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REQUIREMENTS FOR THE PROTECTION AGAINST OUTDOOR NOISE IN VARIOUS COUNTRIES WITH RESPECT TO STANDARDIZATION AND REGULATIONS

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1. INTRODUCTION

Quiet living plays an important role for many people. Especially in highly industrialized and densely populated countries, quiet living has become a precious value because of increasing exposure of traffic noise. In the countries of the European Union today more than 20 % of the population are living in highly exposed areas along roads where the level (L_{Aeq}) exceeds 65 dB(A) at daytime (so called black spots). 2% are living in corresponding areas along railways, 1 % in the surroundings of airports [1].

If quiet outdoor living is not possible because of environmental noise and the use of balconies, terraces, and gardens is restricted at least the acoustical conditions indoors have to be designed in a way that important human activities can be performed without interferences as far as possible.

In this paper, criteria for indoor noise levels related to these activities are presented and compared to regulations for sound insulation from various countries.

2. ASSESSMENT OF NOISE FROM OUTSIDE

The most important criteria for the assessment of noise from outside are interference with communication, recreation especially sleep, mental activities as well as the reduction of well-being (annoyance).

In general, the effects of noise without conspicuous characteristics and to which persons are used can be assessed by means of noise levels quite well. The most preferred noise descriptor is L_{Aeq}. For intermittent noise maximum level, duration, and number of noise events allow for a more differentiated assessment of noise effects especially at night-time. However, typical relationships between L_{Aeq} and maximum levels can

often be taken into account when assessing noise. E. g. the maximum level of a single event with a duration of 15 s (e. g. a passing train) and occurring once per hour exceeds the hourly L_{Aeq}-values no more than 25 dB(A); thus, a limiting value for L_{Aeq} of let's say 30 dB(A) will restrict the maximum level of such an event to 55 dB(A).

Table 1: Criteria for the assessment of noise from outside in dwellings, daytime

Daytime	
L_{Aeq} in dB(A)	Effects
< 30 - 35	no considerable disturbances to be expected
35 - 40	increasing interference with communication possible (*hearing impaired or older persons)* still good speech intelligibility (S/N>10 dB) in relaxed conversation *(normal hearing persons)* increasing interference with recreation
40 - 45	considerable interference with communication (*hearing impaired or older persons)* only fair speech intelligibility in relaxed conversation (*normal hearing persons*) considerable interference with recreation increasing annoyance
> 45 - 50	increased vocal efforts during communication, increasing high annoyance, considerable interference with recreation, indoor situation in highly impacted areas where increased cardiovascular risk is discussed [2][3][4]

The research of noise effects has yielded that the degree of noise effects like annoyance and interferences increase continuously with increasing level above certain thresholds, making recommendations for guideline or limiting values difficult. Table 1 and 2 describe how the activities mentioned above are affected by noise at various levels at daytime and night-time. The level fields are underlayed with different grey stages. White fields indicate the threshold of adverse noise effects, but with higher demands lower levels can still improve the acoustical comfort. Black fields indicate noise levels where negative health effects might have to be taken into account. The WHO [5] recommends that the indoor levels at night-time should not surpass 30 dB(A) (continuous noise) and 45 dB(A) (single events) respectively.

3. REGULATIONS IN VARIOUS COUNTRIES

Preliminary remarks

Sound protection regulations especially serve to create acceptable living conditions. Priority must be given to measures preventing and mitigating noise emissions, e. g. noise conscious behaviour, application of low-noise technology, and temporal restrictions for unduly noisy activities. If all these measures and reduction measures on the propagation path are not

sufficient - as a last resort - passive insulation measures at the building have to be applied.

Table 2: Criteria for the assessment of noise from outside in dwellings, night-time

Night-time		
continuous noise	intermittent noise	
L_{Aeq} in dB(A)	L_{Amax} in dB(A)	Effects
< 25 - 30	< 40	no considerable disturbance of sleep to be expected
> 30 - 40	> 40 - 45	Changes in sleep stage, duration of REM-sleep, deep sleep
	> 50 - 55	stress reactions during sleep [21], vegetative reactions (heart rate, vasoconstriction)
	> 50 - 60	sleep disorders and awakening reactions possible [18]

In many countries, insulation of buildings is not an adequate mean to protect people from noise because of climatic conditions and a preference of living outdoors. But with increasing use of (low-noise!) air-conditioning insulation of dwellings may become more and more important in these countries.

Areas of application

in addition to outdoor noise regulations [20], many countries have passed regulations to protect people inside their dwellings. The following overview will show a selection. The information comes from various sources which are cited. Because of revision of some of the regulations is being considered, the information may not be current.

There are two types of regulations. The first one contains target values for the noise levels indoors. The sound insulation of the enclosure has to be carried out in such a way that these values are complied with. The second type describes acoustical requirements for the enclosure depending on the noise levels outdoors. This approach has some advantages from a practical point of view because no detailed investigation is necessary to determine the conditions (spectrum of noise source, characteristics of the rooms) under which the indoor levels can be reached. Concerning the latter type of regulations different indices are in use in various countries to describe the requirements for sound insulation (standardized level difference D_{nT}, sound reduction index R', weighted apparent sound reduction index R'_w). To make comparison easier the corresponding indoor levels (L_{Aeq}) are calculated approximately.

Table 3 gives an overview over the regulations. It presents the field of application, if necessary the noise source, the noise index in use, and the immission values. It turns out that the regulations can serve different aims and fields of application.

Table 3: Immission values indoors for dwellings

Country	Noise source	Application	Noise index	Immission value in dB(A)		Remarks	Ref.
				Day	Night		
Austria	various	new dwellings	L_{Aeq}	32	22	standard with requirements for R'_w	[6]
	rail	precautionary measures at new and altered railways	L_r	30		rating level with rail bonus of 5 dB	[4]
Canada	road,rail, industry	regional or local noise regulations	L_{Aeq}	45	40	recommendation of Health and Welfare ,Canada	[7]
Denmark	various	new dwellings	L_{Aeq}	30			[8]
France	various	new dwellings	L_{Aeq}	35		standard with requirements for $D_{n,T}$	[8]
Germany	various	classification of dwellings and houses	L_{Aeq}	35/35/30		classes 1 to 3 of acoustical comfort	[9]
	road, rail, industry	new dwellings	L_r	35		standard with requirements for R'_w rating level with rail bonus of 5 dB	[10]
	aircraft	new dwellings	$L_{eq(4)}$	35		ordinance with requirements for R'_w, immission value for noise zone 2 at airports	[12]
	road, rail	precautionary measures at new and altered roads/railways	L_r	40	30	guideline of the Ministry for Transportation rating level with rail bonus of 5 dB	[11]
Great Britain	various	new dwellings	L_{Aeq}	40 35	35 30	design indoor levels based on BS 8233 and BRE Digest 266, levels for higher comfort	[13]
Greece	various	new dwellings	L_{Aeq}	35		guideline with requirements for R'_w	[8]
The Netherlands	road, industry	new dwellings, precautionary, remedial measures	L_{Aeq}	35	25	legal regulation	[14]
	rail	s. above	L_{Aeq}	37	27	legal regulation	[14]
	aircraft	remedial measures at dwellings	L_{Aeq}		26	legal regulation	[14]
Norway	road	new dwellings	$L_{Aeq,24h}$ L_{Amax}	30 - 35 45 - 55		guideline values	[1]
	rail	precautionary measures	$L_{Aeq,24h}$ L_{Amax}	30 50		proposed guideline values	[1][15]
	aircraft	remedial measures at dwellings	EFN	35		EFN noise index similar to L_{DN}	[1]
Sweden	various	classification of dwellings and houses	L_{Aeq}	30/26/22		class 1 to 3 /class 4/class 5 of acoustical comfort	[15]
	road	precautionary measures	$L_{Aeq,24h}$	30		guideline values	[1]
	rail	precautionary measures	$L_{Aeq,24h}$ L_{Amax}	30 50		guideline values of transportation administration	[1]
Switzerland	road, rail, industry, aviation	new dwellings, precautionary, remedial measures	L_r	40	35	ordinance with requirements for R'_w rating level with rail bonus of 5 dB in general	[16]
USA	various	new dwellings	L_{DN}	45		guideline with requirements for noise level reduction	[17]

Classes of acoustical quality of dwellings and houses. The classification of the acoustical quality of dwellings supplies clients, buyers, and tenants with information to get the desired acoustical comfort (intimacy, possibilities for noise intensive activities). As a part of it, requirements for the protection against outdoor noise described. In Table 3, regulations from Germany and Sweden are listed. They lead to indoor levels of 30 dB(A) and 22 dB(A) respectively in the class with the highest comfort.

New houses and dwellings in noisy areas. In many countries, regulations have been passed for the sound insulation of new houses and dwellings. They are of special importance in noisy areas where new dwellings are to be approved exceptionally (e. g . in the surroundings of airports or along busy roads). Table 3 shows the maximum immission values to be tolerated for various countries. It turns out that they vary considerably between countries. At daytime the difference between the highest value of 45 dB(A) (Canada, USA) and the lowest value of 30 dB(A) (Nordic countries) amounts to 15 dB(A). The noise levels cover the range from white fields to grey fields in Table 1.

At night-time, the differences are even higher. The immission values vary from 22 dB(A) (Austria) to 40 dB(A) (Canada). In some Nordic countries, the maximum level L_{Amax} is limited in addition to L_{Aeq}. By this, the protection of sleep can be considerably improved in cases where only a few noise events occur during night-time.

If the immission values are compared to the criteria in Table 1 and 2 it turns out that some countries only make minimum requirements for sound insulation at new dwellings while others want to prevent noise effects to a large extent. It could be argued that it should be left to the client to improve sound insulation with higher demands because he has to pay the cost anyway. But as the client is not always the affected person, the negative effects of noise are recognized very often too late , and remedial measures are very expensive more demanding immission values have to be strongly recommended.

Remedial and precautionary measures at existing houses and dwellings. In some countries, regulations have been passed to support sound insulation in highly exposed areas (remedial measures) or with the construction or considerable alteration of transportation or industrial installations when measures at the source are not possible or too expensive (precautionary measures). Especially in case of precautionary measures the requirements should meet a high standard because the outdoor situation deteriorates. To date comprehensive, legally binding regulations only exist in The Netherlands and Switzerland. In other countries, e. g. Germany, legal regulations only exist for some noise sources.

4. CONCLUSIONS

The comparison of requirements for the protection against outdoor noise from various countries shows a large variety of noise indices and immission values, sometimes even within one country. In some countries, regulations refer to the prevention of health hazards, other countries prefer immission values which guarantee undisturbed human activities as far as possible. As the regulations are most important in situations where the outdoor conditions are poor or deteriorating, a high acoustical standard is strongly recommended to establish comfortable living conditions at least indoors. Classification of the acoustical standard of houses and dwellings should be promoted to help clients, buyers, and tenants to get the desired acoustical comfort and to improve sound insulation by market mechanisms in the long run.

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