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SOUND INSULATION REQUIREMENTS IN OFFICE BUILDINGS AND SCHOOLS

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By order of the Austrian Ministry for Building and Technology the sound insulation between adjacent rooms in schools and office buildings has been measured. Additionally all teachers teaching in classrooms of schools and all employees working in office rooms were asked with a questionnaire to what extent they were satisfied by the acoustical conditions or disturbed by noise from the outside or from neighbouring rooms. From the correlation between the results of the sound insulation measurements and the subjective response, requirements for sound insulation in schools and office buildings have been established.

1. Introduction

In an investigation on sound insulation in office buildings and schools, sound insulation measurements and an inquiry on the subjective satisfaction (or dissatisfaction) with the acoustical conditions have been carried out. From the results some recommendations on the required sound insulation could be derived.

2. Sound insulation measurements

The measurements were performed according to ÖNORM S 5100 (similar to ISO 140). The normalized level difference —referred to 10 m² equivalent absorption area in the receiving room —between adjacent rooms separated by partition walls or floors

$$D_n = L_1 - L_2 + 10 \log 10/A,$$

D_n — normalized level difference in dB, L_1 — sound level in the source room in dB, L_2 — sound level in the receiving room in dB, A — equivalent absorption area in the receiving room in m², was measured in third octave bands from 100–3150 Hz and the weighted normalized level difference D_{nw} was calculated

to *ISO 717*. For floor also the impact sound insulation was measured by the normalized impact sound level – octave band levels in third octave steps referred to 10 m² equivalent absorption area in the receiving room – and the "Trittschallschutzmaß" (impact protection margin) was calculated by using the reference curve[1].

The tested rooms were sampled according to different structural details, e.g. different types of walls, different junctions of partition walls and external walls, to cover all existing types of sound insulation in the buildings. Especially rooms, in office buildings, separated by a partition wall, with or without a door, had to be considered separately.

3. Questionnaire on subjective satisfaction or dissatisfaction with acoustical conditions

A questionnaire has been worked out to ask the following details:
In the buildings:
Disturbance felt in 3 gardes: *slightly disturbed*, *disturbed*, *highly distrubed*
- when discussing with colleagues
- when listening to the telephone
- when performing mental work

caused by activities in the adjacent rooms (generally 4 rooms) as
- speaking, telephoning
- typing noise
- impact noise, chairs and similar

and caused by outside noise sources (e.g. traffic)
- with windows open
- with windows closed.

In school buildings:
Annoyance felt (in 3 grades as before)
- when teaching
- when pupils are speaking
- when tests have to be performed by the pupils

caused by activities in the adjacent classrooms (generally 4 rooms) as
- talking
- singing
- walking
- moving chairs

and caused by outside sources (e.g. traffic, sport areas)
- with windows open
- with windows closed.

The sound insulation measurements and the inquiries have been carried out in 6 schools and in 4 office buildings.

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[1] In Austria the impact sound level is still measured in octave bands and weighted by a shifted reference curve (with $L_n = 70$ dB at 100 Hz).

4. Sound insulation in office buildings

From the results of the inquiry (in summary 736 questionnaires) and of the sound insulation measurements the following recommendations can be derived: The main disturbance in office rooms is caused by traffic noise. E.g. in one building exposed to an A-weighted equivalent sound level of 72–75 dB 22 % of the employees felt disturbed and 50 % highly disturbed with windows open, and with double glazed windows closed 47 % felt disturbed at the telephone and 60 % at mental work, even 20 % disturbed or highly disturbed.

In average the disturbance is the same for all floors. Therefore, designing buildings

– traffic noise at the site

– the required sound insulation of windows and facades according to this as prescribed in ÖNORM B 8115 (see Table 1)

– the necessary air change via a mechanical ventilating system or silenced air-intakes and outlets

have to be considered.

Table 1. Minimum sound insulation of facades of office buildings

A-weighted equivalent sound level [dB]	< 65	$66-70$	> 70
minimum weighted sound insulation index R_w[dB]	33	38	43

Talking (also at the telephone) in the neighbouring room and much less typing in the neighbouring room was the main noise source inside the building. Discussion with colleagues or telephoning is little disturbed by the neighbouring noise sources, disturbance during mental work was quoted much more; the evaluation of required sound insulation was therefore based on this.

The required sound insulation inside the building is shown by the following outcome of the inquiry for different buildings:

It turns out, that a normalized level difference $D_{nw} \geqslant 45$ dB between office rooms may be recommended. In several questionnaires the respondents mentioned, that avoiding disturbance is not as important as ensuring privacy for certain discussions in certain conference rooms or similar. To ensure this a higher normalized level difference of $D_{nw} \geqslant 55$ dB (the minimum requirement between dwellings) is recommended.

The disturbance caused by activities in rooms separated by a partition wall with a door turned out to be very small, though the measured sound level difference was only 24–25 dB. A minimum sound insulation between office rooms connected by a door does not seem necessary.

Table 2. Sound insulation and disturbance in office rooms

Weighted normalized level difference D_{nw} [dB]	Percentage of employees disturbed slightly disturbed highly disturbed disturbed		
	by noise in office rooms separated by a partition wall		
30–36	42	3	–
31–34	45	12	3
34–39	19	5	3
34–39	57	7	2
37–41	30	6	2
	by noise in office rooms separated by a floor		
44–46	very slightly disturbed		
47	no disturbance		
47–48	no disturbance		
61–63	no disturbance		
61–63	no disturbance		

In several questionnaires however disturbance caused by talking and walking in the corridors was mentioned. Therefore it seems necessary to require a minimum sound insulation between office room and corridor with $D_{nw} \geqslant 35$ dB (walls with doors) and $D_{nw} \geqslant 45$ dB (walls without doors).

The required impact sound insulation between office rooms can be derived from the following results of the questionnaires:

Table 3. Impact sound insulation and disturbance in office rooms

Trittschallschutzmaß [dB]	Percentage of employees disturbed slightly disturbed highly disturbed		
+ 3	27	–	–
+ 8	no disturbance		
+11	5	5	–
+30	no disturbance		

An impact sound insulation margin of $\geqslant 10$ dB may be recommended. This should be also ensured between corridor and office room at the same level (impact sound insulation in horizontal direction).

5. Sound insulation in school buildings

From the results of the inquiry (in summary 411 questionnaires) and the sound insulation measurements the following recommendations can be derived:

Disturbance caused by noise outside the building (with open windows) is considerable; not only traffic noise is the sources but also noise produced by the activities of the pupils and the personnel such as sport, kindergarten, parking lots for motorcycles, lawn mawers and similar. When designing school buildings the ground plan should be adjustd to avoid disturbance caused by these sources.

Disturbance from classroom to classroom via the open windows was mentioned in school buildings set around a courtyard. If a ground plan with a courtyard is chosen (e.g. to protect the classrooms against traffic noise) care has to be taken to avoid "cross talking" via the courtyard.

Talking, music and singing (if relevant) in the neighbouring classroom is the main noise source inside the building. The disturbance is quoted about equally during teaching, listening to pupils and at tests.

The required sound insulation within the school building can be derived from the outcome of the inquiry as follows:

Table 4. Sound insulation and disturbance in classrooms

Weighted normalized level difference D_{nw} [dB]	Percentage of teachers quoting disturbance
	by noise in classrooms separated by a partition wall
24–26	100 % quote to be disturbed or highly disturbed
29–30	100 % quote to be highly disturbed
32–34	75 % quote to be disturbed
33–39	single guote to be disturbed, during tests also to be highly disturbed
38–39	25 % quote to be disturbed, 15 % also to be disturbed or to be highly disturbed by music activities
38–45	single quote to be disturbed, especially by singing
44–47	20 % quote to be disturbed
50	15 % quote to be disturbed
	by noise in classrooms separated by a floor
44–46	no disturbance
47–48	single quote to be disturbed by singing
47–48	single quote to be disturbed by music
48–49	no disturbance
51	no disturbance
52–53	single quote to be disturbed by singing

It turns out that the requirement $D_{nw} \geqslant 55$ dB according to ÖNORM B 8115 is ensuring sufficient sound insulation between classrooms, also taking into account music and singing. $D_{nw} \geqslant 55$ dB seems comparably high and it is

therefore — according to the usually existing absorption in classrooms — recommended to sustain the requirement of $D_{nw} \geqslant 55$ dB, but to refer it to an equivalent sound absorption area of 25 m² instead of 10 m².

The impact sound insulation gives the following assessment:

Table 5. Impact sound insulation and disturbance in classrooms

Trittschall schutzmaß [dB]	Percentage of teachers quoting disturbance
−3 dB	15% quote to be disturbed or to be highly disturbed by walking and moving chairs
+5 dB	single quote to be disturbed by walking, 20% quote to be disturbed or to be highly disturbed by moving chairs
+11 dB	single quote to be disturbed by walking, 25% quote to be disturbed or to be highly disturbed by moving chairs
+14 dB	single quote to be disturbed by walking, moving chairs
+14 dB	no disturbance

An impact sound insulation margin $\geqslant 15$ dB, required according to ÖNORM B 8115, seems sufficient to avoid disturbance by walking and moving chairs.