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# SHORT TIME METHODS FOR FIELD MEASUREMENT OF SOUND INSULATION BETWEEN ROOMS

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## INTRODUCTION

The development of short time methods for field measurement of sound insulation is an important issue for buildings with a large number of rooms of similar construction, such as multifamily dwellings and hotel rooms. Therefore, some short time methods have been proposed such as ISO/CD 10052[1)] and CEN survey methods[2)]. To investigate adequate measurement procedures for a fast and simple check of the quality of sound insulation, field measurements of sound insulation between rooms have been carried out for various room conditions. Five measurement procedures were adopted to determine space and time average sound pressure levels in source and receiving rooms. The scanning method showed reasonable results in measuring the sound insulation between rooms. This paper also discussed application of the Synchronized Integration Technique for measuring the sound pressure level in the receiving room. This investigation was conducted by the Working Group for short test methods of sound insulation organized by the Architectural Institute of Japan.

## ROOMS TO BE TESTED

Newly-built hotel rooms and meeting rooms of the Architectural Institute were used for this investigation. The plans of a typical room are shown in Fig. 1. Rooms used for this investigation are shown in Table 1. The partition walls between rooms were built using highly sound-insulating double-wall construction.

Table. 1 Rooms to be used for the field measurements of sound insulation.

| Source room V($m^3$) | Receiving room V($m^3$) | Use | Remarks |
|---|---|---|---|
| 94.6 | 94.6 | Hotel room | Unfurnished |
| 100.0 | 100.0 | Hotel room | Unfurnished |
| 36.3 | 36.3 | Hotel room | Unfurnished |
| 36.3 | 36.3 | Hotel room | Furnished |
| 147.2 | 203.8 | Meeting room | |
| 158.2 | 218 | Meeting room | Reinforced concrete wall |
| 158.2 | 109 | Meeting room | |
| 98.4 | 146.7 | Meeting room | Operable partition wall |

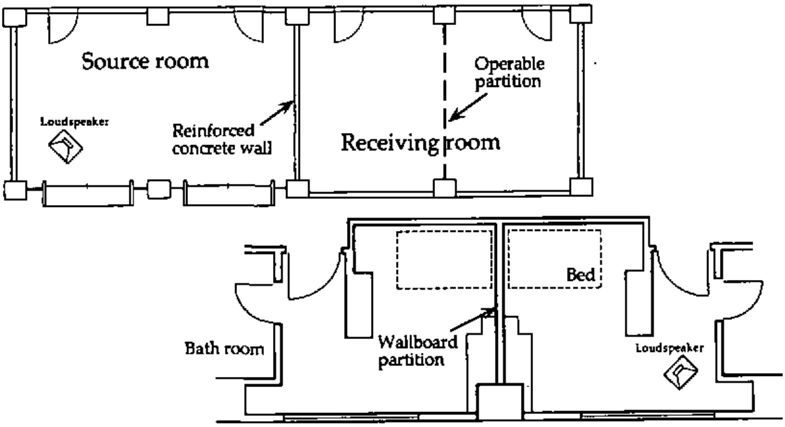


Fig. 1 Plans of a typical room

## TEST PROCEDURES

Thirteen researchers from eight research organizations participated in this investigation. Measurements were carried out using two kinds of loudspeakers for the sound source. One was a corner-type loudspeaker and the other was a septahedoral loudspeaker placed on the center of the floor. Five different measurement procedures were adopted to determine space and time average sound pressure levels in the source and receiving rooms. Of these procedures, one was the discrete points method corresponding to the procedures specified in JIS A 1417[3]. The other four methods were scanning methods with different scanning paths. Details of the measurement procedures are shown in Table 2, together with a data index shown in the measurement result figures.

All measurements were in the octave frequency band, and the frequency range was basically from 125 Hz to 4000 Hz in the center frequency.

Table 2 Measurement methods and equipment.

| Loudspeaker | Source signal | Measurement procedure of sound pressure level | Data index and symbol |
|---|---|---|---|
| BOSE 802-E placed in room corner | Octave band noise | 5 discrete points (on a diagonal line) | JIS, × |
| | | Scanning along 5 diago-points | 5p, □ |
| | | 180° scanning at center of room | CEN, ○ |
| Septahedoral loudspeaker placed on floor center of room | Broad band noise | 180° scanning at center of room | CEN, ○ |
| | | 360° scanning at center of room (small diameter) | 360S, △ |
| | | 360° scanning at center of room (large diameter) | 360L, ▽ |

## TEST RESULTS

### (1) Measurement uncertainty of scanning method for several room conditions

To compare measured results of standardized level difference $D_{n,T}$ obtained using scanning methods with those obtained using the discrete points method, 38 measurements were carried out for eleven room conditions for seven pairs of rooms. Three manual scanning methods including the CEN method were performed using an octave band real-time analyzer that was held out at arm's length. Although the loudspeaker position used with the discrete points method was the same as those used with the scanning methods, octave band analysis was done using band noise for each frequency band.

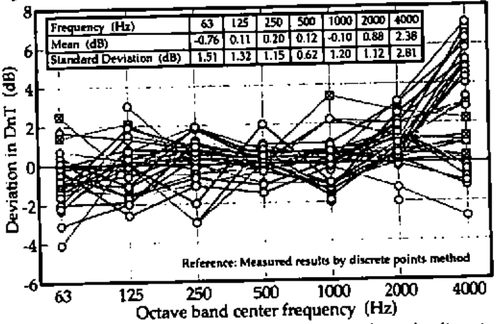

Fig. 2 Deviation of $D_{n,T}$ by scanning method from the discrete points method.

The results shown in Fig. 2 are deviations of $D_{n,T}$ according to manual scanning methods referred from the discrete point method. The maximum difference is about ± 2 dB (standard deviation ≈ 1 dB) in octave bands from 125 Hz to 2000 Hz. The manual scanning method shows reasonable results for the measurement of sound pressure level in the room. The deviation increase in the high frequency region is discussed in the following section.

### (2) Effect of noise caused by the operator during scanning

When the measurements were being taken, we found that noise caused by the operator during the scanning procedure may have fairly serious effects on the determination of time-averaged sound pressure levels. Such noises were, for example:

a) the rustling noise of clothes.

b) the sound of the operator's footsteps.

c) the noise occurring from the sound level meter or microphone being gripped.

d) the creaking noise from the joint of an arm:

Examples of the time history of sound pressure levels are shown in Fig. 3. There are some effects of impulsive noises at high frequencies. In most case, the operator did not notice this kind of noise until the time history was checked, because the spectrum of transmitted noise in the receiving room was primarily at the low frequency region.

By trimming these impulsive parts of the signal during the time-averaging process, 0,3~1,5 dB differences were observed (see Fig. 4). From these results, we concluded that it is important to give warnings for noises produced by the operator. To determine the presence of unfavorable noise, it was effective to do a preliminarily measurement where the same motions

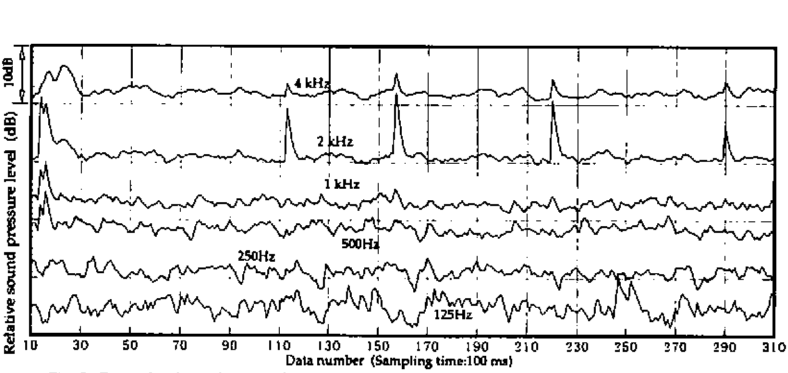


Fig. 3 Example of time history of sound pressure level during time and space averaging process.

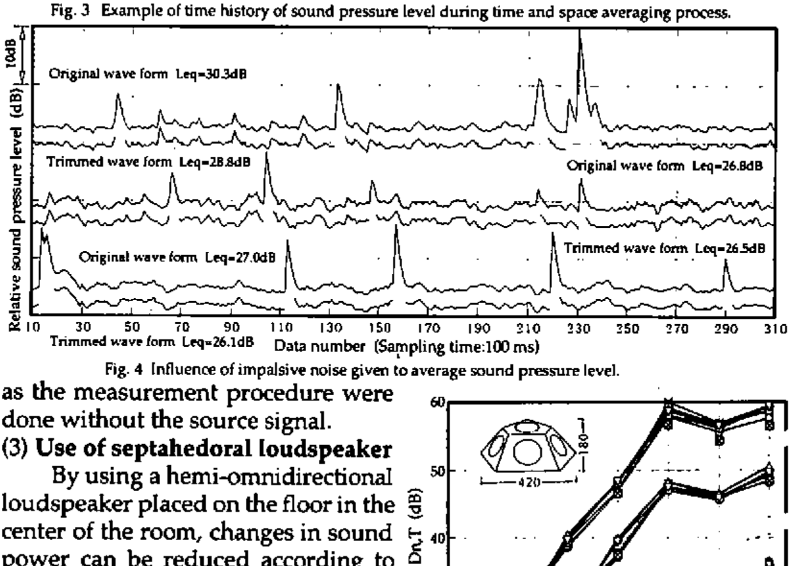


Fig. 4 Influence of impalsive noise given to average sound pressure level.

as the measurement procedure were done without the source signal.

**(3) Use of septahedoral loudspeaker**

By using a hemi-omnidirectional loudspeaker placed on the floor in the center of the room, changes in sound power can be reduced according to differences in the room's boundary conditions. Therefore, it is not necessary to measure the sound pressure level of source rooms of similar dwelling units if the loudspeaker is driven by steady power. During the scanning procedure, to avoid the effect of direct radiation from the loudspeaker, we tried to scan the sound level meter facing away from the loudspeaker in the source room. Two scanning methods (such as drawing a circle) and the CEN scanning method were

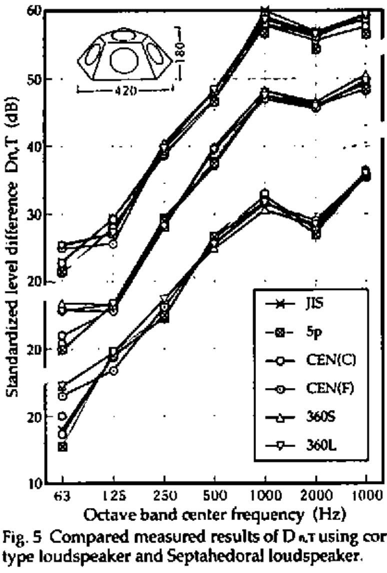


Fig. 5 Compared measured results of $D_{n,T}$ using corner-type loudspeaker and Septahedoral loudspeaker.

used. The measurement results of $D_{nT}$ agree with the results using a corner-type loudspeaker except for the results at 63 Hz. These results are shown in Fig. 5.

## APPLICATION OF SYNCHRONIZED INTEGRATION TECHNIQUE

If broad band noise is used, it is hard to ensure an adequate signal-to-noise ratio in the receiving room. In this case, the Synchronized Integration Technique is an effective method to measure the sound pressure level.

Examples of time history of sound pressure levels in the receiving room are shown in Fig. 6. Since the room was adjacent to a road, the sound pressure level was influenced by background noises of vehicles in all frequency bands. The test signal of broad band noise, which was intermittent noise (2 s turned on and 2 s turned off), was emitted from a loudspeaker. To determine time and space average sound pressure levels, an octave band real time analyzer held out at arm's length was scanned in the receiving room. The time histories of sound pressure levels in each frequency band

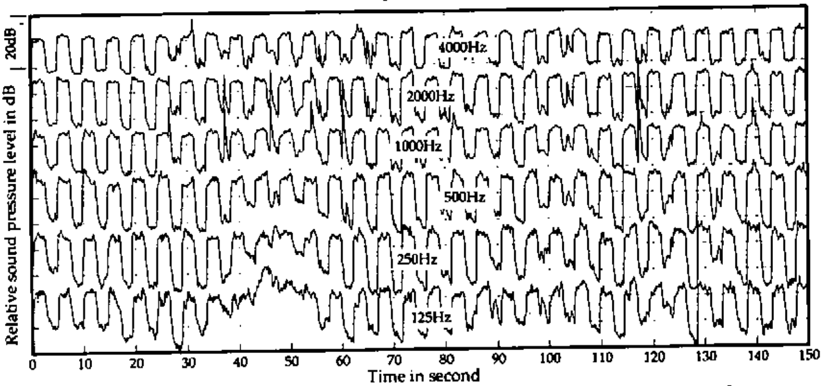


Fig. 6 Example of time history of sound pressure levels in receiving room adjacent to a road.

were stored in the internal digital memory unit. The higher part of the level wave form is the level of signal and background noise combined the lower part is only the background noise level. The sound intensity was alternately integrated in the present or absent period of the test signal. After the integration, the adjusted values of the signal level and background level were calculated by determining the difference in integrated sound intensity. Thus, the Synchronized Integration Technique was applied for five successive time histories of sound pressure level during 30 s measurement time intervals. Calculated results of signal levels and background noise levels are shown in Fig. 7. In spite of fluctuations in the background noise level caused by vehicles passing by, the adjusted signal levels are stable. To ensure the validity of this technique, a source signal lowered by 10 dB was used (see Fig. 7-b). Although the signal-to-noise ratio decreased as the obtained signal level shifted by 10 dB, it was determined precisely. The observation time should be long to increase statistical reliability.

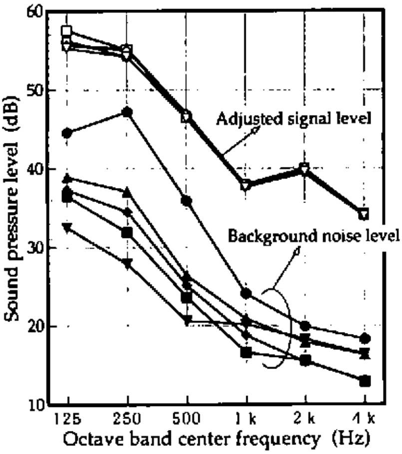


Fig. 7-a Calculated signal level and background noise level.

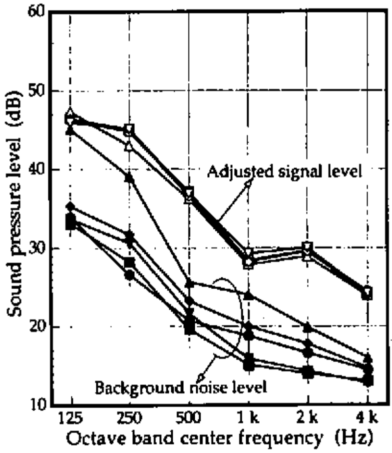


Fig. 7-b Calculated signal level and background noise level (10 dB lowered source signal was used).

## CONCLUSION

In general, we found that the scanning method shows reasonable results for the measurement of sound insulation between rooms. However, it is important to give a warning for noises produced by the operator. The measurement results using the septahedoral loudspeaker agree with the results using a corner-type loudspeaker. Consequently, we can omit the sound pressure level measurement of the source room of a similar dwelling unit if the loudspeaker is driven by steady power. The Synchronized Integration Technique was effective for the measurement of sound pressure levels, situations with a poor signal-to-noise ratio.

However, this investigation is now under going data analysis, e.g., statistical analyses of the measured results. Also, it will be necessary to extend the measured objects for different room sizes, and to make detailed investigations of extended frequency ranges of measurements including the discrete point method.

References


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