SPEECH PRIVACY CLASS FOR RATING THE SPEECH PRIVACY OF MEETING ROOMS

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Introduction

Enclosed offices and meeting rooms are often required to provide speech privacy against eavesdroppers. That is, it should be difficult for people outside the room to understand or in some cases to even hear speech from the meeting room. Measurements of speech privacy must be capable of detecting weaknesses in individual components of the sound insulation of an office or meeting room and should indicate whether an eavesdropper would be able to understand or hear speech from the room. The degree of privacy is related to the probability of a speech privacy lapse.

The Uniform Weighted Signal-to-Noise Ratio

Initial listening tests [1] found a uniform-weighted signal-to-noise ratio (SNR_{UNI32}) to be the best measure for predicting the audibility and intelligibility of transmitted speech in noise. Equation (1) shows SNR_{UNI32} to be the speech level (L_{ts}) – noise level (L_b) differences averaged over the 1/3-octave bands from 160 to 5k Hz. These differences are clipped so that they cannot be less than –32 dB, for which cases speech would be inaudible.

$$SNR_{UNI32} = \frac{1}{16}\sum_{f=160}^{5000}\{L_{ts}(f) - L_b(f)\}_{-32} \qquad (1)$$

Criteria for speech privacy goals were obtained by determining the thresholds of audibility and intelligibility of speech sounds transmitted through walls. These were the SNR_{UNI32} values for which 50% of a panel of good listeners could: just understand one word of a sentence, or just find the speech to be barely audible. These are given in terms of SNR_{UNI32} values in Table 1. The 'intelligibility threshold in rooms' applies to typical meeting rooms. The 'intelligibility threshold in free field conditions' applies to conditions with spatially separated speech and noise sources without significant reflected sounds. The threshold of audibility is not affected by these factors.

Threshold	SNR_{UNI32}
Intelligibility in free field	-16 dB
Intelligibility in rooms	-11 dB
Audibility speech sounds	-22 dB

Table 1. Audibility and intelligibility criteria for speech privacy designs.

New Measurement Procedure

Conventional sound transmission tests measure differences between average levels in the source and receiving spaces. The new speech privacy measurement procedure similarly measures the average levels in the source room because the talker could typically be anywhere in the source room. However, in the receiving space, transmitted levels are measured at spot locations usually 0.25 m from the separating wall/door as illustrated in Figure 1. Speech privacy is evaluated from the level differences between source room average levels and spot receiver levels in the adjacent space.

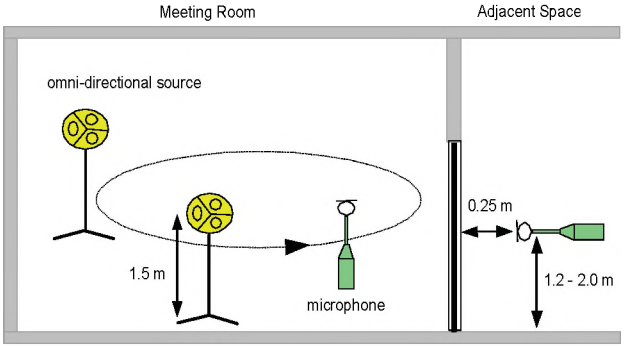

Figure 1. Measurement of level differences from a source room average to spot receiver positions in the adjacent space.

There are 3 reasons for this new approach: (1) the conventional approach assumes diffuse sound fields, but adjacent spaces will often not be at all diffuse (e.g. storage closet, open-plan office), (2) an eavesdropper would be more effective close to the separating partition where higher speech levels would occur, and (3) it is desired to evaluate the weaker components of the sound insulation rather than just an overall average.

Statistics of Speech Levels

The audibility and intelligibility of transmitted speech will depend on the speech levels in the meeting room as well as the sound transmission characteristics to the adjacent spaces. However, speech levels in meeting rooms are statistical in nature and will vary from moment to moment. To characterize these statistical properties, speech levels were recorded over 10 s intervals for 79 meetings in 39 rooms [2]. Speech levels were not related to measures of the room size or the number of occupants, and were combined into one cumulative probability distribution shown in Figure 2. From this figure it is possible to determine how often particular speech levels are exceeded and hence how often there may be speech privacy problems for a particular meeting room.

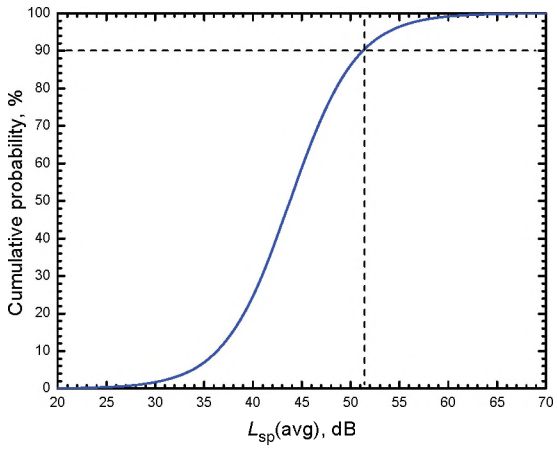

Figure 2. Cumulative probability distribution of measured speech levels in meeting rooms showing example that a 51.5 dB speech level is exceeded 10% of the time.

Speech Privacy Class

The speech privacy of a meeting room depends on both the level of the transmitted speech from the meeting room and the level of the ambient noise outside the meeting room. The Speech Privacy Class (*SPC*) is derived from the definition of SNR_{UNI32} in equation (1). If the –32 dB clipping in equation (1) is ignored, the equation can be re-written as,

$$SNR_{UNI32} \approx L_{ts}(avg) - L_b(avg) \qquad (2)$$

where L_{ts}(avg) is the transmitted speech level and L_b(avg) is the ambient noise level at the receiver, both averaged over frequency from 160 to 5k Hz. L_{ts}(avg) can be replaced by the meeting room speech level L_{sp}(avg) – the measured meeting-room-to-spot-receiver level difference *LD*(avg). In addition, we assign the value –11 dB to SNR_{UNI32} to correspond to meeting the threshold of intelligibility, and obtain,

$$LD(avg) + L_b(avg) \approx L_{sp}(avg) + 11 \qquad (3)$$

$LD(avg)+L_b(avg)$ is the Speech Privacy Class. Using Figure 2, the probability of the speech level L_{sp}(avg) in equation (3) being exceeded and a speech privacy problem occurring can be determined. That is, if L_{sp}(avg) ≥ SPC –11, the transmitted speech level will exceed the threshold of intelligibility and speech privacy will be compromised.

Table 2 lists *SPC* values and describes the related probability of speech privacy problems. As it extends from minimal to extremely high speech privacy, this process can be applied to a wide range of enclosed rooms.

Conclusions

SPC, determined from measurements of sound insulation and ambient noise, is useful for describing the speech privacy of an enclosed room in terms of the likelihood of a privacy lapse.

Acknowledgement

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References

[1] Gover, B.N., and Bradley, J.S., J. Acoust. Soc. Am., 116, (6), 3480-3490 (2004).

[2] Bradley, J.S. and Gover, B.N., "Speech and Noise Levels Associated with Meeting Rooms", IRC Research Report RR-170, March (2004), revised December (2004).

Category	*SPC*	Description
	< 60	Speech expected to be frequently intelligible (more than once a minute) and almost always audible.
Standard Speech Privacy	60–65	Brief phrases expected to be occasionally intelligible (at most once every minute); speech sounds usually audible.
Enhanced Speech Privacy	65–70	Brief phrases expected to be rarely intelligible (at most once every 3.5 minutes); speech sounds frequently audible.
Standard Speech Security	70–75	Speech expected to be essentially unintelligible (brief phrases intelligible at most once every 15 minutes); speech sounds occasionally audible (at most once every minute).
Enhanced Speech Security	75–80	Speech expected to be unintelligible (brief phrases intelligible at most once every hour); speech sounds rarely audible (at most once every 3.5 minutes).
High Speech Security	80–85	Speech unintelligible (brief phrases intelligible at most once every 4.5 hours); speech sounds essentially inaudible (audible at most once every 15 minutes).
Top Speech Security	> 85	Speech unintelligible (brief phrases expected to be intelligible at most once every 20 hours); speech sounds inaudible (audible at most once every hour).

Table 3. Descriptions of the likelihood of transmitted speech being intelligible or audible for a range of SPC categories.