to move about more freely in certain busy shopping districts and encourage the use of public transport rather than private vehicles.

The beneficial effects of these measures from the acoustical standpoint are rather limited, however, owing to the fact that public transport vehicles (buses, trams), though they carry a larger number of individuals, make more noise than private vehicles.

At local level, some municipal authorities have taken steps to protect certain residential areas and hospitals from traffic noise; at night, in particular, traffic is either restricted to private cars or entirely prohibited in streets adjoining hospitals.

NORWAY

4. TOWN AND HIGHWAY PLANNING

Noise abatement through town planning is the responsibility of the Planning Commissions which have been established in the main Norwegian towns. These Commissions receive the papers drawn up by the Nordic Committee on Building Regulations (see chapter on Scandinavia) and by Scandinavian research institutes. The conclusions and recommendations contained in these papers, although having no legal force, are to a large extent taken into account in new urban schemes.

An example of this is the new ring motorway shortly to be constructed in the Oslo suburbs. Since this motorway will pass through residential districts already in existence and through urban development areas, it has been decided to build part of it in a cutting with garages, offices and commercial premises bordering the highway, so that the residential buildings will be shielded from the traffic noise. In the new district of Furuset, (eastern suburbs of Oslo), shops and offices only will be built alongside the motorway. In another new district (Høbraten), the residential buildings will be shielded from noise by garages, which will act as a barrier between them and the motorway.

One of the general principles laid down in connection with highways constructed since 1950 is that no dwelling should be built at less than 30 metres from the road. This principle is however not adequate for roads with high traffic density. The main point of this decision was to allow for any widening of these new highways, but its indirect effect is to keep dwellings away from the noise source constituted by passing traffic.

The fact remains, however, that all efforts to take account of noise problems in town planning schemes are the work of the local authorities alone and no uniform set of regulations has been adopted in this sphere. The same is true of building construction proper. There are no standards setting a given value for sound-level reduction between the outside and the inside of a dwelling. The only standards introduced relate to the quality of the building materials used.

Despite this absence of regulations regarding sound insulation of buildings, there is ample evidence that most dwellings have double-glazed windows. The basic reason for this is the need to provide dwellings with efficient heat insulation throughout the long, hard winters, but one of the side effects is to provide better sound insulation than the conventional-type windows found in most European countries.

5. IMPORTANCE GIVEN TO TRAFFIC NOISE ABATEMENT

The most notable endeavours in the field of noise abatement are those carried out in the large towns, where the problem is becoming increasingly serious. The authorities who have to cope with these questions consider, however, that their hands are somewhat tied until such time as comprehensive and stringent regulations can be promulgated. But, in view of the cost of enforcing such regulations, the authorities consider that international action alone will make it possible to solve the problem of traffic noise; especially since in any endeavour to control noise at its source the isolated action of a small country would be bound to fail.

At all events, increasing attention is being paid to the problem of safeguarding the environment, of which traffic noise is becoming one of the main aspects. The main reason for this is that the results of surveys carried out in Norway (see below) have shown that the public is more annoyed by traffic noise than by any other kind and that the extent of this annoyance is commensurate with the size of the conurbation.

1. INVESTIGATION BY THE NORWEGIAN GALLUP INSTITUTE (1968)
(1,600 persons questioned)

Type of noise	Number of people annoyed per 100 questioned					
	All questioned	Age (years)			Area	
		15-29	30-59	⩾ 60	Urban	Rural
A. Noise from motor vehicles	17	14	16	21	20	11
B. Noise from aircraft	3	2	4	3	4	1
C. Noise from railroads	4	5	3	4	5	1
D. Noise from neighbours	5	7	5	5	6	3

2. INVESTIGATION
BY THE NORWEGIAN STATISTICAL BUREAU (1967)
(2,815 persons questioned)

Type of area	Annoyed by noise
Rural area	8%
Built-up area 200-2,000 inhabitants	16%
Built-up area 2,000-19,999 inhabitants	20%
Built-up area 20,000 or more	27 %

SWEDEN

1. ORGANISATION: BODIES CONCERNED WITH TRAFFIC NOISE ABATEMENT

In June 1969, the Minister of Communications appointed a parliamentary committee to set standards for acceptable noise from civil and military aircraft, motor vehicles and pleasure boats. The object of this committee is to suggest standards concerning noise from the above sources. The standards are to be based primarily on medical grounds, but technical economic and social factors in general are also to be considered. The committee has been asked to suggest actions concerning physical planning required with regard to the standards proposed. Furthermore, the committee is to report different ways of controlling the practical application of these standards. The economic repercussions of these standards on the community are also to be estimated. Besides this committee, a number of governmental bodies are concerned with traffic noise:

Administrative bodies:

Ministry of Communications (Kommunicationsdepartementet);
Ministry of Agriculture (Jordbruksdepartementet);
National Board of Health and Welfare (Socialstyrelsen);
National Road Administration (Statens Vägverk);
National Road Safety Board (Statens Trafiksäkerhetsverk);
National Environment Protection Board (Statens Naturvårdsverk);
National Board for Urban Planning (Statens Planverk);
Swedish Board for Technical Development (Styrelsen för teknist utveckling).

Research bodies:

National Institute of Public Health (Statens institut för folkhälsan);
National Institute for Building Research (Statens institut för byggnadsforskning);
Institutes for Building Acoustics at the Royal Institute of Technology, Stockholm and at Chalmers Institute of Technology, Gothenburg;
Stockholm City Health Authority (Stockholms stads hälsovårdsnämnd).

2. CURRENT PRACTICE REGARDING VEHICLES AND VEHICLE OPERATION

There are as yet no regulations concerning noise emission levels for motor vehicles. A law passed in 1938, however, forbids the use of horns in built-up areas and the Road Traffic Act states that "motor vehicles must be fitted with an effective silencer" and that "any driver, when driving in built-up areas shall operate his vehicle carefully so as not to cause excessive noise emission especially at night".

In 1961, an investigation into vehicle noise emission was carried out by the National Institute of Public Health. The report presented results of a series of measurements on different types of vehicle and suggested a measuring technique. Certain recommendations were made regarding acceptable maximum values for noise from vehicles, but did not bring about any legislation.

As a first step towards more stringent measures, Sweden envisages enforcing the ECE Recommendation (see chapter on United Nations).

According to the Swedish Constitution, regulations such as those concerning vehicle exhaust emission are issued by the Government after consulting parliament. The National Road Safety Board is authorized to prescribe detailed specifications for test procedures and to grant exemptions from the regulations. The Board has facilities for carrying out inspection tests and together with the police is responsible for supervising the observance of regulations.

Before a passenger car, bus or truck is allowed to be used on public roads in Sweden, it must pass an inspection. If a certain number of vehicles of the same type are expected to be sold, the inspection can be carried out as type inspection, i.e. only one vehicle of this type will be tested. The manufacturer or dealer must then guarantee that every vehicle sold under the type inspection certificate corresponds in all details to the type vehicle. If the type is not approved, each individual vehicle must be inspected.

Type inspections are carried out by the type approval section of the National Road Safety Board, and individual inspections by the Swedish Motor Vehicle Inspection Company. The main task of this company is to make the compulsory periodic inspections which every Swedish passenger car, bus, motorcycle and trailer has to pass. Taxis and public service vehicles must pass an inspection from their second year onwards and all other vehicles from their fourth year (as from 1971 from their third year).

This inspection system will also be used for ensuring compliance with the exhaust standards. An effective control can thus be achieved at moderate extra cost. The Swedish authorities consulted consider that once noise emission levels have been fixed by law, their application could be controlled in the course of the periodic inspections

referred to above. In the meantime, noise levels are measured during some safety inspections to obtain an overall picture of the noise emissions presently occurring.

Noise checks, especially at night, have been made in Stockholm several times at frequently changed check points. Drivers of excessively noisy vehicles can be fined and are requested to suppress the noise emission. It is usually the exhaust system which is faulty. Considerable publicity has been given by the press to these noise checks and this has made drivers more aware of the need to keep their vehicle exhaust in good order. Thus, the fairly small number of checks and fines has had, by means of extensive coverage in the newspapers, a considerable widespread and beneficial effect.

In spite of the absence of laws concerning noise emission levels, the police are particularly alert to the noise caused by teenagers with noisy mopeds driving "round the block".

Finally, one might mention a specific measure worthy of note, namely action by the Stockholm authorities regarding the city buses. The tenders for the supply of buses stipulated that the vehicles should not produce more than 83 dB(A). Each of the buses delivered was checked with regard to noise emission and any bus exceeding 88 dB(A) was returned to the manufacturer.

3. CURRENT PRACTICE REGARDING TRAFFIC OPERATION

Certain towns, e.g. Lund and Sollefteå, have included special restrictions on traffic operation at night in their local traffic regulations.

4. HIGHWAY AND CITY PLANNING

In 1967, the Nordic Committee for Building Regulations in Scandinavia presented "Annoyance and City Plan" containing guidelines for traffic noise evaluation and a description of the means whereby traffic noise may be attenuated (artificial and natural screens, building layout, etc.). The report recommends a 24-hour energy-mean outside dwellings of 59 dB(A) which should not be exceeded (see chapter on Scandinavia).

The National Swedish Institute of Building Research and the National Institute of Public Health performed a field study which was presented in a joint report: "Traffic Noise in Living Areas", in 1968.

The report gives the results of technical measurements and calculations as well as sociological surveys on annoyance reactions. A noise

exposure response curve is presented and recommended as a basis for City Planning legislation.

Besides these major studies, several investigations have been made into sound proofing in buildings, window constructions, etc.

There are no regulations stipulating that community development plans should take "noise" into consideration. In 1964, however, general guidelines were drawn up by the National Board of Urban Planning which stated that there should be a distance of at least 100 metres between a motorway and any residential building. These guidelines were distributed to all county architects who scrutinize all city plans. Thereby, one is to a large extent assured that the guidelines are followed. Exceptions are, however, sometimes accepted.

The National Road Administration claims that, whereas the State bears the cost of road construction and of buying the land on which the road is built, and while no money is granted for any "noise strips" at the road-sides, local authorities are responsible for taking the necessary measures to ensure that dwellings are not erected too close to roads. The economic problems involved have not as yet been solved. On several occasions, noise has, however, been taken into account when planning new communities.

The most spectacular practical anti-noise measures have been taken as regards sound insulation of windows. Hospitals, schools and some hotels in the northern suburbs of Stockholm are presently equipped with special windows which provide extra sound insulation. In the new suburbs south of Stockholm, dwelling houses have been equipped with special windows providing a 25 to 30 dB(A) noise attenuation to traffic noise.

In Stockholm itself, where an elevated road has been built close to dwellings, it is planned to expropriate the occupants and to give them compensation to facilitate their rehabilitation in a less noisy district. It should also be noted that, to reduce the noise from this road to a certain extent, a 70 km/h speed limit has been fixed, in spite of the road being considered an "expressway".

Another example of local endeavour to reduce "noise pollution" is the town of Gävle which has commissioned a statistical study of traffic noise levels in the town from the Swedish Acoustic Institute, in order to be able to take appropriate measures such as special acoustic insulation in certain buildings exposed to particularly high levels of noise.

It would appear, therefore, that though anti-noise measures have been limited to a few specific cases, authorities are becoming increasingly aware of the noise problems as an important parameter to be considered in urban planning.

It should also be noted that, in Sweden (as in Norway and Switzerland also), *double-glazing* is used practically without exception to provide thermal insulation against the severe winter climate and to reduce heat loss and excessive heating costs. The use of such double-

glazing, however, has a favourable side-effect in that it provides better sound insulation than single glazing. The noise attenuation of double-glazing is of the order of 20-25dB(A) as compared to 10-15dB(A) with single windows. So, in spite of the absence of specific legislation concerning sound insulation of buildings from traffic noise, the noise level inside Swedish dwellings is considerably less than in other more southern countries.

5. CURRENT TRENDS

Besides the parliamentary committee working on noise regulations mentioned earlier, a committee came into being on 1st January, 1969, composed of representatives from the National Board of Urban Planning, the National Board of Health and Welfare, the National Road Administration and the National Environment Protection Board, with the following terms of reference:

i) definition of noise level limits tolerable in different situations;

ii) definition of a method for forecasting traffic noise;

iii) formulation of recommendations for dealing with noise questions in planning new communities, or in urban renewal.

The first recommendations of this group concern *i*) figures for tolerable noise levels and *ii*) methods of calculating noise with regard to new building construction.

These recommendations and later recommendations, though not mandatory, will have considerable influence on new urban plans, since they will be transmitted to local authorities and will be used by county architects and the concerned boards in their scrutiny. Building plans submitted for building permits will have to take these recommendations into account.

The National Environment Protection Board (Naturvadsverket) has, from July 1969, a special section to co-ordinate activities concerned with noise, particularly with noise from industry, now to be subjected to new legislation in force as from 1st July, 1969, but also with traffic noise. This section is presently studying plans regarding traffic noise in co-operation with the National Planning Bureau, the Road Research Board and the National Board for Health and Welfare, and is also concerned with discussion in parliament on noise from motor vehicles, aircraft and pleasure boats. This section has been created as a result of growing public concern regarding noise and the feeling that regulations have so far been too lax, and should be developed as they have been for air pollution.

At the National Institute of Public Health, Department of Environmental Hygiene, a special noise unit is initiating and performing re-

search mainly devoted to the description of noise exposure and its covariation with effects on man to provide material for the evaluation of the effects of noise on health.

Grants for research are given by the Swedish Council for Building Research and the Swedish Board for Technical Development (the latter created by an Act of Parliament in 1968 and placed under the authority of the Ministry of Industry) and the Research Committee of the National Environment Protection Board.

Large research grants have been given for e.g. the traffic noise investigation and the development of electric automobiles.

SWITZERLAND

INTRODUCTION

By way of introduction one may quote an extract from the Report of the Federal Commission of Experts[1] published in 1963 on Noise Abatement in Switzerland (see also I below).

"The motor vehicle is undoubtedly the source of noise causing the greatest number of complaints... For many years, one has been aware that traffic noise would probably become intolerable. The laws passed in 1932 concerning motor vehicles, and well before that in 1914 the inter-cantonal concordat on motor vehicles, prescribed efficient silencers. Noise abatement measures were strengthened with the increase in motor vehicle traffic after the Second World War. In 1949, the inter-cantonal road traffic commission proposed standards for the measurement of motor vehicle noise. These standards were laid down in circulars issued by the Department of Justice and Police in 1952 and 1953. A circular issued in 1957 gave detailed instructions on how to reduce traffic noise and considerably reduced some of the standard noise levels. Several cantons conducted noise abatement campaigns and controlled the noise emission of motorcycles. Since 1960, the Conference of City Police Chiefs organises an annual noise abatement campaign throughout the whole of Switzerland."

"The abatement of noise from motor vehicles can be approached from different aspects – only an attack on all fronts will provide an effective result. The main areas for action are, of course, measures taken regarding the construction of vehicles and the way in which drivers use them. However, the following approaches are also important: highway planning, traffic control, distance between buildings and highways, vegetation along the road, etc.

"... Motor vehicles should be designed so as not to cause excessive noise. It will not suffice to request that vehicles be silent when correctly used but that they also not cause excessive noise, when they are occasionally ill-used by inexperienced or careless drivers.... It would be technically impossible to avoid noise caused intentionally or

1. "*La lutte contre le bruit en Suisse*". Federal Commission of Experts, Department of Justice and Police, Berne, 1963.

through negligence. A driver intentionally causing noise must therefore be penalized. However, many cars are so designed that they are used at maximum power. ... Since the engine and the exhaust are the principal source of the noise, the latter should be subjected to maximum accepted standards. Any vehicle exceeding these standards should not be allowed on the road. Present standards should be made progressively more severe as technology progresses."

Other recommendations of the Federal Committee of Experts on Noise of relevance to urban traffic noise are referred to in the different sections of the report which follows.

I. ADMINISTRATION: CENTRAL CO-ORDINATING BODY

When the Swiss government deals with problems concerning noise, the Police Division of the Ministry of Justice and Police is consulted. The Federal Division of Police is at present responsible for co-ordinating all anti-noise measures taken at Federal level.

The Federal Government is, however, presently examining the possibility of establishing a Federal Council against Environmental Nuisances (air pollution, water pollution and noise). The Federal Government, through its Federal Justice and Police Department, is very conscious of noise problems. A Federal Commission of Experts established a report in 1963 entitled "Noise Abatement in Switzerland" which recommends appropriate legislative measures to be taken to abate noise. This report is the basis of all recent noise abatement measures currently applied in Switzerland.

The Commission established five working parties:

1. medical, acoustic and technical questions;
2. motor vehicles, railways, ships and cable cars;
3. aircraft noise;
4. building and industrial noise, protection against noise;
5. legal aspects.

The findings and recommendations of the above working parties of relevance to urban traffic noise are contained in the different sections of the report which follows.

The Commission's report resulted in a number of measures, of which the following should be mentioned here:

a) the creation of an Acoustic and Noise Abatement Division at the Federal Materials Testing Laboratory;

b) a Federal circular was addressed to all Federal Departments urging them to take greater account of noise abatement measures;

c) recommendations for the preparation of traffic laws.

In addition to the Federal Police Department in Berne, and the Acoustics and Noise Abatement Division of the Materials Testing Laboratory in Dübendorf, one should mention that all the town and "canton" police authorities are particularly vigilant in the enforcement of noise abatement legislation and have been instructed to apply strictly and vigorously the Federal Laws. The police in Zürich, Lausanne, Berne, Lucerne and other towns have very active noise abatement brigades (see below).

II. CURRENT ADMINISTRATION AND LEGISLATIVE PRACTICES REGARDING VEHICLES AND VEHICLE OPERATION

A. *VEHICLES*

Type Certification: As from 1st January, 1969, vehicle type certification is enforced according to the following table:

Type of vehicle	Noise level dB(A)[1]
1. Mopeds	70
2. Light motorcycles 50cc	73
3. Other motorcycles	
– 50 - 200 cc	82
– more than 200 cc	82
4. Motor cars	
– Diesel engine or 50 h.p./SAE	82
– Other private light motor cars	78
5. Heavy motor vehicles, tractors, industrial vehicles	85

1. Note that Switzerland had previously applied a "B" weighting but has now adopted the "A" weighting which corresponds more closely to resulting human annoyance.

For practical reasons the noise level is measured on a stationary vehicle at full throttle. For type certification precision sound level meters are used which comply with recommendation 179 of the International Electro-technical Commission (CEI). In other circumstances sound level meters complying with the CEI recommendation 123 may be used. Before each series of measurements the meters are calibrated according to the manufacturer's instructions; these meters are calibrated annually by the Federal Office for Weights and Measures. The measurements are made on a horizontal site with no sound-absorbing materials such as grass or snow being present. No object

which may influence the sound perceived is allowed within a radius of 20 metres from the microphones, and no large objects should be allowed within 50 metres. The microphone may be equipped with a wind-shield if necessary. The microphone is placed on a support 1.20m high, such that the direction of its greatest sensitivity is turned towards the source of noise; the microphones are placed at a distance of 7 metres on either side of the vehicle. Two measurements are made with each microphone. In the case of type certification each of the two measurements is made with a different meter. The average of the readings on both sides is taken – but no individual reading should be greater than 2 dB(A) above the allowed limit. When a vehicle is type-certified there is no tolerance margin; in the case of individual vehicles checked after certification or stopped for control during operation, a margin of 2 dB(A) above the accepted limit is tolerated.

Engines are usually tested on stationary vehicles at full power; in the case of cars which do not exceed 10 kg/hp (DIN) and motorcycles exceeding 200 cc the engines are tested at 75% of full power; vehicles with a maximum speed of 50 km/h are tested at full throttle.

In some cases, when the noise of a vehicle is considered to be very annoying despite its not exceeding the above limits, or should it not sound annoying but nevertheless exceed the above limits, the case is referred to the Federal police authorities for decision, based on complementary measurements (frequency analysis, ISO running method). These measurements are made by the Federal Materials Laboratory.

The Road Traffic Laws furthermore stipulate that vehicles should be built so as to cause as little noise as possible – particular attention being given to:

a) adequate exhaust silencer;

b) doors, boots, sun-roofs, which should open and shut easily and noiselessly;

c) horns, which should not exceed 104 dB(A);

d) reduction of vibrations of the body work;

e) the use of loud-speakers on motor vehicles for which special permission is required;

f) reduction of noise from other sources such as brakes, tyres, accessories, transmission, starter, etc.

Police officers have been instructed to stop and examine any vehicle which appears to be excessively noisy. The police officers in the street have no sound level meters – but are accustomed to identifying by ear alone vehicles which are obviously well above the accepted limits. In cases where the driver is of "good faith" and is not aware of his having broken the law, he is merely requested to repair the vehicle (usually the exhaust pipe) so that it does not exceed the accepted noise limits. He is then requested either to send the bill of the repair to the police authorities as proof of his having mended the vehicle or

to present the vehicle within a given time to a police control station where the noise emitted is checked according to standard methods as described above. In cases where the driver is obviously well aware of the unacceptable condition of his vehicle or if he has deliberately tampered with the exhaust or replaced the exhaust by one designed to produce more noise, or if, in the case of mopeds especially, the cylinders have been tampered with to increase the vehicle speed, the vehicle is confiscated on the spot, the registration withdrawn and the driver continues his journey on foot. He must then repair the vehicle and present it for re-registration when it will be checked to ensure that it complies with the accepted standards. In some cases, particularly of a repeated offence, he will also be fined. In exceptional cases the driving licence may be temporarily withdrawn.

Public Transport Vehicles

In its report the Federal Commission of Experts on Noise Abatement also referred to noise from public transport. Complaints against this source of noise – trams and buses – are quite numerous. This is due to the fact that trams and buses operate at frequent intervals in densely populated areas, and at hours when normal traffic tends to subside. Public transport companies, however, do pay attention to the noise emitted by their vehicles including:

- noise measurements before and after maintenance checks;
- tests on various forms of noise insulation and reduction;
- for trams, design of less noisy components in new vehicles; replacement or insulation of noisy components in old vehicles;
- for buses, the engine compartment is acoustically insulated, metal pipes are replaced by plastic ducts, improved engine design, brake design, body-work design, etc.

Attention is also given to the operation of the vehicles so that noise is attenuated as far as possible. The operating staff have been requested to draw attention to any particularly noisy vehicle in use. Tram and bus manufacturers have been asked to reduce the noise emission as much as possible; old and noisy vehicles are replaced by more silent new ones in spite of the additional cost involved. Finally, the transport companies and the manufacturing industries collaborate closely with a view to reducing noise further.

Sale of Noisy Mufflers

At present there are a wide variety of mufflers available on the market, the sale of which is not forbidden by law. Nevertheless, these mufflers cause the vehicles onto which they are adapted to exceed the accepted noise emission levels. These "super" noisy mufflers are frequently adapted to vehicles in as little as a few hours after the vehicle has been registered and certified conform to type. Teenagers are the worst offenders in this respect; they are easily attracted by the

manufacturers' convincing publicity as regards the "prestige" to be gained from a noisier vehicle – which they are erroneously led to believe will be faster also.

In accordance with an ordonnance passed on 27th August, 1969 concerning the construction of road vehicles and their appliances, exhaust devices which are worn out or damaged must be replaced by devices which are as effective as those prescribed for the vehicle originally. Tampering a vehicle in such a way as to cause the vehicle to make unnecessary noise is forbidden even if the accepted level is not exceeded. Furthermore it is envisaged that all exhaust devices be subjected to standard-type approval. As from 1st January, 1970 a vehicle owner adapting an exhaust device not standard-type approved for the vehicle must make this known.

Vehicle Inspection

Vehicles are subjected to inspection primarily for road-worthiness, but noise emission is also taken into consideration. All approved vehicles will be submitted to another official control at least every three years.

B. *VEHICLE OPERATION*

In general terms, the Federal Traffic Laws, Article 54, specify that "... If the police observe ... vehicles causing avoidable noise, they shall be stopped. The police may confiscate the registration papers and when necessary, the vehicle also".

"The police may confiscate on the spot the driving licence of any motor vehicle driver who... deliberately causes avoidable noise".

These general laws and the more specific regulations referred to below give the local and cantonal police authorities adequate backing for intervening vigorously against urban traffic noise offences.

The traffic laws (Article 33) also stipulate that drivers and passengers should cause no avoidable noise, particularly in residential areas and resting areas and during the night. In particular, it is forbidden by law:

- to use the starter excessively and to run the engine at a standstill unnecessarily;
- to rev up the engine at a standstill, and to drive at high speeds in low gears;
- to accelerate too rapidly;
- to drive "round the block";
- to drive with goods not well attached;

- to load and unload goods without proper care and to transport barrels and other noisy containers without securing them well or isolating them one from another;
- to slam doors, engine bonnets, boot lids, etc.;
- to cause annoyance to the neighbourhood by the abusive use of wireless or other sound-producing equipment in the car.

The above offences are fined and may lead to the withdrawal of the driving licence.

The traffic laws (Article 29) stipulate that a vehicle should be so driven that the use of a horn is not necessary. It is forbidden to use the horn unnecessarily, and headlamps should be used instead of horns at night.

Local Measures regarding Vehicles and Vehicle Operation

A number of towns and cantons have taken special measures regarding vehicles and vehicle operation in an attempt to reduce noise. The three following examples are reported here:

i) *Lausanne Police Anti-Noise Brigade*

The Lausanne Police Anti-Noise Brigade was set up in 1959, as a result of a number of successful noise abatement campaigns organised throughout Switzerland. The Brigade consists of five police officers, and is equipped with sound level meters and a "control station". The Brigade is concerned with reducing and controlling noise from all sources: traffic, aircraft, construction sites, industry, bars, dance halls, etc., but has mainly focused its activity on the most pervasive source of noise, namely traffic. Since one of the Brigade's major concerns is to safeguard a quiet environment during sleeping hours, it usually operates at different points throughout the town from 10.00 p.m. to 6.00 a.m. The Brigade is, of course, assisted night and day by all the city police officers who, as throughout Switzerland, have been specifically instructed to be vigilant to noise. When on patrol in the street the Brigade identifies the noisy vehicles *by ear alone* and stops them. Experience has shown that a police officer accustomed to this work rapidly acquires a sensitive ear and can identify with remarkable accuracy drivers of vehicles causing noise levels over and above the accepted limits. Having signalled to the driver to stop, the Brigade briefly inspects the vehicle to ascertain whether all parts are in good working order. Should one or more components of the vehicle show signs of poor road-worthiness and not conform to accepted standards, the vehicle is immediately confiscated and towed to a garage for repair, after which the owner is requested to bring the vehicle to the Brigade's control station for approval before he is allowed to drive it again. In the case of minor faults, the registration plates are withheld and a temporary permit given to the owner, who will retrieve the plates when once his car is in order. If the vehicle's driver disagrees with the faults found on his car he is invited to bring it to the control

station, where the faults can be technically proven to him. If complaints are received concerning a given vehicle, the owner is summoned by the police to the control station, which is fully equipped, to check whether the complaints are justified; the owner may often mend the vehicle before presenting it for inspection – but these "recent" repairs are easy to identify. In most cases, offenders also receive a fine; for minor faults, or when they are obviously not aware of having broken the law, they merely receive a warning notice.

In doubtful cases, where the Brigade can find no obvious technical fault in a vehicle, but which is nevertheless causing excessive noise, the driver is obliged to leave his car on the spot or may exceptionnally be allowed to continue his way at moderate speed without making too much noise. The car registration plates are temporarily withdrawn and the driver is summoned to the control station where his vehicle is checked.

The worst offenders stopped by the Anti-Noise Brigade are teenagers with mopeds who, immediately after acquiring their vehicle, tamper with the air intake, remove or make holes in the exhaust pipe or modify the carburettor, in order to make more noise and attain greater speeds.

In 1968, as a result of the Brigade's patrols, 674 private cars, 582 mopeds and motorcycles, and 18 trucks were checked at the control station. From this number, registration plates were withdrawn from *110 vehicles*, and the owners fined. 621 private cars and 574 mopeds and motorcycles were intercepted, and the registration plates temporarily withdrawn; in those cases the driver was fined or given a warning, but allowed to continue his way.

Ninety-seven private cars and 170 motorcycles were stopped on the spot, the drivers fined and obliged to continue their way on foot. In two cases the driving licence was withdrawn. For the same year 1,188 vehicles (all categories) were found to have defective exhaust,[1] 183 were stopped for driving noisily in low gears, 43 for unnecessary use of horns, 26 for door slamming.

ii) *Zürich Police Noise Abatement and Control Office*

The police authorities in Zürich have a special office for noise abatement and control dealing with noise from all sources, including as one of its major concerns traffic noise. In 1968, there were 2,793 reported cases of noise (against 2,849 in 1967), of which 1,009 were due to vehicles (as opposed to 1,169 in 1967), broken down as shown in the table on page 151.

In 1968, of 999 motor vehicles stopped, 105 had their registration removed; in 1967, of 1,102 motor vehicles stopped, 215 had their registration removed.

1. It should be noted that in general cars registered in Switzerland are kept in good condition by their owners; because of the severe winters, however, the use of de-icing chemicals on the road, particularly salt, accelerates the deterioration of exhaust through corrosion.

	1968	1967
Mopeds	99	207
Motorcycles and scooters [1]	27	32
Private cars	565	809
Trucks	64	54
Avoidable traffic noise	221	22
General traffic noise	19	3
Motor boats	1	–
Aircraft noise (including model aircraft)	4	24
Railways	9	18

1. These figures may seem low; the reason for this is that the number plate on these vehicles is very small and not readable except on a stationary vehicle.

In addition to its action in the street, the Zürich police Noise Abatement Office also organises training and information courses on noise questions for police officers from other Swiss towns and from abroad. The office also receives numerous written requests for information concerning noise problems and in this way acts as a general information and advisory bureau for both private individuals and public authorities. Courses on acoustical and noise abatement problems are organised for the Zürich police officers at the Zürich Polytechnic.

iii) *Moped Campaign, 12th-24th May, 1969*

The police authorities of the Vaud municipalities organised a "moped campaign" between 12th and 24th May, 1969. During this campaign 9,160 vehicles (8,520 mopeds, 640 other two-wheeled vehicles) were checked. Of the 8,520 mopeds, 5,095 were found to be in good order and were given a road-worthiness adhesive stamp; 3,425 were found not to be in order, of which 181 were temporarily confiscated for inspection by the canton vehicle inspectors. In 38 cases, some of the vehicle components not complying with the regulations were merely destroyed; in eight cases the vehicle was confiscated for good. Fines were imposed in only 27 cases since the policy of such campaigns is to educate drivers rather than to penalize them. The age of drivers with faulty vehicles ranged from 15 to 20 years.

In general, the public was responsive to the campaign; a few moped drivers hid their vehicles during the campaign. Car drivers questioned expressed their satisfaction with the campaign, particularly because of the anticipated awareness of road safety that it would produce. Headmasters of schools and factory directors were very co-operative throughout the campaign, and the public in general expressed its appreciation of the attempt made to reduce the noise produced by teenagers. Local press, TV and radio supported the campaign fully; the Swiss Touring Club and the Swiss Automobile Club provided some financial support. Moped sales agents were very co-operative in repairing faulty vehicles.

III. CURRENT PRACTICE REGARDING TRAFFIC

The following maximum speed limits are to be observed:

– mopeds	30 km/h
– all vehicles in built-up areas	60 km/h (or less if indicated)
– passenger cars on open road	no limit, unless specifically indicated
– passenger cars pulling a trailer	80 km/h
– trucks	80 km/h
– tractor-trailers	60 km/h
– motorcyles with trailers	60 km/h

Other special vehicles have specific speed limitations.

In order to safeguard a quiet environment during sleeping hours, heavy trucks ($\geqslant$3.5 tons) are not allowed to operate at night from 9.00 p.m. to 5.00 a.m. (from 1st November to 31st March) and from 10.00 p.m. to 4.00 a.m. (from 1st April to 31st October). Certain heavy vehicles such as public transport vehicles, fire engines or vehicles carrying perishable goods are exempt from this law – but they are nevertheless obliged to operate so as to cause as little noise disturbance as possible.

In special areas where a quiet environment is particularly necessary, restrictions on certain types of traffic may be imposed and are indicated by special road signs. In Zürich, for example, some ten streets are closed to mopeds and motorcycles at night (10.00 p.m. to 7.00 a.m.) because of neighbouring hospitals and residential schools.

In Lausanne the avenue d'Ouchy is forbidden to motorcycles between midnight and 6.00 a.m. The Lausanne-Berne traffic which used to pass by the Lausanne hospital district has been diverted since 1959 between 10.00 p.m. and 6.00 a.m. These are just a few examples of traffic diversion imposed *for noise reasons alone*. Any municipality is free to take whatever measures it wishes in this respect.

IV. HIGHWAY PLANNING

As regards new development projects, it is proposed that major highways should avoid built-up areas and particularly residential districts, that motorway feeders should by-pass residential districts or run through tunnels and that new buildings should be sited at a suitable distance from main roads (Federal Law of 8th March, 1960 on

Federal Highways). It is generally accepted that houses should not be built at less than 7 metres from a road – but this varies from one locality to another.

Use of Natural and Artificial Screens

Research has been conducted to evaluate the effectiveness of certain wooded areas or specific types of barriers in attenuating the propagation of road traffic noise. Conifers which, being evergreens, have practically the same effect in summer and winter, reduce traffic noise only slightly; a belt 100 metres wide gives an attenuation of about 4 to 6 dB. The use of natural screens provides above all a "psychological effect"; when the source of noise is not visible it appears to be less annoying even though the noise level may be approximately the same. The same research work also showed that very high barriers located as close to the road as possible provide a substantial reduction and it is suggested that shops be situated between residential districts and major roads. As a follow-up to this work, measurements were made in the vicinity of the Berne-Schönbuhl motorway where it runs through a cutting with retaining walls. The cutting not only acted as an acoustic barrier and reduced the noise perceived 50 metres from the middle of the carriageway [peak noise reduced by about 15dB(A)] but also substantially modified the frequency distribution, which rendered the noise less annoying.

V. BUILDING REGULATIONS AND ZONING

There are as yet no *regulations* concerning the insulation of buildings from noise from the outside, nor concerning the distance of buildings from major highways. The Association of Swiss Engineers and Architects (Schweizerischer Ingenieur und Architekten Verein) has recently prepared proposed *standards* concerning sound insulation in buildings which will be enforced in the near future. Though most of the standards proposed concern sound insulation *between* apartments the following measures are recommended as concerns noise from the street: bedrooms should be separated from noisy rooms by means of corridors, entrance halls, living rooms, and should be situated in the quietest side of the building away from external noise.

Attention is drawn to the fact that noise insulation of outside walls decreases with increased window and door surfaces. Sanitary installations, lift shafts, garbage disposal shafts, chimney ducts and ventilation shafts should be placed on the noisy side of the building. The *minimum* acoustic insulation of windows should be *20 decibels* and where possible *30 decibels*.

SWITZERLAND

The Federal Materials Testing Laboratory – in support of the standards proposed – has prepared a list of suggested ways of improving sound insulation in residential buildings in noisy areas. The suggestions are as follows:

Heavy buildings

External walls: 500 kg + / sq. metre
e.g. brick walls at least 32 cms thick, with plaster on both sides.

No large windows

Ratio of window surface/floor surface: 20 % or less.

Sound-insulating windows

30-35 dB (measured in laboratory)
e.g. double-glazing – outer pane: 5-6 mm thick
– inner pane: 3 mm thick
air space between the two panes: 30 mm
accompanied by good sealing in joints and frames.

Furthermore, the Association of Swiss Engineers and Architects has included in its proposed standards the recommendations formulated in 1963 by the Federal Commission for Noise Abatement (see Section I above) in its guiding principles for Noise Control. The Federal Commission suggested tolerated noise levels for various *zones*; if these levels are exceeded, the authorities must, if requested, take all legal and practical measures to reduce the noise. The values, in dBA, as measured at an open window, are given below.

Zone	Background noise level [2]		Frequent peaks [3]		Infrequent peaks [4]	
	Night [1]	Day	Night [1]	Day	Night [1]	Day
Resting	35	45	45	50	55	55
Quiet residential	45	55	55	65	65	70
Mixed	45	60	55	70	65	75
Commercial	50	60	60	70	65	75
Industrial	55	65	60	75	70	80
Main arterial road	60	70	70	80	80	90

1. "Night" is considered to be from 10.00 p.m. to 6.30 a.m.
2. Background noise level: average value (mean level without peaks).
3. Frequent peaks: 7-60 peaks per hour.
4. Infrequent peaks: 1-6 peaks per hour.

The six zones referred to above are defined as follows:

– *Resting:* hospital, convalescence homes, etc.;

– *Quiet Residential:* residential buildings with local shops and schools;

– *Mixed:* residential buildings, with restaurants, small workshops, e.g. large villages or urban districts with small workshops, shops, etc.;

– *Commercial:* business area;

– *Industrial:* districts with several factories and large workshops, warehouses, etc.;

– *Main Arterial Road:* immediate vicinity of roads with through traffic.

VI. MISCELLANEOUS

1. *Social Surveys*

No surveys have been conducted concerning the feelings of the public as regards *traffic noise specifically* (note: surveys are being conducted as regards aircraft noise). A general survey – involving 900 persons in the neighbourhood of Zürich – revealed that more than 50% of those questioned declared that they would be willing to pay the cost of more adequate noise insulation in their homes.

In Lausanne, another enquiry on noise was conducted in 1960 and gave the following results (3,290 persons questioned):

– the noise from motorcycles and mopeds annoyed 90% of those questioned;

– the noise from cars annoyed 32% of those questioned;

– the noise from trams annoyed 23.5% of those questioned;

– the noise from construction sites annoyed 22% of those questioned;

– the noise from trucks annoyed 17.5% of those questioned.

2. *Press*

The press has played an active and helpful role in supporting noise abatement campaigns and the police in its endeavours to check and reduce noise. Both national and local newspapers constantly publish articles reminding their readers of the existing legislation regarding noise and the penalties imposed on offenders.

3. *Drivers' Associations (Touring Club, Automobile Club, etc.)*

The Swiss Touring Club is also active in reminding its members of noise legislation in its bulletins and by means of illustrated pamphlets urging its members to use their vehicles as quietly as possible, particularly at night. The Automobile Club is also conscious of the problem and takes part in noise abatement measures.

4. *International Co-operation*

The Swiss authorities consulted in the course of this enquiry urged that there be closer international co-operation with a view to uniform vehicle-noise legislation between countries. This plea is prompted by the fact that Switzerland receives over 30 million tourist vehicles annually and that a considerable proportion of these vehicles emit noise over and above the levels accepted in Switzerland.

As visitors' vehicles are not subjected to Swiss laws, Switzerland would be interested in an international rule concerning vehicle noise.

UNITED KINGDOM

CENTRAL BODY FOR CO-ORDINATING GOVERNMENT ACTION WITH REGARD TO NOISE ABATEMENT

Since October 1970 general responsibility for all environmental matters, including noise, has been vested in the Secretary of State for the Environment and his Department which was formed by a merger of the previous Ministries of Transport, Housing and Local Government, and Public Building and Works. The Department of the Environment (DOE) also has specific responsibilities for aspects of noise abatement dealt with by the old Ministries. In particular, DOE is responsible for the regulation of vehicles and traffic, and the planning and design of roads. In addition to the extensive resources within his Department, the Secretary of State is advised by an Advisory Council on Noise which includes both laymen and others with expert knowledge of various aspects of the noise problem. The Government is also advised by a standing Royal Commission on Environmental Pollution.

REGULATIONS AND CURRENT PRACTICE REGARDING VEHICLES, VEHICLE OPERATION AND TRAFFIC OPERATION

Vehicles in use

There are long-standing regulations on the construction and use of vehicles which require:

a) Motor Vehicles to be fitted with a silencer for reducing as far as may be reasonable the noise caused by the escape of exhaust gases.

b) Silencers to be maintained in good and efficient working order and not to be altered in a way that would increase noise.

c) Vehicles not to make an excessive noise.

d) The horn not to be used on stationary vehicles and not to be used at all in built-up areas between 11.30 p.m. and 7.00 a.m.

UNITED KINGDOM

These regulations are enforced by the police; prosecutions and fines for the year 1969 are summarized in the following table.

NUMBER OF OFFENCES RELATING TO MOTOR VEHICLE NOISE IN ENGLAND AND WALES, 1969

Type of offence	Total of alleged offences	Total findings of guilt	Total fines imposed £
Noise caused by faulty silencer	15,330	12,707	41,769
Excessive noise due to defect or lack of repair, faulty packing of load	468	338	1,078
Not stopping engine so far as necessary to prevent excessive noise when stationary	108	54	160
Sounding horn in built-up areas between 23.30 and 7.00	276	149	395
Sounding horn when stationary	154	83	199
Excessive noise through lack of reasonable care by driver	319	238	900

The general practice is for the police to stop a vehicle which appears excessively noisy and examine its silencer. Evidence of deterioration, for example the presence of holes, or of tampering, for example the removal of baffle plates, is sufficient to secure a prosecution for offences against the silencer regulations. As can be seen from the table, rather fewer prosecutions are obtained for "excessive" noise, as this is difficult to substantiate in court. In the United Kingdom view it is not possible by means of regulation alone to prevent unnecessary "revving up" and use of the horn in the quiet hours or when the vehicle is stationary; these offences are transitory and leave no physical evidence, and the degree to which the regulations are observed must depend largely on the considerateness of individuals.

A further regulation made in 1968 provided for the use of noise meters and roadside checks. The procedure laid down in the regulation requires a microphone to be set up precisely 17 feet from the kerbside at a place where there are no walls nearby to reflect sound. The road surface must be dry and there must be no extraneous noises, such as that caused by another vehicle on the far lane of the carriageway, when the meter reading is taken. The regulation lays down maximum permitted noise levels in decibels; if a reading in excess of the permitted level is attained the enforcement officer manning the meter must signal a police officer further along the road to stop the vehicle, and court proceedings are then taken against the driver.

The procedure has been tried by several police forces assisted by the Department's vehicle examiners, but only 6 successful prosecutions have been obtained. It has been found that to stand any chance of catching an offending vehicle the check point must be at place where vehicles are using their engines to the full, for example a hill leading away from traffic lights. Even so, the driver can reduce engine noise momentarily by lifting his foot from the accelerator, either deliberately or in the process of changing gear, as he passes the microphone. The police and the Department have concluded that the procedure is not cost effective and cannot be used as a general tool of enforcement.

New vehicles

Until very recently, the only requirement on manufacturers was that vehicles should be provided with a reasonably efficient exhaust silencer. However, from 1st April 1970 new vehicles have had to meet specified noise levels when tested by British Standard 3425 – 1966 (which is virtually identical to the ISO test procedure for moving vehicles). In December 1970 the Secrétary of State published draft amending regulations which would decrease the permitted noise levels for most classes of vehicles, but temporarily increase the level permitted for heavy vehicles of over 200 horsepower. The following table sets out the levels at April 1970, and the levels proposed for vehicles first used after October 1973.

NOISE LEVELS PERMITTED FOR NEW VEHICLES

Class of Vehicle	April 1970 limits dB(A)	Limits proposed for October 1973 dB(A).
Motorcycles		
a) not more than 50 cc	77	77
b) more than 50 cc but not more than 125 cc	82	82
c) more than 125 cc but not more than 500 cc	86	84
d) more than 500 cc	86	86
Passenger cars	84	80
Light goods vehicle not less than 3,5 tons gross weight	85	82
Motor tractor not more than 1,5 tons	89	82
Heavy vehicles		
a) of not more than 200 h.p.	89	86
b) of more than 200 h.p.	89[1]	89

1. It is proposed that this limit should be raised to 92.

UNITED KINGDOM

In the longer term the United Kingdom authorities hope that vehicle noise limits can be lowered considerably further, but progress must depend on the success of research and development of new techniques.

Annex II

DIRECTIVES CONCERNING MAXIMUM NOISE LEVELS

United Nations (ECE, Geneva)
European Economic Community

UNITED NATIONS

ECONOMIC COMMISSION FOR EUROPE (ECE)

MAXIMUM LIMITS OF SOUND LEVEL
(New Vehicles) [1]

Category of vehicle	*Values expressed in dB(A)*
A. *Two-wheeled motor vehicles*	
a) with a two-stroke engine of cylinder capacity:	
– over 50 cm3 but not exceeding 125 cm3	82
– over 125 cm3	84
b) with a four-stroke engine of cylinder capacity:	
– over 50 cm3 but not exceeding 125 cm3	82
– over 125 cm3 but not exceeding 500 cm3	84
– over 500 cm3	86
B. *Three-wheeled motor vehicles* (except public works vehicles, etc.)	
– with a cylinder capacity exceeding 50 cm3	85
C. *Motor vehicles with four or more wheels* (except public works vehicles, etc.)	
a) private motor cars and conversions of such vehicles	84
b) goods transport vehicles of permissible maximum weight:	
– not exceeding 3.5 t.	85
– over 3.5 t. but not exceeding 12 t.	89
– over 12 t. – with an engine of 200 h.p. DIN or less	89
– with an engine of 200 h.p. DIN...	92

1. Extract from Addendum 8 (Rule No. 9 – *Uniform Provisions Concerning the Approval of Vehicles with Regard to Noise* – ECE, Geneva, 1968) *to the Agreement Concerning the Adoption of Uniform Conditions of Approval and Reciprocal Conditions of Approval for Motor Vehicles and Parts*, Economic Commission for Europe, Geneva, 1958.

UNITED NATIONS (ECE)

c) motor buses and motor coaches of permissible maximum weight:

– not exceeding 3.5 t.	85
– over 3.5 t. – with an engine of 200 h.p. DIN or less	89
– with an engine of more than 200 h.p. DIN	92

EUROPEAN ECONOMIC COMMUNITY

On 6th February, 1970, the Council of the European Communities laid down a directive concerning the harmonization of legislation of EEC Member states on the acceptable sound level and exhaust systems of motor vehicles, which was notified in the journal Officiel des Communautés Européennes No. 142 of 23rd February, 1970.

The Member states to whom this directive is addressed must bring into force the required national regulations within 18 months of the date of notification.

The directive applies to any road motor vehicle, with or without a body, having at least 4 wheels and designed for a maximum speed of over 25 km/h, excluding vehicles on rails, agricultural tractors and machinery and construction and civil engineering equipment.

It contains requirements in respect to the measuring apparatus, conditions and method of measurement and the exhaust system (silencer). The acceptable noise levels are laid down as follows:

Class of Vehicle	*Acceptable noise levels* [1]
Passenger vehicles with seating capacity for not more than 9 persons including the driver	82 dB(A)
Passenger vehicles with seating capacity for more than 9 persons including the driver and a maximum permissible weight not exceeding 3.5 tons	84 dB(A)
Goods vehicles with a maximum permissible weight not exceeding 3.5 tons	84 dB(A)
Passenger vehicles with seating capacity for more than 9 persons including the driver, and a maximum permissible weight of more than 3.5 tons	89 dB(A)

1. These figures are subject to a tolerance of 1 1 dBA and measurements are made at a distance of 7.5 metres.

EEC

Goods vehicles with a maximum permissible weight of more than 3.5 tons	89 dB(A)
Passenger vehicles with seating capacity for more than 9 persons including the driver and powered by an engine of 200 h.p. DIN or over	91 dB(A)
Goods vehicles powered by an engine of 200 h.p. DIN or over and having a maximum permissible weight of over 12 tons	91 dB(A)

OECD SALES AGENTS
DÉPOSITAIRES DES PUBLICATIONS DE L'OCDE

ARGENTINE
Libreria de las Naciones
Alsina 500, BUENOS AIRES.

AUSTRALIA – AUSTRALIE
B.C.N. Agencies Pty, Ltd.,
178 Collins Street, MELBOURNE 3000.

AUSTRIA – AUTRICHE
Gerold and Co., Graben 31, WIEN 1.
Sub-Agent: GRAZ: Buchhandlung Jos. A. Kienreich, Sackstrasse 6.

BELGIUM – BELGIQUE
Librairie des Sciences
Coudenberg 76-78, B 1000 BRUXELLES 1.

BRAZIL – BRESIL
Mestre Jou S.A.,
Rua Guaipá 518, SAO PAULO 10.
Rua Senador Dantas 19 s/205-6, RIO DE JANEIRO GB.

CANADA
Information Canada
OTTAWA.

DENMARK – DANEMARK
Munksgaard Boghandel, Ltd., Nørregade 6
KOBENHAVN K.

FINLAND – FINLANDE
Akateeminen Kirjakauppa, Keskuskatu 2,
HELSINKI.

FORMOSA – FORMOSE
Books and Scientific Supplies Services, Ltd.
P.O.B. 83, TAIPEI,
TAIWAN.

FRANCE
Bureau des Publications de l'OCDE
2 rue André-Pascal, F 75 PARIS 16e
Principaux sous dépositaires :
75 PARIS: Presses Universitaires de France,
49 bd Saint-Michel, 5e
Sciences Politiques (Lib.): 30 rue Saint-Guillaume, 7e
13 AIX-EN-PROVENCE: Librairie de l'Université.
38 GRENOBLE: Arthaud.
67 STRASBOURG: Berger-Levrault.
31 TOULOUSE: Privat.

GERMANY – ALLEMAGNE
Deutscher Bundes-Verlag G.m.b.H.
Postfach 9380, 53 BONN.
Sub-Agents: BERLIN 62: Elwert & Meurer.
HAMBURG: Reuter-Klockner; und in den massgebenden Buchhandlungen Deutschlands.

GREECE – GRECE
Librairie Kauffmann, 28 rue du Stade,
ATHENES 132.
Librairie Internationale Jean Mihalopoulos et Fils
75 rue Hermou, B.P. 73, THESSALONIKI.

ICELAND – ISLANDE
Snæbjorn Jónsson and Co., h.f., Hafnarstræti 9,
P.O.B. 1131, REYKJAVIK.

INDIA – INDE
Oxford Book and Stationery Co.:
NEW DELHI, Scindia House.
CALCUTTA, 17 Park Street.

IRELAND – IRLANDE
Eason and Son, 40 Lower O'Connell Street,
P.O.B. 42, DUBLIN 1.

ISRAEL
Emanuel Brown :
9 Princess Mary Avenue, JERUSALEM.
35 Allenby Road, and 48 Nahlath Benjamin St.,
TEL-AVIV.

ITALY – ITALIE
Libreria Commissionaria Sansoni :
Via Lamarmora 45, 50 121 FIRENZE.
Sous-dépositaires:
Editrice e Libreria Herder,
Piazza Montecitorio 120, 00 186 ROMA.
Libreria Rizzoli, Largo Chigi 15, 00 187 ROMA.
Libreria Hoepli, Via Hoepli 5, 20 121 MILANO.
Libreria Lattes, Via Garibaldi 3, 10 122 TORINO.
La diffusione delle edizioni OCDE è inoltre assicurata dalle migliori librerie nelle città più importanti.

JAPAN – JAPON
Maruzen Company Ltd.,
6 Tori-Nichome Nihonbashi, TOKYO 103,
P.O.B. 5050, Tokyo International 100-31.

LEBANON – LIBAN
Redico
Immeuble Edison, Rue Bliss, B.P. 5641
BEYROUTH.

MALTA – MALTE
Labour Book Shop, Workers' Memorial Building,
Old Bakery Street, VALETTA.

THE NETHERLANDS – PAYS-BAS
W.P. Van Stockum
Buitenhof 36, DEN HAAG.
Sub-Agents: AMSTERDAM C: Scheltema and Holkema, N.V., Rokin 74-76, ROTTERDAM: De Wester Boekhandel, Nieuwe Binnenweg 331.

NEW ZEALAND – NOUVELLE-ZELANDE
Government Printing Office,
Mulgrave Street (Private Bag), WELLINGTON
and Government Bookshops at
AUCKLAND (P.O.B. 5344)
CHRISTCHURCH (P.O.B. 1721)
HAMILTON (P.O.B. 857)
DUNEDIN (P.O.B. 1104).

NORWAY – NORVEGE
Johan Grundt Tanums Bokhandel,
Karl Johansgate 41/43, OSLO 1.

PAKISTAN
Mirza Book Agency, 65 Shahrah Quaid-E-Azam,
LAHORE 3.

PORTUGAL
Livraria Portugal, Rua do Carmo 70, LISBOA.

SPAIN – ESPAGNE
Mundi Prensa, Castelló 37, MADRID 1.
Libreria Bastinos de José Bosch, Pelayo 52,
BARCELONA 1.

SWEDEN – SUEDE
Fritzes, Kungl. Hovbokhandel,
Fredsgatan 2, STOCKHOLM 16.

SWITZERLAND – SUISSE
Librairie Payot, 6 rue Grenus, 1211 GENEVE 11
et à LAUSANNE, NEUCHATEL, VEVEY,
MONTREUX, BERNE, BALE, ZURICH.

TURKEY – TURQUIE
Librairie Hachette, 469 Istiklal Caddesi, Beyoglu,
ISTANBUL et 12 Ziya Gökalp Caddesi, ANKARA.

UNITED KINGDOM – ROYAUME-UNI
H.M. Stationery Office, P.O.B. 569, LONDON
S.E.1.
Branches at: EDINBURGH, BIRMINGHAM,
BRISTOL, MANCHESTER, CARDIFF,
BELFAST.

UNITED STATES OF AMERICA
OECD Publications Center, Suite 1207,
1750 Pennsylvania Ave, N.W.
WASHINGTON, D.C. 20006. Tel.: (202)298-8755.

VENEZUELA
Libreria del Este, Avda. F. Miranda 52,
Edificio Galipan, CARACAS.

YUGOSLAVIA – YOUGOSLAVIE
Jugoslovenska Knjiga, Terazije 27, P.O.B. 36,
BEOGRAD.

Les commandes provenant de pays où l'OCDE n'a pas encore désigné de dépositaire peuvent être adressées à :
OCDE, Bureau des Publications, 2 rue André-Pascal, 75 Paris 16e
Orders and inquiries from countries where sales agents have not yet been appointed may be sent to OECD, Publications Office, 2 rue André-Pascal, 75 Paris 16e

O.E.C.D. PUBLICATIONS, 2, rue André-Pascal, Paris-16e - No. 28.879 1971
PRINTED IN FRANCE