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Standard Test Method for Objective Measurement of the Speech Privacy Provided by a Closed Room[1]

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INTRODUCTION

This test method is one of a set of standards for evaluating speech privacy in buildings. It is designed to measure the degree of speech privacy provided by a closed room, indicating the degree to which conversations occurring within are kept private from listeners outside the room. A related method (Test Method E1130) deals with assessing speech privacy in open plan spaces.

1. Scope

1.1 This test method describes a test procedure for measuring the degree of speech privacy provided by a closed room, for conversations occurring within the room, and with potential eavesdroppers located outside the room.

1.2 The degree of speech privacy measured by this method is that due to the sound insulation of the room structure—the walls, floor, ceiling and any other elements of the room boundaries—and to the background noise at listening positions outside the closed the room.

1.3 Potential eavesdroppers are assumed to be unaided by electronic or electroacoustic equipment, and not touching the room boundaries. Determined efforts to eavesdrop are not addressed.

1.4 The method may be applied to any enclosed room, whether specifically intended to be protected against eavesdropping or not.

1.5 The method does not set criteria for adequate speech privacy. A non-mandatory appendix provides guidance on how the results of this test method may be used to estimate the probability of an eavesdropper being able to understand speech outside a closed room, and how to set criteria for such rooms.

1.6 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C634 Terminology Relating to Building and Environmental Acoustics

E1130 Test Method for Objective Measurement of Speech Privacy in Open Plan Spaces Using Articulation Index

2.2 *ANSI Standards:*

S1.11 Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters[3]

S1.43 Specifications for Integrating-Averaging Sound Level Meters[3]

3. Terminology

3.1 The following terms used in this test method have specific meanings that are defined in Terminology C634:

airborne sound
average sound pressure level
background noise
decibel
level
octave band
pink noise
sound attenuation
sound isolation
sound level
sound pressure level
source room
white noise

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *receiving point*—a location outside the closed room under consideration where someone might accidentally overhear or deliberately listen to speech occurring within the room.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

3.2.2 *speech privacy class (SPC)*—an objective rating of the speech privacy provided by a closed room, calculated as a sum of factors related to sound isolation provided by the room, and background noise at the receiving point.

4. Summary of Test Method

4.1 Sound is generated at a high level in the closed room under consideration. To improve spatial uniformity, a source loudspeaker is to be placed successively at two or more locations within the room.

4.2 Receiving points outside the closed room under consideration that are near potential weak spots in the sound insulation or that are possible locations for an eavesdropper are selected for measurement.

4.3 With the source operating in each successive location, measurements of sound pressure level are made within the closed room to obtain source room levels, and at receiving points outside the closed room to obtain received levels.

4.4 With the source turned off, measurements of sound pressure level are made at the receiving points to obtain background noise levels.

4.5 The differences in average source room levels inside the closed room and received levels at each receiving point are determined, and are used to calculate a single number for each receiving point that indicates the degree of sound isolation provided by the room boundaries.

4.6 The single number rating of sound isolation is combined with the measured background noise levels to obtain the Speech Privacy Class—a single number rating for each receiving point that is related to the degree of speech privacy at each receiving point.

5. Significance and Use

5.1 This test method provides a means of measuring the sound isolation between the interior of a closed room and locations outside the room, and also the background noise levels at the locations outside the room. The results can be used to rate the degree of speech privacy, or to estimate the probability of speech being intelligible or audible at each receiving point.

5.2 People speak at different levels and vary their voice level in reaction to room noise and other acoustical factors. Consequently it is not possible to say definitely whether a room is protected against eavesdropping. One can only assign a probability of being overheard. The owners or managers of the closed room under consideration must set criteria for this probability according to their specific goals and circumstances. The non-mandatory appendix gives an approach to setting criteria.

6. Sound Sources

6.1 Sound sources shall be loudspeaker systems driven by power amplifiers.

6.2 The input signal to the amplifiers shall be random noise containing an approximately uniform and continuous distribution of energy and frequencies over each test band. White or pink electronic noise sources satisfy this condition.

7. Frequency Range

7.1 *Bandwidth and Filtering*—The overall frequency response of the electrical system, including the filter or filters in the source and microphone sections, shall for each test band conform to the specifications in ANSI S1.11 for a one-third octave band filter set, class 1 or better.

7.2 The frequency range for measurement shall be the sixteen one-third octave bands from 160 to 5000 Hz.

8. Measurement of Sound Pressure Levels

8.1 *Overview:*

8.1.1 For multiple positions of the source, sound pressure levels shall be measured inside the closed room under consideration with multiple fixed microphone positions, or with a moving microphone.

8.1.2 For each position of the source inside the closed room, sound pressure levels shall be measured at each receiving point outside the room.

8.1.3 Measurements of sound pressure level shall be made at each receiving point with the source not operating, to measure the background noise levels.

8.1.4 The number of source positions used will affect the uncertainty in the final result, which can be calculated according to Appendix X1. More source positions will result in a smaller uncertainty. Users of this test method can choose to use the minimum number of source positions specified and obtain a result with unknown, but limited, uncertainty. Users can alternatively decide upon a maximum acceptable uncertainty and repeat measurements with additional source positions until satisfactory results are obtained.

8.2 *Measuring Equipment:*

8.2.1 Measurement quality microphones that are 13 mm or smaller in diameter and that are close to omnidirectional below 5000 Hz shall be used.

8.2.2 Microphones, amplifiers, and electronic circuitry to process microphone signals and perform measurements shall satisfy the requirements of ANSI S1.43 for Type 1 sound level meters, except that B and C weighting networks are not required.

8.3 *Source Room:*

8.3.1 The sound pressure level in the closed room under consideration will depend on the position of the source. To account for this, at least two source positions shall be used. The sound pressure level measured in the closed room will also vary with microphone position, so several microphone positions or a moving microphone shall be used for each source position.

8.3.2 Select source positions in the closed room according to one of the following two ways, depending on the directionality of the loudspeakers used:

8.3.2.1 *Method 1*—For approximately omnidirectional loudspeakers, such as those in the shape of a regular polyhedron with a driver mounted in each face (**1**),[4] source positions shall be at least 1.2 m apart and shall be representative of typical locations of talkers in the room. The source positions shall be 1.5 m above the floor.

NOTE 1—Source positions for omnidirectional loudspeakers should normally be located in the central part of the room, at least 1.0 m from the walls. In smaller rooms, it may be necessary to locate the source near a wall or corner.

8.3.2.2 *Method 2*—For conventional directional loudspeakers, source positions shall be selected in the corners of the room opposite the wall that is being used for receiving points. The loudspeakers shall be moved to different corners to measure receiving points near different walls. Using a conventional directional loudspeaker will increase the total number of measurements required.

NOTE 2—For the same number of source positions, the uncertainty in the measurement of average source room levels will be higher for conventional loudspeakers than for approximately omnidirectional loudspeakers such as one with drivers mounted in the faces of a regular polyhedron (**2**). Additionally, for conventional loudspeakers, the number of source positions possible for a given receiving point is generally limited to the two opposite corners in the room, whereas for approximately omnidirectional loudspeakers, additional source positions can be selected in the central area of the room, to reduce uncertainty.

8.3.3 With the source operating at each source position in the closed room, the average sound pressure level in the room shall be measured in one of the two following ways:

8.3.3.1 *Method 1*—Measure the sound pressure level using at least five fixed microphone positions. The microphone positions shall be at least 1.2 m apart, at least 1.5 m from the sound source and at least 1 m from the surfaces of the room. The microphone positions should provide as complete and uniform coverage of the allowable part room volume as possible. The sound pressure level $L_{sij}(f)$ in each frequency band, f, shall be measured for at least 15 seconds for each source position i and each microphone position j.

8.3.3.2 *Method 2*—Measure the average sound pressure level in each ⅓-octave band in the closed room with a moving microphone and using a sound level meter or an equivalent analyzer set to measure the time-averaged sound levels also known as L_{eq}. For larger rooms, the operator shall walk slowly, moving the microphone in a circular path of at least 0.5 m diameter in front of their body to evenly sample as much as practical of the measurement space. The sound level meter or microphone shall be held well away from the operator's body—at least 0.5 m (a boom serves to increase the distance). The microphone speed shall remain as constant as practical. The operator shall take care to assure that the path does not significantly sample any part of the allowable room volume for more time than other parts. The microphone shall always be more than 1.5 m from the sound source and more than 1 m from the walls of the closed room. The integration time shall be at least 30 seconds. This measurement shall be repeated for each source position i to give $L_{si}(f)$, the average source room level in each band, for source position i.

NOTE 3—Measurement of the levels in the closed room with a moving microphone and an integrating sound level meter will enable only approximate estimation of the uncertainty in the final result.

NOTE 4—Different microphone locations or moving microphone paths may be required for each source position. Once a source has been moved to a subsequent location, microphone positions are allowed in its previous vicinity. This approach can be useful in particular for measurements in small rooms.

8.4 *Receiving Points:*

8.4.1 Select receiving points outside the closed room under consideration. Measurements should be made at all locations in the receiving area where the speech privacy is of interest. The regions near doors, windows and other types of weak elements in the boundaries of the room are obvious locations that should be included.

8.4.2 To evaluate speech transmission through walls and other components (for example, doors), microphones should be 0.25 m from the nearest outer surface of the closed room and between 1.2 and 2 m above the floor.

NOTE 5—If the microphone is closer than 0.25 m, the measured level is sensitive to distance from the wall.

8.4.3 Survey for additional locations where sound leaks may occur by performing initial listening tests. Position the sound source near the middle of the closed room under consideration and generate a signal so that the A-weighted average sound pressure level in the room is at least 80 dB. With all doors closed, listen carefully near the boundaries of the room and identify the locations of probable sound leaks where measurements should be made to assess the speech privacy. In some cases, spot measurement locations may not be adjacent to the room boundary. Where there is sound transmission from the room via flanking sound paths such as through ducts, spot measurements should be made at locations where a potential eavesdropper might be located.

8.4.4 In addition to the locations identified as probable weak spots, select other positions around the closed room so as to provide complete and uniform coverage of the periphery. Some receiving points will be close to the surfaces of the closed room. Others may be selected close to suspected weak spots such as ventilation duct openings.

8.4.5 The sound pressure level shall be measured at each stationary receiving point for each source position i in the closed room for at least 15 seconds. Measure the received levels with the source operating, $L_{rbi}(f)$, and the background noise levels with the source switched off, $L_{bi}(f)$.

9. Calculations

9.1 All calculations shall be made using unrounded, measured values.

9.2 *Source Room Levels:*

9.2.1 If source room measurements were made using fixed microphone positions, determine $L_{si}(f)$, the average sound pressure level in each band, for source position i, as follows:

$$L_{si}(f) = 10\log\left[\frac{1}{m}\sum_{j=1}^{m} 10^{L_{sij}(f)/10}\right] \quad (1)$$

[4] The boldface numbers in parentheses refer to the list of references at the end of this standard.

where:

m = the number of microphone positions.

9.2.2 Calculate $L_s(f)$, the mean source room sound pressure level in each frequency band, using:

$$L_s(f) = 10\log\left[\frac{1}{n}\sum_{i=1}^{n} 10^{L_{si}(f)/10}\right] \quad (2)$$

where:

n = the number of source positions.

9.2.3 Calculate $L_s(avg)$, the arithmetic average of source room level over the 16 ⅓-octave frequency bands from 160 to 5000 Hz from:

$$L_s(avg) = \sum_{f=160}^{5000} L_s(f)/16 \quad (3)$$

9.3 *Received Levels at Each Receiving Point:*

9.3.1 For each source position i, the received level in each frequency band f at each receiving point shall be corrected for background noise as follows:

9.3.1.1 If the difference $L_{rbi}(f) - L_{bi}(f)$ is more than 10 dB then no corrections for background noise are necessary and $L_{ri}(f) = L_{rbi}(f)$.

9.3.1.2 If the difference $L_{rbi}(f) - L_{bi}(f)$ is between 5 and 10 dB, the adjusted value of the received level, $L_{ri}(f)$, shall be calculated as follows:

$$L_{ri}(f) = 10\log(10^{L_{rbi}(f)/10} - 10^{L_{bi}(f)/10}) \quad (4)$$

9.3.1.3 If the difference $L_{rbi}(f) - L_{bi}(f)$ is less than 5 dB, then set $L_{ri}(f) = L_{rbi}(f) - 2$. In this case, the measurements provide only an estimate of the upper limit of the received level. Identify such measurements in the test report.

9.3.2 Calculate $L_r(f)$, the average received sound pressure level in each band for each receiving point using:

$$L_r(f) = 10\log\left[\frac{1}{n}\sum_{i=1}^{n} 10^{L_{ri}(f)/10}\right] \quad (5)$$

where:

n = the number of source positions.

9.3.2.1 If any of the $L_{ri}(f)$ values are limited by background noise, then the corresponding $L_r(f)$ provides only an estimate of the upper limit of the average received level. Identify such measurements in the test report.

9.3.3 For each receiving point, calculate L_r *(avg)*, the arithmetic average of received level over the 16 ⅓-octave frequency bands from 160 to 5000 Hz from:

$$L_r(avg) = \sum_{f=160}^{5000} L_r(f)/16 \quad (6)$$

9.4 *Background Noise Levels at Each Receiving Point:*

9.4.1 Calculate $L_b(f)$, the average background noise level in each band for each receiving point using:

$$L_b(f) = 10\log\left[\frac{1}{n}\sum_{i=1}^{n} 10^{L_{bi}(f)/10}\right] \quad (7)$$

where:

n = the number of source positions.

9.4.2 For each receiving point, calculate L_b *(avg)*, the arithmetic average of background noise level over the 16 ⅓-octave frequency bands from 160 to 5000 Hz from:

$$L_b(avg) = \sum_{f=160}^{5000} L_b(f)/16 \quad (8)$$

9.5 *Level Differences:*

9.5.1 For each receiving point, calculate the difference in average source room level and average received level in each band:

$$LD(f) = L_s(f) - L_r(f) \quad (9)$$

9.5.2 For each receiving point, calculate *LD(avg)*, the average level difference over the 16 ⅓-octave frequency bands from 160 to 5000 Hz from:

$$LD(avg) = \sum_{f=160}^{5000} LD(f)/16 \quad (10)$$

9.6 *Speech Privacy Class:*

9.6.1 For each receiving point, calculate *SPC* from the arithmetic sum of $LD(avg)$ and $L_b(avg)$:

$$SPC = LD(avg) + L_b(avg) \quad (11)$$

NOTE 6—The background noise outside of the closed room under consideration may vary from time to time, so the measured value is representative of that during the measurement period only. For the purposes of estimating *SPC* for different noise conditions, the background noise may additionally be measured at different times, or assumed from other knowledge.

9.7 *Confidence Interval:*

9.7.1 The 95 % confidence interval for *SPC* can be calculated according to the non-mandatory Appendix X1. Users of this test method can decide what is an acceptable 95 % confidence interval. If the initial number of source positions does not give an acceptable value, then more source positions must be used.

10. Report

10.1 Report the following information:

10.1.1 *Statement of Conformance to Standard*—If it is true in every respect, state that the tests were conducted in accordance with the provisions of this test method.

10.1.2 *Description of Test Environment*—Give a general description of the closed room under consideration and furnishings. Give a sketch showing the relationship of the receiving points to the closed room. State the volume of the closed room.

10.1.3 *Description of Measurement Method*—Identify the type of loudspeaker used and the microphone method used to measure the levels in the closed room. Indicate the source positions used on the room sketch.

10.1.4 *Statement of Precision*—If the confidence interval for *SPC* was calculated, report it, otherwise state that the uncertainty of the result is not known.

10.2 Provide a table giving the values of $L_s(f)$, and for each receiving point of $L_r(f)$, $LD(f)$ and $L_b(f)$ at the specified frequencies, rounded to the nearest 1 dB. Identify those values of $L_r(f)$ and $LD(f)$ that are contaminated by background noise (see 9.3.1.3).

10.3 Provide a table giving the values of $L_s(avg)$, and

$L_r(avg)$,$LD(avg)$,$L_b(avg)$, and *SPC* for each receiving point.

11. Precision and Bias

11.1 *Precision*—The reproducibility of this test method has not been established by having different operators make measurements in accord with the test method. Precision of the measurements of sound pressure level is limited by the measurement instrumentation. Typically this uncertainty will be about 0.1 dB. Precision of the measurement of the average sound pressure level in the closed room varies with frequency and room properties, the number of source positions, type of loudspeakers used, and the number of microphone positions. Using the minimum specified number of source and fixed microphone positions (i.e., 2 source positions, 5 microphone positions) in a wide range of rooms, the average 95 % confidence interval for L_s has been found to be ±1.1 dB using omnidirectional sources, and ±1.6 dB using directional sources (**2**). Rooms that are smaller than 60 m^3 or larger than 200 m^3 with a reverberation time less than 0.6 s will likely have larger uncertainties. Precision of the measurement of the received levels at the receiving points depends on the number of source positions and type of loudspeakers used, and the properties of the receiving space. The precision of the final result *SPC* can be estimated by using Appendix X1.

11.2 *Bias*—There is no known bias in this test method.

12. Keywords

12.1 speech privacy; speech security

APPENDIXES

(Nonmandatory Information)

X1. DETERMINATION OF CONFIDENCE INTERVALS

X1.1 *Source Room Levels*:

X1.1.1 If the fixed microphone method was used, calculate the 95 % confidence interval for the source room average according to the following.

X1.1.1.1 For each measurement of source room levels at microphone position *j* for source position *i*, calculate the average over frequency $L_{sij}(avg)$:

$$L_{sij}(avg) = \sum_{f=160}^{5000} L_{sij}(f)/16 \quad (X1.1)$$

X1.1.1.2 Calculate the 95 % confidence interval for $L_s(avg)$ according to:

$$\Delta L_s(avg) = \frac{1.96}{\sqrt{mn}} \sqrt{\frac{1}{mn-1}\sum_{i=1}^{n}\sum_{j=1}^{m}(L_{sij}(avg) - L_s(avg))^2} \quad (X1.2)$$

X1.1.2 If the integrating microphone method was used, determine an approximate estimate of the 95 % confidence interval for the source room average according to the following.

X1.1.2.1 For each measurement of source room level for source position *i*, calculate the average over frequency $L_{si}(avg)$:

$$L_{si}(avg) = \sum_{f=160}^{5000} L_{si}(f)/16 \quad (X1.3)$$

X1.1.2.2 Estimate the 95 % confidence interval for $L_s(avg)$ according to:

$$\Delta L_s(avg) \approx \frac{1.96}{\sqrt{n}} \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(L_{si}(avg) - L_s(avg))^2} \quad (X1.4)$$

X1.2 *Received Levels*:

X1.2.1 For each receiving point, calculate the frequency averaged received level $L_{ri}(avg)$ for source position *i* according to:

$$L_{ri}(avg) = \sum_{f=160}^{5000} L_{ri}(f)/16 \quad (X1.5)$$

X1.2.2 Calculate the 95 % confidence interval for $L_r(avg)$ according to:

$$\Delta L_r(avg) \approx \frac{1.96}{\sqrt{n}} \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(L_{ri}(avg) - L_r(avg))^2} \quad (X1.6)$$

X1.3 *Level Differences*:

X1.3.1 For each receiving point, calculate the 95 % confidence interval for *LD(avg)* using:

$$\Delta LD(avg) = \sqrt{[\Delta L_s(avg)]^2 + [\Delta L_r(avg)]^2} \quad (X1.7)$$

X1.4 *Background Noise Levels*:

X1.4.1 For each receiving point, calculate the frequency averaged background noise level $L_{bi}(avg)$ for source position *i* according to:

$$L_{bi}(avg) = \sum_{f=160}^{5000} L_{bi}(f)/16 \quad (X1.8)$$

X1.4.2 Calculate the 95 % confidence interval for $L_b(avg)$ according to:

$$\Delta L_b(avg) \approx \frac{1.96}{\sqrt{n}} \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(L_{bi}(avg) - L_b(avg))^2} \quad (X1.9)$$

X1.5 *Speech Privacy Class*:

X1.5.1 For each receiving point, calculate the 95 % confidence interval for *SPC* using:

$$\Delta SPC = \sqrt{[\Delta L_b(avg)]^2 + [\Delta LD(avg)]^2} \quad (X1.10)$$

X2. APPLICATION OF *SPC*

X2.1 *Background*:

X2.1.1 Whether speech from an adjacent closed room is intelligible or even audible to listeners depends on four factors: *(a)* the sound isolation due to the room boundaries, *(b)* the levels of speech sounds in the room, *(c)* the levels of ambient noise at listener positions outside the room, and *(d)* the skill of the listener. For the present purposes, all listeners are assumed to be skilled, which implies minimal hearing loss and good language skills, and attentive. When the transmitted speech sounds are loud enough relative to the ambient noise at some listener position, the speech will be audible and sometimes also intelligible.

X2.1.2 Conditions for which 50 % of skilled listeners can just understand some speech can be defined as the threshold of intelligibility. Conditions for which 50 % of skilled listeners can just hear speech can similarly be defined as the threshold of audibility, which corresponds to a higher degree of privacy than the threshold of intelligibility.

X2.1.3 Research has established that the measure that best relates to both intelligibility and audibility judgments is a uniformly-weighted frequency-averaged signal-to-noise ratio, denoted SNR_{UNI32} (**3-5**). The signal is the speech transmitted through the room walls, doors etc., and the noise is the background noise at the listener position. SNR_{UNI32} is given by the average of the ⅓-octave band signal-to-noise level differences as follows:

$$SNR_{UNI32} = \sum_{f=160}^{5000} [L_{ts}(f) - L_b(f)]/16, \text{ dB} \qquad (X2.1)$$

where in each ⅓ octave band with mid-band frequency *f*:

$L_{ts}(f)$ = the transmitted speech level at the listener position, and

$L_b(f)$ = the background noise level at the same listener position.

X2.1.3.1 The quantity in the square brackets should be limited so if it is less than –32 dB, then it is replaced by –32 dB.

X2.1.4 The measured level differences between the source room and receiving points can be used to calculate SNR_{UNI32} by rearranging Eq X2.1 as follows:

$$SNR_{UNI32} = \sum_{f=160}^{5000} [L_{sp}(f) - LD(f) - L_b(f)]/16 \qquad (X2.2)$$

where:

$L_{sp}(f)$ = the source-room average speech level, and

$L_{ts}(f)$ = $L_{sp}(f) - LD(f)$.

X2.1.4.1 The value in the square brackets is usually not less than –32 dB. In such cases Eq X2.2 can be re-written more simply as:

$$SNR_{UNI32} = L_{sp}(avg) - LD(avg) - L_b(avg) \qquad (X2.3)$$

where $L_{sp}(avg)$, $L_b(avg)$ and $LD(avg)$ are the arithmetic averages of the ⅓ octave band values from 160 to 5000 Hz. $LD(avg)$ and $L_b(avg)$ are measured according to the main part of this test method.

X2.2 *Setting Criteria for SPC*:

X2.2.1 Eq X2.3 provides a basis for interpreting the measured values $LD(avg)$ and $L_b(avg)$ in terms of expected speech privacy. It can be rewritten as follows:

$$LD(avg) + L_b(avg) = L_{sp}(avg) - SNR_{UNI32} \qquad (X2.4)$$

which states that the total sound isolation plus background noise at the receiving point is equal to the speech level inside the closed room less the index SNR_{UNI32}. Conditions that correspond to a particular criterion privacy level (e.g., the threshold of intelligibility) are indicated by a particular value of SNR_{UNI32}, say $SNR_{UNI32,0}$. The relation:

$$LD(avg) + L_b(avg) \geq L_{sp}(avg) - SNR_{UNI32,0} \qquad (X2.5)$$

is true for all conditions not less private than the criterion. The left-hand side of Eq X2.5 is the Speech Privacy Class, $SPC = LD(avg) + L_b(avg)$.

X2.2.2 For a given speech level, Eq X2.5 indicates that the sum of the sound insulation measure $LD(avg)$ and the background noise $L_b(avg)$ must equal or exceed some fixed value to ensure conditions at or below the criterion conditions. The measured $LD(avg)$ alone is not sufficient to describe the expected speech privacy of a room, the ambient background noise $L_b(avg)$ is also a factor.

X2.2.3 The ambient noise levels outside a room may fluctuate with time, and may vary significantly during a 24 hour period, if for example ventilation systems cycle on or off. Over a given period of time they can usually be represented by some average value. The background noise measured according to the main part of this test method gives an indication of the noise during the measurement period only. If knowledge of the noise at other times of day or over a longer time period is required then it should be measured separately. The background noise could also be assumed from some other knowledge.

X2.2.4 The statistical distribution of speech levels in meeting rooms has been measured for a large number of meetings, and can be used to select appropriate levels for interpreting *SPC* and the degree of speech privacy (**6**). Table X2.1 gives an indication of values for *SPC* that correspond to different likelihoods of speech being intelligible, derived from the statistical distribution of speech levels in meetings, and Eq X2.5. The higher the sound isolation and background noise that is, the higher the *SPC*), the lower the probability of speech being intelligible. Users of this test method will have to decide on criteria appropriate for their own needs.

NOTE X2.1—The statistics of speech levels in meetings, used to derive the descriptions in Table X2.1, may not be appropriate for all situations, for example where people can be expected to speak with a lowered voice. In these cases, the descriptions in Table X2.1 may not be appropriate.

X2.3 *Design Stage Specification* :

X2.3.1 At the design stage, it is necessary to specify an assembly that will, after construction, provide the desired

TABLE X2.1 Interpreting *SPC*: Descriptions of the Likelihood of Speech Being Audible or Intelligible for Various Ranges of *SPC*, Based on Speech Levels in Meeting Rooms and Offices (6)

Category	*SPC*	Description
Minimal Speech Privacy	70	One or two words will be intelligible at most once each 3 minutes, and speech sounds will frequently be audible (at most once each 0.6 minutes).
Standard Speech Privacy	75	One or two words will be occasionally intelligible (at most once each 18 minutes) and frequently audible (at most once each 2 minutes)
Standard Speech Security	80	One or two words will very rarely be intelligible (intelligible at most once each 2.3 hours) and occasionally audible (at most once each 12.5 minutes)
High Speech Security	85	Speech essentially unintelligible (as most once each 16 hours) and very rarely audible (at most once each 1.5 hours)
Very High Speech Security	90	Speech not intelligible and very rarely audible (at most once each 11 hours)

degree of speech privacy. Usually the only information available is transmission loss data of individual specimens, measured in the laboratory according to Test Method E90. The transmission loss data can be used to estimate the level difference between a uniform sound field on one side, and the received level at 0.25 m from the partition. Therefore, *SPC* can be estimated at the design stage. Designers must be aware that the performance of partitions is almost always degraded by flanking transmission, and that laboratory performance is usually not realized in the field.

X2.3.2 Measurements for a range of walls and with a wide range of acoustical absorption on both sides of the walls have demonstrated **(7)** that for a uniform field incident on one side of a wall, the received level at 0.25 m on the other side can be estimated from:

$$L_{0.25}(avg) = L_s(avg) - TL(avg) - 1 \quad (X2.6)$$

where:

$L_{0.25}(avg)$ = the received level at 0.25 m from the wall,
$L_s(avg)$ = the level of the uniform field on the source side of the wall,
$TL(avg)$ = the transmission loss of the wall, and
(avg) = the arithmetic average over all 16 bands from 160 to 5000 Hz.

X2.3.2.1 Eq X2.6 is correct within ± 0.5 dB for most rooms with reverberation times less than about 1.2 s, and can be rewritten to predict the required level difference $LD(avg) = L_s(avg) - L_{0.25}(avg)$ as follows:

$$LD(avg) = TL(avg) + 1 \quad (X2.7)$$

X2.3.3 Eq X2.7 can be used to predict the Speech Privacy Class from transmission loss data as follows:

$$SPC = TL(avg) + L_b(avg) + 1 \quad (X2.8)$$

which allows designers to estimate the degree of speech privacy from published laboratory test data, and an assumption or knowledge of the background noise in the listening space. The descriptions in Table X2.1 can be used to set criteria for *SPC*.

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