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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Sound system equipment –
Part 16: Objective rating of speech intelligibility by speech transmission index

Equipements pour systèmes électroacoustiques –
Partie 16: Evaluation objective de l'intelligibilité de la parole au moyen de l'indice de transmission de la parole

IEC 60268-16:2011

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SOUND SYSTEM EQUIPMENT –

Part 16: Objective rating of speech intelligibility by speech transmission index

FOREWORD

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International Standard IEC 60268-16 has been prepared by IEC technical committee 100: Multimedia equipment and systems.

This fourth edition cancels and replaces the third edition, published in 2003, and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- development of more comprehensive, complete and unambiguous standardization of the STI methodology;
- the term STI_r is discontinued. A new function for the prediction of auditory masking effects is introduced;
- the concept of 'speech level' and the setting of the level of the test signal have been introduced;

- additional information has been included on prediction and measurement procedures.

NOTE See Introduction for a historical summary referring to the various changes from the first to the fourth edition (current edition).

This bilingual version corresponds to the monolingual English version, published in 2011-06.

The text of this standard is based on the following documents:

FDIS	Report on voting
100/1812/FDIS	100/1849/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

The French version of this standard has not been voted upon.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in the IEC 60268 series, published under the general title *Sound system equipment* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

The Speech Transmission Index (STI) is an objective measure to predict the intelligibility of speech transmitted from talker to listener by a transmission channel. The STI method has been the subject of ongoing development and refinement since its introduction in the 1970s. Major improvements of the STI have been consolidated by incorporating them in successive revisions of IEC 60268-16.

The history of revisions is as follows.

- Revision 1: 1988. In the first version of the STI standard, a gender-independent test signal spectrum was used.
- Revision 2: 1998. Gender specific test signals were introduced, for male and female talkers, each gender relating to a specific set of weighting factors. In addition, weightings were introduced for redundancy factors. The term STI_r was introduced to signify the use of these redundancy factors.
- Revision 3: 2003. Important differences between Revision 2 and Revision 3 are the introduction of
  - level dependent masking functions,
  - the STI derivative STIPA.

  STIPA was specially developed as a fast measurement method that could deal with electro-acoustic and acoustic effects while determining the speech transmission quality of PA systems.
- Revision 4: 2010. The aim of Revision 4 (this revision) is to provide a more comprehensive, complete and unambiguous standardization of the STI methodology. The term STI_r is now discontinued. A new function for the prediction of auditory masking effects is introduced.

Speech is considered to be the major method of communication between humans. In many situations the speech signal is degraded by the signal path or the transmission channel between talker and listener, resulting in a reduction of the intelligibility of the speech at the listener's location.

To quantify the deterioration of the speech intelligibility induced by the transmission channel, a fast and objective measuring method was developed; the Speech Transmission Index (STI). The STI method applies a specific test signal to the transmission channel and by analysing the received test signal; the speech transmission quality of the channel is derived and expressed in a value between 0 and 1, as the Speech Transmission Index (STI). Using the obtained STI-value, the potential speech intelligibility can be determined.

Although there are limitations to the STI method, the use of STI has proved useful in many situations and has gained international acceptance.

Items that have changed in this revision

Specific changes that have been incorporated in this revision are:

- refinement of the STI model with respect to the level dependent masking function;
- Room Acoustic Speech Transmission Index (RASTI) has become obsolete and should not be used;
- calculations to add or remove the effects of background noise and to change the speech level and a worked example;
- notes regarding limitations of the STI method;
- methods to predict the STI performance of transmission channels based on the predicted (as distinct from measured) performance of parts or all of the transmission channel;

- introduction of STI corrections for non-native language listeners;
- introduction of STI corrections for listeners with some specific forms of hearing loss;
- relationships between STI and 'Listening Difficulty' scale.

Potential applications of STI

STI may be used to measure the potential intelligibility of a wide range of electronic systems and acoustic environments. Typical applications include:

- measurement of Public Address and Sound Reinforcement Systems;
- measurement and Certification of Voice Alarm and emergency sound systems;
- measurement of communication channels / systems such as intercoms and wireless communication;
- measurement of potential speech intelligibility and communication in rooms and auditoria;
- evaluation of direct speech communication (situations without electronic amplification) in rooms or acoustic spaces including vehicles;
- evaluation of the potential intelligibility of Assistive Hearing Systems;

NOTE The STI method is not validated for the measurement and evaluation of speech privacy or speech masking systems.

Potential users of STI

The range of users of STI measurements is diverse. Among the users who may apply this method are:

- certifiers of voice alarm and other types of emergency systems;
- certifiers of sound reinforcement and audio systems;

- audio and telecommunication equipment manufacturers;
- audio and communication engineers;
- acoustical and electro-acoustical engineers;
- sound system installers;
- researchers into STI methods and developers of instruments to measure STI.

To avoid misinterpretation of STI results, it is important that all users have an understanding of the basic principles, the application domain and its limitations.

SOUND SYSTEM EQUIPMENT –

Part 16: Objective rating of speech intelligibility by speech transmission index

1 Scope

This part of IEC 60268 specifies objective methods for rating the transmission quality of speech with respect to intelligibility.

The objective of this standard is to provide a comprehensive manual for all types of users of the STI method in the fields of audio, communications and acoustics.

This standard does not provide STI criteria for certification of transmission channels (e.g. criteria for a voice-alarm system).

Three methods are presented, which are closely related and are referred to as STI, STIPA, and STITEL. The first two methods are intended for rating speech transmission performance with or without sound systems. The STITEL method has more restricted uses.

NOTE None of the methods are suitable for the measurement and assessment of speech privacy and speech masking systems, as STI has not been validated for conditions that represent speech privacy applications [1][1].

The following information is included:

- measurement techniques;
- prediction techniques.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies:

IEC 61260:1995, *Electroacoustics – Octave-band and fractional-octave-band filters* Amendment 1 (2001)

ISO 18233:2006, *Acoustics – Application of new measurement methods in building and room acoustics*

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

3.1
speech intelligibility
rating of the proportion of speech that is understood

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1 Figures in square brackets refer to the Bibliography.

3.2
speech quality
rating of sound quality of a speech signal

3.3
speech transmission index
STI
metric ranging between 0 and 1 representing the transmission quality of speech with respect to intelligibility by a speech transmission channel

3.4
speech intelligibility index
SII
objective method for prediction of speech intelligibility based on the Articulation Index

3.5
STI method
FULL STI
objective method for prediction and measurement of the speech transmission index that uses 14 modulation frequencies over a range of 7 octave bands

3.6
distortion
any unintentional and generally undesired change of the form of a signal occurring in a speech transmission channel

NOTE Distortion can include both linear and non-linear effects in both frequency and time domain.

3.7
speech transmission index for public address systems
STIPA

method obtained by using a condensed version of the STI method but still responsive to distortions found in room acoustics and/or public address systems

NOTE STIPA is applied as a direct method.

3.8
speech transmission index for telecommunication systems
STITEL
method obtained by using a condensed version of the STI method but still responsive to distortions found in communication systems

NOTE STITEL is applied as a direct method.

3.9
room acoustical speech transmission index
RASTI
method obtained by using a condensed version of the STI method, to be used for screening purposes only and focused on direct communication between persons without making use of an electro-acoustic communication system

NOTE 1 RASTI accounts for noise interference and distortions in the time domain (echoes, reverberation).

NOTE 2 RASTI is now obsolete.

3.10
direct STI method
method using modulated (speech like) test signals to directly measure the modulation transfer function

3.11
indirect STI method
method using the impulse response and forward energy integral (Schroeder integral) to derive the modulation transfer function

3.12
speech transmission channel
acoustic or electro-acoustic signal path between a talker and a listener

3.13
public address system
PA
electronic sound distribution system, employing microphones, amplifiers and loudspeakers, used to reinforce or amplify a given sound (such as an announcement or a pre-recorded message) and distributing the sound within a building or a space

3.14
voice alarm system
VAS
sound distribution system that broadcasts speech messages or warning signals, or both, in an emergency

3.15
real speech level
signal level of a speech signal in dB A where only the segments that contribute to the speech signal are taken into account; pauses and silences between words and sentences are ignored

NOTE See also Annex J.

3.16
reference speech level
speech level equivalent to 60 dB A at 1 m distance in front of the talker's mouth

3.17
vocal effort
exertion of the speaker, quantified objectively by the A-weighted speech level at 1 m distance in front of the mouth and qualified subjectively by a description

3.18
artificial mouth
device consisting of a loudspeaker mounted in an enclosure and having a directivity and radiation pattern similar to those of the average human mouth

NOTE The degree of similarity required cannot be easily specified and depends on the particular application. See for example ITU-T P.50 [47].

3.19
non-native speaker
person speaking a language which is different from the language that was learned as primary language during the childhood of the speaker

3.20
absolute speech reception threshold
absolute threshold of hearing increased by the minimal required dynamic range for the correct recognition of speech

3.21
auditory masking
process by which the threshold of hearing (audibility) for one sound is raised by the presence of another (masking) sound

NOTE Within the STI method, auditory masking is also referred to as the upward spread of masking.

3.22
artificial ear
device with similar characteristics as the human ear for the reception of acoustic signals

NOTE See IEC 60318 [2].

3.23
intensity function
the squared amplitude signal as a function of time

3.24
envelope function
envelope of the intensity function

3.25
envelope spectrum
relative contribution of spectral components of the envelope function

3.26
modulation frequency
frequency of the sinusoidal variation of the envelope function

NOTE The modulation frequency f_m is expressed in Hertz (Hz).

3.27
modulation index
value between 0 and 1 that describes the depth of a sinusoidal modulation of the intensity function

3.28
modulation transfer ratio
ratio between the modulation depth of the received and the original (transmitted) modulation depth of the intensity function

3.29
modulation transfer function
MTF
modulation transfer ratios as a function of the modulation frequency

3.30
octave band weighting factor
α
relative contribution of each octave band to the speech transmission index

3.31
octave band redundancy factor
β
fraction of information overlap between two adjacent octave bands with respect to the speech intelligibility

3.32
background noise
all sounds including noise remaining in the absence of the speech or test signal

3.33
fluctuating noise
continuous sound or noise whose sound pressure level varies significantly, but not in an impulsive manner, during the observation period

3.34
impulsive noise
sound or noise characterized by brief bursts of sound pressure

3.35
signal-to-noise ratio
SNR
difference between the sound pressure level of the speech or test signal and the sound pressure level of the background noise where the sound pressure levels are determined with a standardized frequency weighting

NOTE The signal-to-noise ratio *SNR* is expressed in decibels (dB).

3.36
effective signal-to-noise ratio
SNR_{eff}
difference between the level of the intensity modulation and the level of the intensity of all the distortions of a received STI test signal

NOTE 1 The effective signal-to-noise ratio is expressed in decibels (dB).

NOTE 2 Examples of distortions are reverberation field levels, ambient noise levels, non-linear distortion levels and masking levels.

3.37
crest factor
difference between the peak and the RMS sound pressure levels during a given time-interval

NOTE The crest-factor is expressed in decibels (dB).

3.38
Lombard effect
spontaneous increase of the vocal effort induced by the increase of the ambient noise level at the speaker's ear

NOTE Voice pitch shift at higher talking levels is not accounted for here.

3.39
fractional-octave-band filter
bandpass filter for which the ratio of upper cut-off frequency f_2 to lower cut-off frequency f_1 is two raised to an exponent equal to the fraction of an octave band

NOTE 1 In symbols, the ratio of the cut-off frequencies is $f_2/f_1 = 2^{1/b}$, with 1/b denoting the fraction of an octave.

EXAMPLE 1 For half-octave band filters, the frequency ratio is $2^{1/2} = \sqrt{2}$.

EXAMPLE 2 For octave band filters, the frequency ratio is 2.

NOTE 2 For further information, refer to IEC 61260.