



Speech Privacy Standards

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As employees in open office environments are more frequently reporting speech/acoustic privacy concerns, there becomes a need to understand what employees are experiencing and how to best define and measure acoustic privacy.

The acoustics industry relies on several different speech privacy standards to determine and quantify the level of acoustic privacy an environment may have. These standards can apply as a function of field tests performed on site (i.e. recording acoustical measurements), or as a calculation performed prior to construction.

For many years, acoustical engineers have known that acoustic privacy is primarily a function of speech intelligibility. That is, as conversations in an environment are audible and intelligible the acoustic privacy is said to be poor, but as conversations become less audible and less intelligible the acoustic privacy is said to be good. It follows then, that many standards aim to measure speech intelligibility first and promote lower values of intelligibility for improved privacy.

It is important to note that none of the following metrics/standards aim to set criteria for adequate speech privacy. These standards simply provide means to measure the acoustic privacy. Specific criteria for any space should be set by an acoustical consultant or a qualified person with a working knowledge of acoustics and speech privacy.

Articulation Index (AI) – The original work for Articulation Index dates back to the 1930s and 1940s when acoustical engineers such as H. Fletcher, W.A. Munson, N.R. French, and J.C. Steinberg first published their studies on the subject of speech intelligibility. In 1969, ANSI released their standard, S3.5, titled American National Standard Methods for Calculation of Articulation Index. Later, Articulation Index was included in ASTM E1130 (the last revision of which occurred in 2008). As defined by ASTM E1130-08 (Standard Test Method for Objective Measurement of Speech Privacy in Open Plan Spaces Using Articulation Index), this standard defines a range from 0 to 1, whereby 0 represents perfect speech privacy and 1 represents no speech privacy at all.

The standard offers the following range of values:

- AI 0.0 – 0.05 = confidential speech privacy
- AI 0.05 – 0.2 = normal speech privacy
- AI 0.2 – 1.0 = minimal or no speech privacy

It is important to note that AI is only intended to define privacy in open office environments using partial height partitions. Thus, this standard does not apply to closed spaces such as private offices, conference rooms, exam rooms, etc.

Privacy Index (PI) – Privacy Index is integrated into ASTM E1130 as an appendix, and is simply defined as the inverse of AI expressed as a percentage. Mathematically, is it calculated as follows: $PI = (1 - AI) * 100$. It follows that a PI of 100% - 95% represents confidential speech privacy, 94% - 80% represents normal speech privacy, and anything below 80% represents minimal or no speech privacy. This unit of measure has enjoyed more wide spread adoption than AI likely because of the use of percentage. Confusingly, while PI uses percentage it does not represent a linear scale; hence, PI 80% does not mean that 80% of words are unintelligible.

Speech Intelligibility Index (SII) – Speech Intelligibility Index is the successor to Articulation Index, and was originally defined in an update to ANSI S3.5 in 1986 (another update was provided in 1997). SII provides a method to calculate speech intelligibility using speech spectrum level, noise spectrum level, hearing threshold level, and a modulation transfer function. The inclusion of a modulation transfer function was particularly important as it allowed the metric to account for distortion of a signal in the time domain (i.e. reverberation).

Much like Articulation Index, SII is only intended to be used in acoustic environments, and is not suitable for electronic communication equipment. The standard defines a good communication system as having a SII rating in excess of 0.75 and a poor communication system as one with a SII of below 0.45.

Speech Privacy Criteria (SPC) – Speech Privacy Criteria is a relatively new standard defined in ASTM E2638 (Standard Test Method for Objective Measurement of the Speech Privacy Provided by a Closed Room) that aims to define the speech privacy of closed rooms such as private offices or conference rooms. This standard is a test procedure that is carried out in an existing space, thus it is not currently intended to be used for design purposes or prediction.

The standard offers a range of values as follows:

- SPC 70 – minimal speech privacy
- SPC 75 – standard speech privacy
- SPC 80 – standard speech security
- SPC 85 – high speech security
- SPC 90 – very high speech security

IEC-60268 Sound System Equipment – This standard provided by IEC (International Electrotechnical Commission) has 18 sub sections that each defines audio standards relating to equipment and performance. Of particular importance is sub section 16 (IEC 60268-16) titled "Objective Rating of Speech Intelligibility by Speech Transmission Index". As the name implies this standard is based on Speech Transmission Index (STI), and is simply a review of STI and its subsets STITEL, RASTI, and STIPA. In Edition 4 (released in 2011), the standard also defines auditory masking and specifically the upward spread of masking whereby lower frequency sounds have the ability to mask higher frequency sounds.

Speech Transmission Index (STI) – This standard was originally developed in the 1970's and has since undergone several updates and additions. Other versions of the standard include: STITEL (Speech Transmission Index – Telecommunications Systems), RASTI (Room Acoustical Speech Transmission Index), and STI-PA (Speech Transmission Index – Public Address).

STI was created on the basis of human speech, which can be seen as a function of two primary components: transient response in the time domain, and response in the frequency domain. Using (14) time domain modulation frequencies and (7) frequency octave bands, STI calculates 98 modulation index values to ascertain how well a signal is

passed through a set of electronics or through an acoustic environment. In practice, STI is calculated from an impulse response measurement of a system, which can be time consuming and requires specialized measurements and post processing equipment.

STI has enjoyed global acceptance because it simultaneously accounts for distortions in both the time domain as well as the frequency domain. This makes STI especially useful in determining speech intelligibility in reverberant spaces.

STI has a range of values as follows:

- STI 0 – 0.3 = Bad
- STI 0.3 – 0.45 = Poor
- STI 0.45 – 0.6 = Fair
- STI 0.6 – 0.75 = Good
- STI 0.75 – 1.0 = Excellent

Bear in mind that higher levels of STI represent higher levels of speech intelligibility, when acoustic privacy is desired, lower levels of STI are needed.

Room Acoustical Speech Transmission Index (RASTI) – RASTI is a subset of STI and is also defined in IEC 60268-16; it was created as a condensed version to allow for easier calculation of the speech intelligibility. Note that as of Edition 4 of IEC 60268-16, RASTI has been made obsolete and is no longer recommended for use.

As opposed to the 98 modulation index values that STI requires, RASTI simplifies the procedure by utilizing just (9) values. The values are obtained by using (5) time domain modulation frequencies for the 2 kHz octave band and (4) time domain modulation frequencies for the 500 Hz octave band. While the simplification offered by RASTI made computations much quicker and easier, serious limitations were found when used to evaluate sound systems.

Speech Transmission Index – Public Address (STIPA) – Similar to RASTI, STIPA was developed as a simplified approach to STI to allow for quicker/easier measurement of speech intelligibility. Though, not formally provided as

such, STIPA is the successor to RASTI, and has seen widespread adoption throughout the industry.

Mathematically, STIPA uses all (7) frequency octave bands from 125 Hz to 8 kHz, but uses just (2) time domain modulation frequencies for each octave band. This results in (14) total modulation index values to determine the speech intelligibility of the signal, a significant reduction from the (98) values required for the full STI calculation.

As the popularity of STIPA has increased, manufacturers have introduced measurement devices that allow for the direct measurement of STIPA. Generally, a test signal is transmitted through the electronic signal chain (audio processors, equalizers, amplifiers, loudspeakers, etc.) where it is heard in the acoustic environment. A handheld meter is used to measure the resulting signal in the acoustic environment and calculate the STIPA value, typically in 15 – 20 seconds.

ISO 3382-3 – Part 3 of this standard by the International Standards Organization is titled “Open Plan Offices” and is specifically designed to provide a method of measuring speech privacy using STI in open office environments. The standard was introduced in 2012 and represents a new part of the ISO 3382 suite of standards. Using a combination of acoustical measurements and STI measurements, the standard defines a single number “distraction distance” as well as a single number “privacy distance”. This standard is unique in that it provides a distance measurement as part of the reported value, and requires the following to be reported:

- STI in the nearest workstation (to the source)
- Distraction Distance
- Privacy Distance
- Spatial decay rate of A-weighted SPL of speech
- A-weighted SPL of speech at 4 meters
- Average A-weighted background noise

The standard also requires that the report include a graph of STI values as a function of distance that is used to determine the Distraction Distance and the Privacy Distance. Although the standard does not provide recommended values, it does provide two examples:

Poor/Insufficient Acoustic Conditions:

- Distraction Distance greater than 10 meters
- A-weighted SPL of speech at 4 meters greater than 50 dB
- Spatial decay rate of A-weighted SPL of speech less than 5 dB

Good Acoustic Conditions:

- Distraction Distance less than or equal to 5 meters
- A-weighted SPL of speech at 4 meters less than or equal to 48 dB
- Spatial decay rate of A-weighted SPL of speech greater than or equal to 7 dB