THE EFFECT OF LOCALIZED SOUND LEAKS ON THE SPEECH PRIVACY OF CLOSED ROOMS

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1. INTRODUCTION

Speech privacy is related to how difficult it is for a listener to hear or understand speech. For a closed room, conversations occurring within are to be private from listeners outside the room, in the adjoining spaces. The degree of audibility or intelligibility of the speech at the listening positions will depend on the sound insulation provided by the building. Near a localized area of reduced sound insulation (i.e., a sound leak), the speech sounds could be much more audible or intelligible. This paper reports results on the detectability and severity of several sound leaks intentionally introduced into a test wall.

2. SPEECH PRIVACY MEASUREMENT

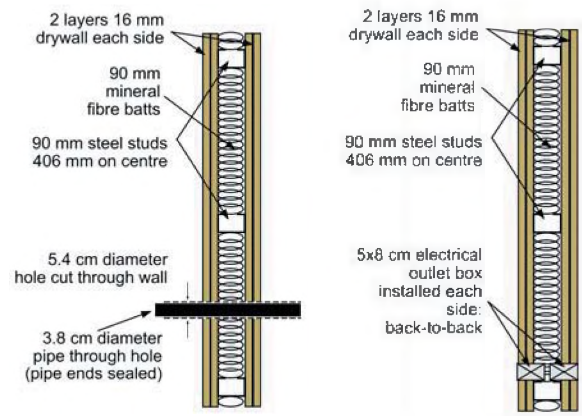
At a listening position outside of a closed room, the speech privacy can be rated according to a new measurement procedure [1]. A uniform sound field is established inside the closed room using multiple source positions and a white noise test signal. The one-third-octave band levels within the room $L_S(f)$ (room-averaged) and at each spot listening position outside the room $L_R(f)$ are measured. These are used to determine the band level differences $LD(f) = L_S(f) - L_R(f)$. These level differences are an objective measure of the architectural sound insulation to each listening position. They are used to calculate the *Speech Privacy Index, SPI*, according to

$$SPI = \frac{1}{16}\sum_{f=160Hz}^{5kHz}\left[S(f) - LD(f) - N(f)\right]_{-32} , \qquad (1)$$

where in each one-third-octave band centred at frequency f, $S(f)$ is the average speech level in the closed room, and $N(f)$ is the background noise level at the listening position. The SPI has been shown to be well correlated with responses of listeners in intelligibility tests [2]. The point at which 50% of listeners were able to understand at least one word from the test sentences is referred to as the *threshold of intelligibility*, and corresponds to an SPI value of –16 dB.

3. TEST WALL MEASUREMENTS

A test wall sample (2.44-by-3.66 m) was constructed between two reverberation rooms. The wall consisted of 2 layers of 16 mm drywall mounted on both sides of 90-by-33 mm lightweight steel studs (406 mm on centre). The cavities of the stud spaces were filled with 90 mm mineral fibre batts. From this base configuration, a 3.8 cm diameter sealed pipe was inserted through a 5.4 cm diameter hole in the wall, as shown in Fig. 1(a). The pipe was not touching the drywall, and the absorptive batts were not removed from the wall. After the wall was repaired, two standard 5-by-8 cm (6.5 cm deep) duplex electrical boxes were installed back-to-back, as shown in Fig. 1(b). The absorptive batts were not removed from the wall; the boxes compressed it between them.



(a) (b)

Fig. 1. Wall configurations: (a) sealed pipe passed through wall, (b) back-to-back electrical boxes.

For each wall configuration: 1.) A conventional ATSM E90 test was conducted to measure the transmission loss versus frequency, and determine the STC; and 2.) The speech privacy measurement procedure was used to obtain $LD(f)$ at each of 63 (a grid of 7-by-9, spaced 0.45-by-0.38 m) receiving positions 0.25 m from the test wall. At each position, SPI was calculated from Eq. (1) assuming a speech level of 65.7 dBA with a spectrum corresponding to a "Raised" effort, and a noise level of 31.5 dBA with a –5 dB/octave "neutral" spectrum [3], typical of HVAC noise.

The transmission loss versus frequency is shown in Fig. 2 for the base case of no intentional leaks (solid line with no markers, STC 56), the pipe through the wall (dashed line, STC 56), and for the back-to-back electrical boxes (solid line with square markers, STC 55). The pipe through the wall had a very small effect on the transmission loss, and no effect on the STC. The back-to-back electrical boxes caused a noticeable reduction of the transmission loss between 400 and 1600 Hz, but only resulted in a one point change of STC.

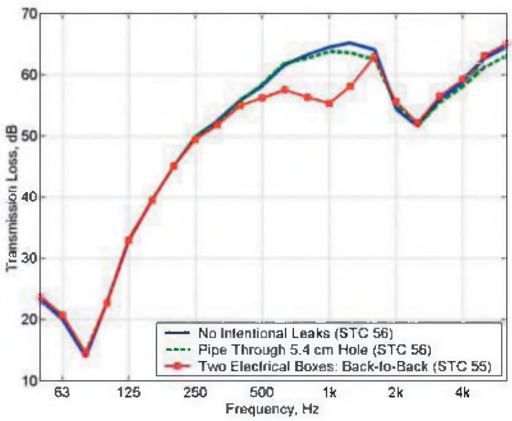


Fig. 2. Transmission loss versus frequency for: no intentional leaks (solid curve), pipe through wall (dashed curve), and back-to-back electrical boxes (solid curve with square markers).

The results of the new speech privacy measurement are shown in Fig. 3(a) for the base case of no intentional leaks. The grayscale plot indicates the value of *SPI* at locations 0.25 m from the wall. There are no features indicating any weak spots. The range (difference of maximum and minimum) of values was 1.2 dB, with a standard deviation of 0.3 dB. At all locations, *SPI* was less than –16 dB, indicating conditions below the threshold of intelligibility.

In Fig. 3(b) are the results for the case of the pipe through the wall. The range of values was 2.0 dB, with a standard deviation of 0.4 dB. At most locations, *SPI* was below –16 dB, except near the penetration. Only in the vicinity of the pipe were conditions above the threshold of intelligibility. The location of the maximum *SPI* accurately indicates the location of the defect (indicated by the black square).

In Fig. 3(c) are the results for the case of back-to-back electrical boxes. The range of values was 2.5 dB, with a standard deviation of 0.4 dB. At almost all locations, *SPI* was greater than –16 dB, corresponding to conditions above the threshold of intelligibility. The maximum value of *SPI* occurred at the location of the defect (indicated by the black square). The back-to-back electrical boxes degraded the speech privacy conditions near the wall at almost all locations, not just in their immediate vicinity.

4. CONCLUSIONS

The new speech privacy measurement procedure is capable of identifying the presence, location, and severity of localized sound leaks in a test wall. The results accurately indicate reduced speech privacy, depending on the severity of the penetration, even if the conventional transmission loss test does not reveal any problems.

REFERENCES

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[2] B.N. Gover and J.S. Bradley, "Measures for assessing architectural speech security (privacy) of closed offices and meeting rooms," J. Acoust. Soc. Am., **116**, 3480–3490 (2004).

[3] J.S. Bradley and B.N. Gover, "Speech and Noise Levels Associated with Meeting Rooms," IRC Research Report 170 (March 2004). http://irc.nrc-cnrc.gc.ca/ircpubs/

ACKNOWLEDGEMENTS

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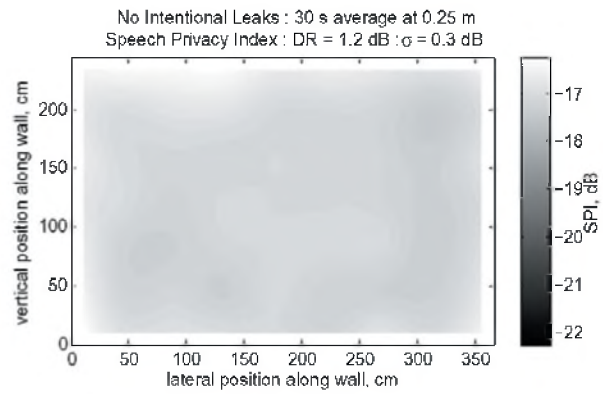
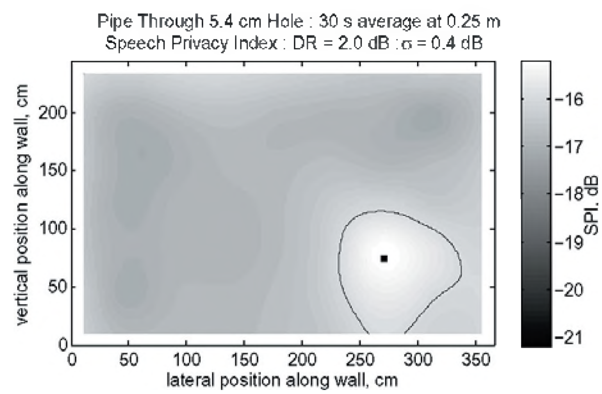
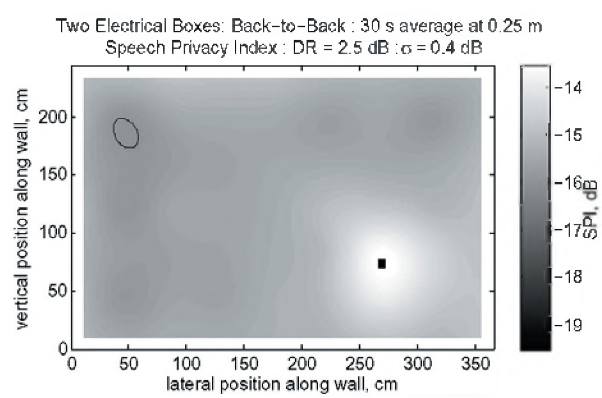


(a) No intentional leaks



(b) Pipe through hole in wall



(c) Back-to-back electrical boxes

Fig. 3. *SPI* at 0.25 m from the wall, calculated for 65.7 dBA speech and 31.5 dBA noise. The contour is for –16 dB, which corresponds to the threshold of intelligibility. All plots self-normalized so that lightest grey corresponds to peak *SPI*.