Suggestions for revision of ISO 3382

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Introduction

Room acoustic quantities such as the reverberation time have two main fields of application: the description of the acoustic perception by humans and the physical description of the acoustical energy for further parameters (such as diffuse-field absorption, scattering coefficient, sound insulation, sound power). In both fields, precise measurements are essential. Therefore, measurement and calculation procedures for performances spaces are standardized in ISO 3382-1 from the year 2009 [1]. This contribution gives an overview about recent studies that investigate inherent uncertainties and external influences on room acoustic measurements and post-processed parameters. Modifications for the next revision of ISO 3382 are proposed to enhance the accuracy and repeatability of room acoustic measurements.

Stationary Noise

Stationary noise inevitably occurs during room acoustic measurements and is one of the largest error sources. Various noise compensation techniques can be applied before evaluating the room acoustic parameters. It has been shown that the performance of different techniques vary strongly [2]. One very effective technique, subtraction of the estimated noise energy [3], is not mentioned in ISO 3382 and can therefore not be applied.

Table1: Overview of the used techniques in the five investigated noise compensation methods.

Method	**truncation of impulse response**	**correction for truncation**	**subtract noise energy**	**allowed in ISO 3382**
A				√
B	√			√
C	√	√		√
D			√	
E	√	√	√	

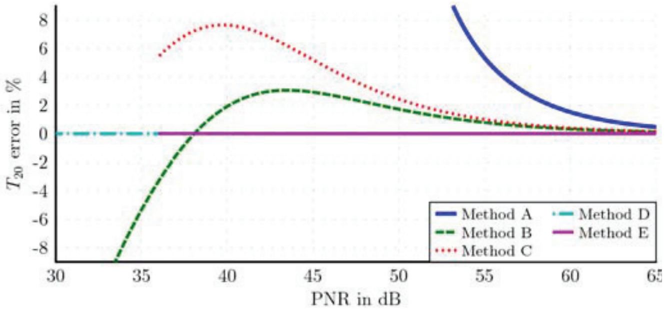

Figure 1: Relative Error in T20 as function of the peak-signal to noise ratio (PNR) for five noise compensation techniques. The correct behavior of Method D and Method E base on perfect noise estimation and constant noise.

Suggestions for ISO revision

- Include the 'subtraction of noise'-method proposed by Chu [2].
- Prescribe usage of a noise compensation technique (exclude Method A).
- The peak signal-to-noise ratio and the applied noise compensation method should be included in the measurement report, so that an estimation of the systematic error is possible afterwards.

Impulsive Noise

Especially for the commonly used sweep measurement technique, the occurrence of impulsive noise during the measurements can result in large errors of the evaluated room acoustic parameter.

An automatic technique has been presented that is able to detect the occurrence of impulsive noise in measurements allowing an immediate repetition of the measurement if necessary [4].

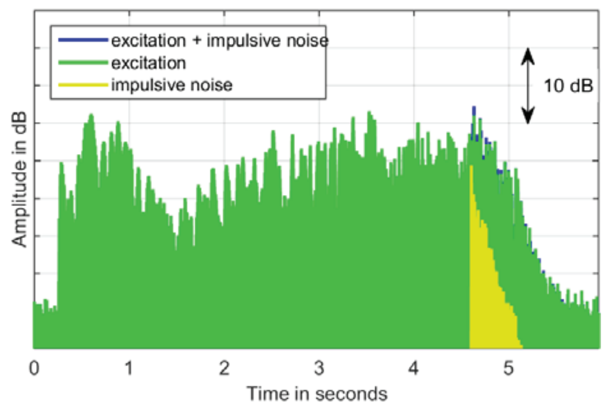

Figure 2: An impulsive noise event at 4.5 s with amplitudes below the excitation signal can hardly be detected.

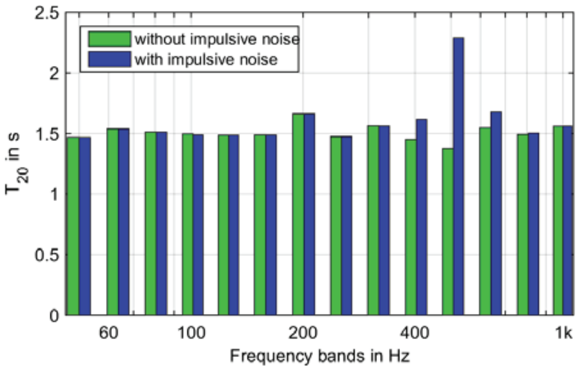

Figure 3: The resulting error of reverberation time at 500 Hz is larger than 50 %.

Suggestions for ISO revision

- Draw attention to the danger of impulsive noise for sweep measurements.
- Advise to use a technique to detect impulsive noise in measurements.

Persons in the room

In general, for practical reasons persons are present in the room during measurements, since several source-receiver combinations have to be measured.

A special measurement scenario was designed to investigate the effect of human-size scattering objects. A adult-sized human dummy has been placed in the middle of a microphone array and the room acoustic parameters with and without scattering object have been compared [5].

The clarity index C_{80} show a large influence of the object while the effect for reverberation times is negligible.

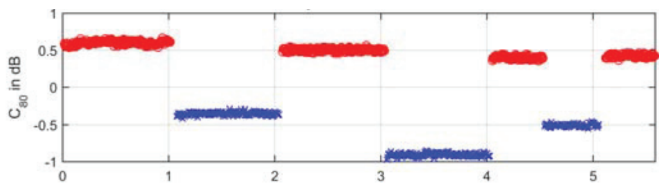

Figure 4: Evaluated clarity index C_{80} of 1 kHz octave band as function of time (in h). Measurements without scattering object are shown in red and with scattering object in blue.

Suggestions for ISO revision

- Recommend a minimum distance of at least 10 m to microphone and loudspeaker during the measurement, especially for clarity measurements.

Temperature change during measurement

Investigations with real measurements showed that the critical limits for temperature changes during within one measurement are smaller than the theoretical predictions [6].

For T_{20} the product of temperature change and midband frequency $\Delta\Theta/^{o}C \cdot f/Hz$ has to be smaller than 42 to ensure an error
$\leq$ 5%. This leads to a maximum tolerable temperature change of 0.021 °C for 2 kHz. The clarity index C_{80} is more robust to temperature changes ($\Delta\Theta/^{o}C \cdot f/Hz \geq 252$).

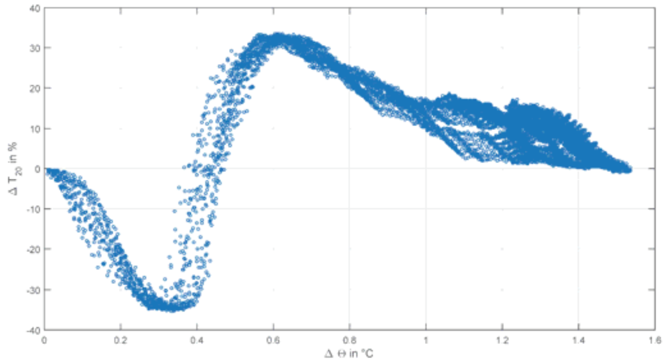

Figure 5: Relative error in reverberation time T20 as function of temperature change during the measurement. The measurement shows larger errors than predicted by theory.

Suggestions for ISO revision

- Mention the high sensitivity of measurement to temperature changes during one measurement.
- Prohibit measurements directly after a start-up or a shut-down of the air conditioning system.
- Guidelines to minimize errors:
  - Prefer sweeps over MLS.
  - Prefer longer excitations signals over averaging.

More information can be found in [6].

References

[1] ISO 3382-1 „Measurement of room acoustic parameters – Part 1: Performance spaces" (2009).

[2] M. Guski and M. Vorländer. "Comparison of Noise Compensation Methods for Room Acoustic Impulse Response Evaluations". Acta Acustica united with Acustica 100 (2) (2014), pp. 320–327.

[3] W. T. Chu. "Comparison of reverberation measurements using Schroeder's impulse method and decay-curve averaging method" J. Acoust. Soc. Am. 63 (5) (1978), pp. 1444–1450.

[4] M. Guski and M. Vorländer. "Impulsive noise detection in sweep measurements". *Acta Acustica united with Acustica* 101 (4)(2015), pp. 723– 730.

[5] M. Guski and M. Vorländer. "The influence of single scattering objects for room acoustic measurements". In: *DAGA 2015* (2015).

[6] M. Guski „Influences of external error sources on measurements of room acoustic parameters". PhD dissertation RWTH Aachen University, Logos Verlag Berlin. 2015