Less noise • More sound

Myths & Facts about Speech Intelligibility

NTI Acoustilyzer with STI-PA functionality

Public address systems in building complexes have to inform persons about escape directions in case of emergency. Such public buildings include airports, railway stations, shopping centers or concert halls. However if such announcements are misunderstood due to poor system quality, tragic consequences may result. Therefore, it is essential to design, install and verify sound reinforcement systems properly for intelligibility. In addition, a variety of other applications such as legal and medical applications may require intelligibility verification.

National standards as shown in the table below require electro acoustic sound systems for emergency purposes to be verified under realistic circumstances, in order to ascertain a minimum level of speech intelligibility in case of an actual emergency.

Thereby, speech intelligibility from a regulatory view isn't a subjective measurement, but can be verified with several, more or less complex methods that have been standardized in IEC 60268-16.

Other national or local regulatory bodies implement recommendations or requirements to conduct these measurements for maintaining minimum speech intelligibility.

Various local to national jurisdictions also then define whether or not it is mandatory to conduct the intelligibility measurements. These by-laws may vary depending on the type of business or venue, and the national or regional regulations, although the trend is certainly in the direction to require this testing.

Standard:	
IEC 60268-16	*Objective rating of speech intelligibility by speech transmission index*
National standards:	
ISO 7240	*Fire detection and alarm systems, section 16 & 19*
NFPA 72	*National Fire Alarm Code 2002 (2002 edition, section 7.4.1.4)*
BS 5839-8	*Fire detection and alarm systems for buildings. Code of practice for the design, installation and servicing of voice alarm systems*
DIN 60849	*System regulation with application regulation DIN VDE 0833-4*

Standard recommendations for STI-PA

How does STI-PA compare to STI and RASTI

STI measured in public address systems has been very time consuming. A complete set of 98 measurements of modulation transfer functions (MTF) has to be obtained and summed. Due to the complex nature and the time required almost no really useful STI measurement systems were available for years. With the appearance of MLS based systems, STI was more often obtained, as it can be calculated out of the transfer function, as long as the entire system is strictly linear and synchronous, i.e. there must not be any non-linear processing or conditions, including compressors or limiters and close to zero wind, which is a rather rare situation. Microphone and speaker aren't allowed for movements during the measurements, which prohibits employment of handheld instruments. Thus it doesn't make sense to support MLS measurements in handheld instruments. Alternatively by using the dedicated STI-PA test signal, measurements can be accomplished with handheld instruments.
STI-PA, a derivative of STI, has been developed specifically to cope with the non-linear processing environment common to advanced sound systems, and to reduce the measurement time required to a practical level.

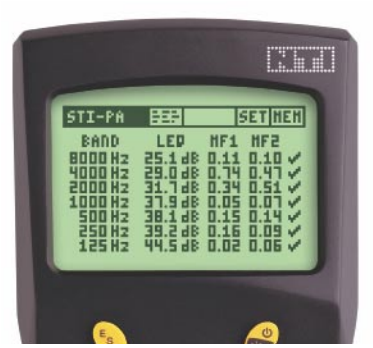
RASTI - Room Acoustics Speech Transmission Index

RASTI has been developed for special cases, such as a human lecturer speaking into a small room without echo's, but not for electro-acoustic systems. In order to cope with the long test time required for each STI measurement, a faster method called RASTI was developed. RASTI acquires only few points of a complete set of modulation indices. But this in turn weakens its ability for comprehensive testing and heavily compromises its resistance against outside interference. This also leads to poor correlation between subjectively evaluated STI and RASTI. However, RASTI used to be the only method to measure the quality of speech transmission with a portable instrument for a long time, thus it has been utilized in the aviation industry to measure public announcement systems, disregarding the above mentioned development restrictions of RASTI.

Calculation of % Alcons from STI-PA Measurement

Alcons (%) = 10^((1-STI)/0.45)
The calculation of STI-PA based on Alcon measurements is not reasonable due to the difference in the measurement principles.

Now STI-PA



Acoustilyzer AL1 STI-PA test results with modulation indices

A rising awareness for security issues, new technology, and the shortcomings of RASTI together triggered the speaker manufacturer Bose and the research institute TNO to develop a new method for measuring the quality of speech transmission of PA installations. The result of these efforts is STI-PA, which supports fast and accurate tests with portable instruments. STI-PA stands for Speech Transmission Index for Public Address systems.
Portable STI-PA analyzers, e.g. NTI's Acoustilyzer, are able to evaluate speech intelligibility within 15 seconds per room position and are thus well suited for wide-area measurements and high productivity.

Who can and should conduct STI-PA measurements?

Even though the background of the STI-PA method is complex, the operation of STI-PA using the AL1 Acoustilyzer is very simple. Operators with a basic acoustic knowledge can easily conduct these measurements. The instrument's internal storage functionality also simplifies the measurements in larger buildings, where many measurements at many locations must be taken. The detailed access to the measured MTF (Modulation Transfer Function) matrix enables experts to post-process all measurement data.

Is this a research product or widely used?

STI-PA is the standardized result of extensive scientific research. But unlike RASTI, within two years as many as four international test instrument manufacturers have implemented the STI-PA approach and offer varying solutions. It is therefore perfectly valid to say that STI-PA is the widely accepted standard for measurements of the quality of speech transmission, combining the accuracy and advantages of full STI measurements with the benefit of extremely short measurement time of only 15 seconds per location.

Who is TNO?

TNO is a research and certification institute in the Netherlands, Europe. They are focusing on research around defense, security and safety and they have originally developed the STI as well as the STI-PA technology. Their knowledge is freely useable and not patent protected.

Compatibility?

Thanks to TNO, acting as a certification body, it is guaranteed that instruments from all certified test and measurement vendors will provide compatible measurement results. Three vendors are currently certified by TNO. Studies and comparisons conducted by Peter Mapp Associates, Colchester, Essex UK, confirmed that all certified vendors provide stable and comparable measurement results. Details of the comparison may be found in the AES publication titled "Is STI-PA a robust measure of speech intelligibility performance?"

Patent protected?

Even though the research part of STI and STI-PA is not patent protected, BOSE of America has been recently been granted the US-Patent 6,792,404B2 for the idea to implement STI or STI-PA onto a hand held analyzer. NTI maintains a license agreement with BOSE for this patent and is therefore able to market the STI-PA implementation available for the Acoustilyzer in the US.

Can I buy STI-PA for my AL1?

Yes, STI-PA is an optional function for the Acoustilyzer AL1. Any AL1 user may obtain a STI-PA license. With the key of the license he may request the activation key for his Acoustilyzer AL1 and full functionality is then activated.

I have an ML1. Can I run STI-PA as well?

NTI offers a cross grade package that converts the functionality of the Minilyzer into an AL1 Acoustilyzer with 100% compatibility in functionality and specification. This functional extension, including the STI-PA option, is then available as with any other regular Acoustilyzer AL1.

What is a TalkBox? / Do I need a TalkBox for STI-PA measurements?

The TalkBox is NTI's calibrated acoustical sound source with built in digital solid state signal generator. You don't necessarily need a TalkBox if you are testing only the portion of the system beyond the microphone. But the use of the NTI TalkBox as speaker substitute is advisable if:

NTI TalkBox

- Regulations require a complete end-to-end system check including the microphone. This is the most realistic system check in any event.
- No electrical input is available to induct the electrical test signal.
- The level of the test signal is not clearly defined
- The characteristics of the speaker's acoustical environment are not negligible and flat.
- The characteristics, sensitivity and frequency response of the speaker's microphone is not known but needs to be considered.
- As above, if for any other reason it is desirable to test the entire signal chain under real conditions.

The TalkBox is also capable of delivering white and pink noise and other special signals, and so is a very useful overall tool for system tuning and testing.

STI-PA Test Result

- The intelligibility index is measured in the range from 0 to 1, whereby 1 is perfect and the minimum requirement including measurement uncertainty and variation is >= 0.5.
- The variation of STI-PA test results shall be smaller than 0.03 STI at one test position, thus to fulfill measurement conditions for ambient noise characteristics. The actual variation shall be measured at a representative location.
- Best intelligibility is achieved at message levels in the range of 70-80 dBSPL. At higher sound pressure levels the self-protection of the ear comes into action, which is reflected in a reduced intelligibility index, such as a STI of 1 at 70 dBSPL may be down to 0.7 STI at higher sound pressure level.
- Based on the random STI-PA test signal the typical variations of the measurements is 0.01 – 0.03 STI. Thus at applications with STI-PA values < 0.63 STI the measurement has to be repeated twice and the arithmetical average of all 3 measurements calculated.
- In case variations are higher than 0.03 STI, further 3 measurement shall be carried out and all 6 readings arithmetical averaged.
- In case variations at the same test location are higher than 0.05 STI, causes for these discrepancies shall be detected, eliminated and the measurement repeated.

STI-PA Measurement Hints

- Any background noise has to be sufficiently static during the measurement, e.g. pink noise fulfills this requirement.
- Verify the environmental conditions prior testing. Complete STI-PA measurements without any test signal. The results shall be < 0.20 STI.
- Impulsive background noise during the measurement, such as speech, causes severe measurement errors. The STI-PA result is usually too high.
- In case such impulsive noise can not be prevented, the measurements might be shifted e.g. to night time, and afterwards corrected with the averaged daily background noise, using external post processing.
- Any CD-Players used to reproduce the STI-PA test signal have to be accurate as only limited time-shifts (+/- 200 ppm) are allowed to ensure reliable STI-PA test results. Pitch control and shock protection shall be disabled. NTI recommends using professional players only. You may verify the time shift of your CD-Player with a 9 kHz test signal:
  - Generate a 9000 Hz sine signal using the NTI Wavefilegenerator (available for download at the Acoustilyzer website) and copy this on a CD
  - Insert this CD into the CD player and play the 9 kHz test signal
  - Connect the Acoustilyzer to the audio output directly and measure the signal frequency in the RMS/THD mode, the displayed frequency shall be in the range from 8998 to 9002 Hz (the last digit equals 111 ppm at 9 kHz)

- The STI-PA test signals of other test system manufacturers may sound similar but are not compatible. Only the NTI STI-PA test signal CD V1.1 or higher shall be used in combination with the Acoustilyzer AL1.
- STI-PA measurement of alarm systems shall be carried out at emergency conditions (same sound pressure level and all components are activated).
- At locations undergoing different circumstances, e.g. public areas with few people or crowded areas, the worst case STI-PA results has to be measured.
- Select typical locations, such as positioning the microphone at 1 - 1.2 meters above ground in sitting areas or 1.5 - 1.8 meters in standing areas (typical measurement positions are normally not directly in front of the speakers)

STI-PA Post Processing

Measuring speech intelligibility index under realistic environment conditions is often not applicable, e.g. playing the test signal in a railway station at emergency levels during peak hours will irritate passengers. Additionally at rush hours the characteristics of back ground noise might be highly impulsive. But a prerequisite for accurate STI-PA measurements is a negligible impulsivity in the background noise.
Under such circumstances the STI-PA measurement should be shifted to a more suitable time of the day, e.g. night time. Such STI-PA measurements taken at untypical background noise conditions have to be post-processed. Post processing combines the STI-PA measurement data taken at quasi noise-free ambient conditions with the unweighted octave band noise levels (Leq) taken e.g. during day time, at realistic environmental conditions.
The NTI STI-PA Post Processing Software is exactly tailored for this application e.g. to combine the night and day-time measurement.
The Post Processing Software is free for download at www.nti-audio.com.

What to do if Impulsive Noise is permanently present?

In a 24 hours factory or on a highway impulsive noise may be permanently present, thus STI-PA measurements shall not be carried out. In such instances the onsite conditions have to be simulated in a laboratory for STI-PA testing:

a. The real noise spectrum shall be measured e.g. with the Acoustilyzer RTA/ LEQ function, averaging over a sufficient amount of time.
b. A diffuse sound field of non-impulsive noise with same frequency shape and octave band levels as measured at pos. a. has to be generated in the laboratory.
c. The real speaker - listener situation has to be reproduced acoustically in the laboratory as close as possible.
d. Then the actual STI-PA measurement can be carried out. No post processing is required.

This approach will also be mandatory for systems including automated gain control (AGC), if they can't be tested in the original environment due to annoyance of people exposed to the test signal due to the impulsive background noise. For further information please visit www.nti-audio.com.