
Noise and the Sound Insulation of Buildings

F. Ingerslev

Phil. Trans. R. Soc. Lond. A 1972 **272**, 595-602

doi: 10.1098/rsta.1972.0066

Email alerting service

Receive free email alerts when new articles cite this article - sign up in the box at the top right-hand corner of the article or click [here](#)

To subscribe to *Phil. Trans. R. Soc. Lond. A* go to: <http://rsta.royalsocietypublishing.org/subscriptions>

Noise and the sound insulation of buildings

BY F. INGERSLEV

*Acoustics Laboratory, Technical University of Denmark,
Lyngby, Denmark*

It is claimed that noise results from failure to take into account the full consequences of our activities. Noise causes today an unjustifiable interference with human comfort and well-being. An outstanding task for the building industry in the 1980s is to ensure a proper noise climate in new buildings. The target must be to obtain a noise level which is so low that the noise causes no interference with human activities.

Problems related to indoor noise sources in buildings are discussed. It is to be expected that the public demand in the 1980s will call for more severe requirements than at present. There will be a request for having within a dwelling one room which is highly insulated from the other rooms. The 1980s will present a request for apartment buildings with flexible flats. This will call for special sound insulation provisions.

The noise level produced by intruding outdoor noise causes today severe nuisance. The use of building façades giving a high sound insulation is not an ideal method to be used for sound reduction. Reducing the noise emitted by outdoor sound sources provides the most attractive and most effective means of noise abatement. It is unlikely that the outdoor noise level can ever be reduced to such a level that outdoor noise produces no problem. Other methods for reducing the noise level at the façades of noise-exposed buildings must be applied.

Screening is a useful measure. Buildings used for noise-insensitive activities can be utilized. Earth banks or barriers are other examples of screening devices.

Effective noise abatement will, however, not be possible unless land use planning is radically reconsidered in view of its use as a tool for noise abatement.

1. INTRODUCTION

‘The fight against pollution is not a search for villains. For the most part, the damage to our environment has not been the work of evil men, nor has it been the inevitable by-product either of advancing technology or of growing population. It results not so much from choices made, as from choices neglected; not from malign intention, but from failure to take into account the full consequences of our actions.’

Everyone engaged in noise abatement can endorse this statement made by Richard Nixon in a message to the Congress, 11 February 1970.

Noise causes today an unjustifiable interference with human comfort and well-being.

Noise cannot, of course, be totally eliminated, but noise can usually be reduced to an acceptable level.

An outstanding task for the building industry in the 1980s is to ensure a proper noise climate in new buildings. The noise climate shall be far better than in the buildings of the 1960s.

A proper noise climate can, however, only be obtained if building and planning authorities will also acknowledge their responsibility in this connexion.

We know what should be done to ensure a proper noise climate.

We have already the necessary know-how.

It is not a question of innovations.

There is consequently no excuse for neglecting to secure an acceptable noise climate. It is a matter of will. It is a must.

The topic of this paper is a very broad one. Many aspects of the topic are widely known. Therefore, it was decided not to present a synoptic paper but to focus on the more vital problems within the topic.

2. TARGET

For the purpose of this paper noise is defined as: 'sound which is undesired by the recipient'. This is an important definition which should be borne in mind by authorities and everybody engaged in the building industry.

The target for noise abatement seems in certain circles to be the noise level which can be forced on the citizen without causing serious protests. This is indeed a false target. The target must be the noise level which is so low that the noise causes no interference with human activities, including rest and sleep. It may in this context be valuable to recall the World Health Organization's definition of health: 'Health is a state of complete physical, mental, and social well-being, and not merely an absence of disease and infirmity.'

It is clearly impossible to institute an elaborate noise-abatement policy without defining the noise-abatement target in proper technical terms. It is, for the purpose of this paper, adequate to use as target the noise levels for dwellings recorded in the Wilson Report (1963).

The noise level inside living rooms and bedrooms should, according to the Wilson Report, not be exceeded for more than 10% of the time by the values stated in table 1.

TABLE 1

situation	day	night
country areas	40 dB (A)	30 dB (A)
suburban areas, away from main traffic routes	45 dB (A)	35 dB (A)
busy urban areas	50 dB (A)	35 dB (A)

Today millions of people in cities all over the world live in homes where the noise levels exceed these values. The number will increase rapidly in the years to come. A drastic increase in our noise-abatement campaign is the only measure which can stop this development. Immediate results can be obtained in connexion with new buildings, especially when situated in new residential areas. Significant improvements of the noise climate in existing buildings will generally not manifest themselves until a great many years have passed.

3. INDOOR NOISE SOURCES IN BUILDINGS

Indoor noise sources in homes are chiefly of four types: (1) automatic home appliances, e.g. dishwashers, washing machines, and vacuum cleaners; (2) heating and air-conditioning systems, water installations, and lifts; (3) neighbours' voices and impacts; (4) entertainment devices, e.g. musical instruments, tape-recorders, radio and television.

Indoor noise sources in other buildings, e.g. office buildings, schools, and hospitals belong to the same categories.

The importance of having a good noise climate inside buildings was generally accepted 30 to 40 years ago. The building codes of a number of countries, especially countries in the northern part of the European continent, include among their regulations also regulations which have the purpose to ensure a proper noise climate inside buildings. Permissible noise levels produced by automatic home appliances, e.g. heating and air-conditioning systems, water installations, lifts, etc., are prescribed. The noise level due to neighbours' voices and impacts as well as neighbours' entertainment devices are controlled through requirements concerning airborne and impact sound insulation.

It is to be expected that the public demand in the 1980s will call for more severe requirements than present requirements, especially in connexion with sound insulation between semi-detached houses.

It is also to be expected that there will be a request for having within a dwelling one room which is highly insulated from other rooms. This will make it possible for a member of the family to retire to this room either when he wants to relax or to listen to stereo music without being disturbed or disturbing the remainder of the family.

No doubt the building industry will also have to face the fact that the 1980s will present a request for apartment buildings with flexible flats. This will call for special sound insulation provisions.

It is to be expected that a great number of old residential buildings will be renovated during the coming years. It will often be difficult to fulfil the modern requirements for sound insulation in such buildings. The extent to which it will be possible depends on the actual construction of the buildings.

A number of old residential houses having a great number of rooms will be divided up into a number of separate rooms. In such cases the fulfilment of modern sound insulation requirements may also be difficult.

Since the principles used to fulfil the present requirements concerning indoor noise sources are well known, and since identical principles shall be used in future when more severe requirements may be introduced, the discussion about the problems related to the indoor noise sources will be restricted to the comments already presented.

4. OUTDOOR NOISE SOURCES

The greater part of outdoor noise sources can be classified in the following seven groups: (1) motor vehicles; (2) aircraft; (3) railways; (4) industrial and commercial enterprises; (5) demolitions, construction, and road works; (6) racing tracks, amusement parks, night clubs, discotheques, etc.; (7) local human activities such as noisy persons, slamming of car doors, lawn mowers, and the like.

It is only during the last 10 to 20 years that attention has been paid to intruding outdoor noise. During this period of time the noise level outside buildings has increased to such an extent that intruding outdoor noise causes severe nuisance.

No doubt control of the intruding outdoor noise will be one of the major problems to be solved in the 1980s.

Four methods of action can be applied: (1) sound insulation of the building façade against outdoor noise; (2) reduction of the noise emitted by outdoor sound sources; (3) screening; (4) land use planning.

4.1. *Sound insulation of the building façade against outdoor noise*

The insulation of building façades against outdoor noise has not hitherto been regarded as a matter of utmost importance, except for special buildings such as concert halls and theatres.

The use of building façades giving a high sound insulation is not a method which can be generally introduced as the solution of the noise problem presented by outdoor noise sources.

It is unrealistic and criminal if our children will have to ensconce themselves in highly sound-insulated buildings when they want to live in an acceptable noise climate in their homes. It is a human right to be able to open the window, to spend part of the day, the evening, or even the night in the garden or on a balcony without being drowned in noise.

Therefore, once more: building façades giving a high sound insulation are not a universal solution to the noise problem caused by outdoor noise sources. This does not mean, however, that façades giving high sound insulation may not be advantageous in certain cases. Buildings, e.g. office blocks, provided with effective ventilating systems, may face noisy streets if they have façades giving high sound insulation.

It may also be useful to improve the sound insulation of the façades of residential buildings if the buildings are situated in an area where the outdoor noise level is high. The residents in the buildings will then – if the sound insulation of the façades is sufficiently high – live in an acceptable noise climate when the windows are closed.

4.2. *Reduction of the noise emitted by outdoor sound sources*

Reducing the noise emitted by outdoor sound sources provides the most attractive and most effective means of noise abatement. This is of course especially an effective measure when the sound source is mobile such as, for instance, a motor vehicle, an aircraft, or a train.

Motor vehicles

Governments in many countries have already introduced standards which specify the permissible noise emissions from various types of vehicles.

In many countries the standards are fairly lenient. Considerably more strict standards should be introduced. They should be set in the light of the best technology available at the time of institution, e.g. in terms of the noise-emission characteristics of the most quiet 25 to 50 % of the vehicles in each category. The standards should be made progressively more stringent to reflect evolutionary advances in technology. The most rapid rate of reduction in permissible noise-emission levels should be applied to the noisiest classes of vehicles.

The task of developing the technology of quieter motor vehicles lies primarily with private industries. The government should, however, encourage this development.

An international coordination of the efforts to reduce noise from motor vehicles, especially with respect to more stringent standards for permissible noise levels, would be of great value, both for economic and health reasons.

Aircraft

It is well-known that the violent reaction against noise from jet-aircraft has launched a considerable research activity with the object of reducing the noise emission. Valuable advances may be expected in the future, but further progress should certainly be aimed at. The introduction last year of noise certifications of aircraft is an important event.

Railways

It is not possible to report on a general move for reduction of the noise from railways. It should, however, be easy to start one since the railways in most countries are State railways. It seems justified to request that the governmental authorities take firm action against the noise emission from railways.

Industrial and commercial enterprises

During the last two or three decades considerable attention has been paid to the control and reduction of noise from industrial and commercial enterprises.

It is well known that industrial and commercial enterprises often give rise to complaints from residents in neighbouring residential areas. Some countries have already recommendations for maximum permissible noise levels produced by industrial and commercial enterprises at the boundaries of their sites. It is to be expected that these recommendations will be transformed into actual mandatory regulations in the years to come.

It is evident that many industrial and commercial enterprises will have to reduce the noise emitted from their activities – industrial processes and machinery – if they are to comply with strict regulations of the type mentioned.

Demolitions, construction and road works

Both authorities and manufacturers of certain types of machinery to be used for demolitions, construction, and road works have paid a fair amount of attention to the noise emission from such machinery. So-called ‘noiseless’ models of certain types of machinery are already on the market. Some countries have already introduced regulations. Such regulations can take the form of prescribed type tests which shall be carried out to prove that the maximum permissible noise emission is obeyed. The regulations can also be specified in terms of maximum permissible level at certain specific noise sensitive points, e.g. at the windows of residential buildings close to the building site or close to the road under repair or construction. In the latter case, it is possible to use fairly noisy machinery when the distance from the site to the residential buildings is great.

Racing tracks, amusement parks, night clubs, discotheques, etc.

Noise problems caused by such outdoor noise sources may be solved through conditions attached to licensing legislations.

Local human activities such as noisy persons, slamming of car doors, lawn mowers, and the like

Noise problems caused by these noise sources should primarily be avoided by convincing the citizens about the importance of avoiding producing unnecessary noise which may disturb neighbours.

4.3. Screening

It must be realized that it is unlikely that the outdoor noise level can ever be reduced to such a level that noise produces no problems. This is especially the case close to airports, highways, main streets in cities, and sites for heavy industries.

Screening is a useful measure which can contribute to a reduction of the outdoor noise level at the façades of noise-exposed buildings.

Buildings used for noise-insensitive activities can be utilized to screen buildings and areas used for noise-sensitive activities.

Typical examples of buildings used for noise-insensitive activities are garage buildings, storehouses, supermarkets, department stores, restaurants, exhibition buildings, buildings for industrial and commercial enterprises, cinemas, and office blocks if provided with effective ventilating systems.

Such buildings can face, for instance, noisy streets and thus screen the area behind the buildings, making it possible to place buildings used for noise sensitive activities, e.g. residential buildings, fairly close to a noisy street. It is of course necessary to avoid noisy activities in rooms in a screening building which faces the residential buildings unless the building façade gives a high sound insulation. It should also be realized that any form of interruption of the row of buildings along the noisy streets causes transmission of noise into the screened area.

Earth banks or barriers (of timber, steel, or concrete) can also be used as screening devices. The height of earth banks or barriers will usually be restricted to 5 to 10 m. Maximum noise reductions will be obtained by placing the earth banks or the barriers either close to the noise source or close to the receiver.

For urban areas shrubbery and trees can be used as a measure for visual screening, but their noise screening effect is low.

Tunnels are an ideal solution giving 100 % screening of traffic noise.

The described screening methods – with the exception of the tunnel method – are also useful when screening noise from industrial and commercial enterprises.

4.4. *Land use planning*

The increasing noise level produced by outdoor noise sources has made it evident that effective noise abatement will only be possible if land-use planning is radically reconsidered in view of its use as a tool for noise abatement.

The International Organization for Standardization (1971) has published a guide, Recommendation R 1996, 'Noise assessment with respect to community response', which gives the authorities valuable information to be used when drawing up rules for land use planning. This Recommendation specifies a method for the measurement of noise, the applications of corrections to the measured levels (according to duration, spectrum characteristics, and peak factor), and a comparison of the corrected levels with a noise criterion which takes account of various environmental factors. It is to be expected that some countries in the near future will introduce regulations which specifies maximum permissible noise levels produced by industrial and commercial enterprises in various districts as, for example, recreational areas, rural residential areas, suburban residential areas, and industrial areas.

Table 2 gives a Danish proposal for maximum permissible outdoor noise levels produced by new industrial and commercial enterprises. These levels are the Rating Sound Level, determined as described in I.S.O. Recommendation R 1996. The levels are even more strict than those recorded in the Wilson Report (see table 1). It should be remembered that the values in table 1 are indoor noise levels contrary to the noise levels in table 2, which are outdoor noise levels.

It is evident for people familiar with noise produced by industrial and commercial enterprises that the values given in table 2 can only be met if the authorities revise radically the principles for land use planning in view of the specified permissible noise levels. Industrial areas should, for instance, be kept properly separated from residential areas. It will be useful to introduce zoning of industrial areas, placing the more noisy enterprises at the centre of the areas and less

TABLE 2

area	daytime		
	Monday to Friday, 07.00–18.00; Saturdays, 07.00–14.00	all evenings, 18.00–22.00; Saturday, 14.00–18.00; Sundays and holidays, 07.00–18.00	night-time 22.00–07.00
area for very noisy industrial and commercial activities	70 dB (A)†	70 dB (A)†	70 dB (A)†
area for other industrial and commercial activities	60 dB (A)†	60 dB (A)†	60 dB (A)†
area with multi-storey residential houses	50 dB (A)	45 dB (A)	40 dB (A)
area with one-storied and two-storied residential houses; villages; recreational areas in cities	45 dB (A)	40 dB (A)	45 dB (A)
areas with week-end cottages; country areas	40 dB (A)	35 dB (A)	35 dB (A)

† The site belonging to the industrial or commercial enterprise is excluded. The stated noise level is only at the site of other enterprises within the area.

noisy enterprises at the border of the areas. It is also evident that it is advisable to have fairly large industrial areas and not to have many, small industrial areas, as is the usual practice today.

It should be noted that it is only new industrial and commercial enterprises which will have to comply with the noise levels stated in table 2. This does not mean, however, that the values cannot be used as a guidance when evaluating the justice of a complaint due to noise from an existing industrial or commercial enterprise.

It is also evident that this calls for new directives for land-use planning around highways and airports. The planning should be prepared in view of the traffic which may be expected about 30 to 50 years after the construction of the highway or airport. The far-sighted authority should prefer rather to overestimate than to underestimate the amount of future traffic.

Land-use planning along streets within cities is a complicated task.

It is often difficult to avoid that existing residential buildings are exposed to traffic noise having a level above the level considered to be the maximum acceptable level. This may occur when the traffic intensity increases rapidly or when a new street for through traffic is built.

If it is impossible to remove such residential buildings – or other buildings for noise sensitive activities – it may in certain cases be possible to utilize such buildings for other, less noise sensitive activities such as office activities. If it is necessary to continue to use the buildings as residential buildings, an improvement of the sound insulation of the front façade may be the only possible way to improve the internal noise climate.

5. CONCLUSIONS

A proper noise climate in buildings calls for sound insulation against indoor and outdoor noise sources. The requirements for the noise climate are expected to be more severe in the 1980s than the present requirements.

The principles used today for insulation against indoor noise sources will also be used in the 1980s.

The noise level outside buildings has, during the last 10 to 20 years, increased to such a level that intruding outdoor noise causes severe nuisance. No doubt control of the intruding outdoor noise will be one of the major problems to be solved in the 1980s.

Building façades giving a high sound insulation are not a universal solution. They may, however, be advantageous in certain cases.

Reducing the noise emitted by outdoor sound sources provides an effective means for noise abatement.

Buildings used for noise insensitive activities can be utilized to screen buildings and areas used for noise sensitive activities.

Earth banks or barriers (of timber, steel, or concrete) may also be used as screening devices.

The most effective noise-abatement procedure is, however, land use planning.

REFERENCES (Ingerslev)

- Wilson Report. 1963 Final report of the Committee on the Problem of Noise, Cmnd. 2056. London: H.M.S.O.
International Organization for Standardization 1971 Recommendation R 1996 'Noise assessment with respect to community response'.