**Room criteria**

dBBATI32 allows the user to compute the following room criteria :

* Quality criteria : RT, EDT, Clarity, Definition, ST1.
* Intelligibility criteria : STI, RASTI.

This chapter present the definition of each index and a brief introduction to their meanings.

[Reverberation time](#tr)
[Energy criteria](#nrj)
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These criteria are obtained from echogram curves per frequency bands. These curves result from an analysis by digital filtering from an impulse response of the room. This response may be obtained by MLS technique.
For each criterion, the computation principle is identical. It may describe as follow:

For each frequency band (octaves or third octaves) :

* Detection of the arrival of the direct wave and computation of the background noise level before the source signal is emitted.
* Detection of the end of signal emission and computation of the background noise level after source emission.
* Calculation of the cumulated energy between the start and a given point of the echogram, with or without background noise removal.
* Calculation of the criterion with or without background noise removal, by cumulating difference.

Refer to pages [Room criteria measurements](../11_Mesure_Crit_salles/Mesure_criteres_salle.htm) and [Room criteria analysis](../18_Analyse_Criteres/Analyse_Criteres_salle.htm) to know how to compute room criteria.

[nrjnrj](#nrj)**Reverberation time** [hauthaut](#haut)

* RT 60

The reverberation time, for a given frequency and a given location in space, is defined as the time taken for a sound to decay by 60 dB after the sound source is abruptly switched off. The decay must be more or less constant.
The reverberation time is usually estimated between -5 to -35 dB of sound decay.

Subjective evaluation
The RT60 is an indicator of the reverberant feel, or sonorousness, of a sound field. If the reverberation time is too short, the acoustic field of a room may be considered as too " dry ". If the reverberation time is too long, the acoustic field of a room may be considered as too " confuse ".
For speech : The RT value must not be too long in order to avoid a masking effect (RT 60 < 1 to 1,3 s).
For music : The RT value must not be long, otherwise the sounds may not be distinguished from one another. The obtained result is a confuse.
The influence of RT 60 may not evaluated on its own as it always combine the level of the reverberant part of the echogram with respect to the direct sound.

* EDT (Early Decay Time)

The Early Decay Time could be considered as a short reverberation time computed on the first 10 dB of the sound decay. The EDT is measured between 0 and -10 dB and extrapolated to a 60dB sound decay.

The idea to limit the RT measurement dynamic to 10 dB comes from the fact that, during a concert, the human ear can only rarely listen to sound decay of greater dynamic.

The EDT value is compared to the RT 60 value. It allows us to estimate the balance between the early sound energy and the overall sound energy. The more the energy is concentrated at the beginning of the response (sound not useful), the greater the sound decay slope, and the shorter the EDT. The EDT is useful because it takes into account the effect of the first sound reflections in a room, and therefore it is closer to the subjective judgement of the listeners.

Subjective evaluation
This criterion appears to be closely related to the reverberation feel of the room, although it interpretation remains difficult. The EDT is linked to several others sensations such as the sharpness of attacks and their intensity.
For the same room (same volume), there is a significant difference between the RT60 and EDT values. The EDT varies more quickly as a function of distance than the RT.

[intint](#int)**Energy criteria** [trtr](#tr)

Calculation of cumulated energy and energy criteria

The cumulated energy is calculated for a point P by adding the energy of each point located between the beginning of the echogram and the point P. If one wishes to calculate the criteria with background noise removal, the cumulated energy is calculated while subtracting the background noise energy at each point of the echogram.

Each integral used to compute the criteria correspond to the difference between two cumulated energies. For example, the Clarity 80 will give :

There is a relationship between the sound energy contained in a given time interval and the sound energy in the following time interval. Several time intervals have been proposed : 33, 35, 50, 80 and 95 ms. For each interval, the main idea is the same : the energy contained in this interval is considered as useful and the energy of the next time interval is considered as secondary or even harmful in particular cases.

This comes from the functioning of the ear. The ear cannot differentiate sound reflections that occur in less than 35, 50 or 80 ms. The individual contributions of the first reflections are therefore added. These energy relationships describe the subjective indicators such as Clarity.

* Clarity 80

This criterion, defined by Reichardt, is the ratio between the sound energy contained in the first 80 milliseconds of the impulse response after the arrival of the direct wave (where the time T is set to zero) and the energy contained in the rest of the impulse response. It draws a relationship between the subjective sensation of a sound field and the interpretation of reflected sounds by the ear :

(en dB)

with h(t) the impulse response of a room.

This parameter is negative when the energy after 80ms is greater than the energy in the range 0-80ms. It is positive when the energy after 80ms is less than the energy in the range 0-80ms (E80 > Erev).

Subjective evaluation
This criterion is mainly employed for music. It translates subjective sensations dealing with :

* The definition
* The discrimination
* The sharpness of attacks
* The differentiation between different voices
* The transparency
* The source location, etc.

Values
The measurement of the clarity coefficient C80 is performed with an Omni-directional microphone.

Examples of values for known auditory (1) :

|  |  |  |  |
| --- | --- | --- | --- |
| Salle | Valeur la plus petite | Valeur moyenne | Valeur la plus élevée |
| Gross Musikhereinsalle(Vienne) | -5,30 | -2,90 | -0,30 |
| Salle Pleyel(Paris) | -3,37 | -0,70 | 4,37 |
| Auditorium M. Ravel(Lyon) | -3,07 | -0,13 | 2,88 |

(1) JULLIEN J.P.
Acoustique des Salles, CNET LANNION, 1982, p.19

In general, values around 0 dB mean that the acoustics of a room is well suited for listening to symphonic music. For music, the limits that are usually used range form -2 to +2 dB. For operas, C80 must lie in the range 1 to 4 dB.

* Clarity 50

This criterion, as for C80, is calculated as the ratio between the sound energy contained in the first 50 milliseconds of the impulse response after the arrival of the direct wave (where the time T is set to zero) and the energy contained in the rest of the impulse response. The 50ms threshold is mainly used for speech and very little for music.

* Definition

We use the criterion "Definition" (D) of index 50 which is in fact the ratio E50 / Etot :

Expressed in en %.

* ST1

We use again an energy ratio.

(in dB)

**Intelligibility criteria** [nrjnrj](#nrj)

An intelligibility criteria is essential to characterise the acoustic field of a conference room, a theatre and in more general terms, any place where speech is important. When a speech signal is produced in a room, normally or with the aid of a speech amplification system, the syllables tends to mask each other because of the multiple reflections and the reverberant sound spoken word so that the listener may not clearly distinguish them. When the speech sound level is too weak with respect to the background noise, the intelligibility is too low because of this masking effect.

Various objective criteria are available to qualify the speech intelligibility of a room. The C50 Clarity coefficient OR the D50 definition (see preceding paragraph) can be used to estimate speech intelligibility although they do not take into account the background noise level.

* STI (Speech Transmission Index)

The STI index is an objective criterion that characterise speech intelligibility. The STI is an indicator that takes into account all the possible causes of speech intelligibility alterations, excepted the non-linear effect.

STI formula

Let first recall that any alteration of the signal modulation may be expressed at a signal to noise ratio. We start with the acquisition of a M.T.F.(Modulation Transfer Function) for the octave bands ranging from 125Hz to 8kHz, covering the whole frequency range of speech phones.

Any modification of the room characteristics result into an effective reduction of the signal modulation with a delay. The M.T.F may be obtained from the impulse response of the room h(t) by calculation of the modulation index m(F) for low frequencies F, contained in the speech modulation.

The numerator is the squared Fourier transform of the impulse response. Ispeech and Inoise are the respective sound intensities of speech and noise.

Let compute signal to noise ratio per frequency bands such as:

We then calculate the mean after limitations of the S/Nk(F) to ±15 dB.

n being the modulation frequency number.

Let now calculate Transmission indices for speech per frequency band :

The STI is the weighted sum of the TIk :

Use of the STI index

The STI allows us to measure the critical distance dc for which speech intelligibility becomes bad. Indeed, it decays relatively quickly at short distances of the orator, then from the distance "dc", it becomes more or less constant, reflected sounds being predominant.

For conference rooms with absorption coefficients varying from 0,1 to 0,4, the distance dc is between 15 to 20 meters.

* RASTI (RApid Speech Transmission Index)

The RASTI method allows us to perform objective measurements of the qualities of speech intelligibility. The computation technique is similar to the STI calculation, with the following differences :

- The octave bands 500 Hz and 2 kHz are not taken into account
- All signal to noise ratios (Xi) are limited to ±15 dB
- The arithmetical average for all Xi are performed

RASTI = ( + 15) / 30

There are additional limitations to the validity of RASTI measurements :
- Distortion and non-linear cut-offs are not considered.
- The emerging pure tones of the background noise outside the frequency range 500 Hz - 2 kHz are not allowed. It is assumed that the background noise is stationary during the whole measurement.

Values
The STI and RASTI criteria vary between 0 and 1. There is a scale to interpret the intelligibility from the se values:

References
This annex uses extracts from :
- The study report from C.LUQUET and J.BEAUMONT established for Laboratoire Régional des Ponts et Chaussées of Strasbourg (France) on room acoustics. It itself refer to the work of J.P. VIAN and R. CROCOMBETTE (Master in acoustics) carried out at the CSTB (Centre Scientifique et Technique du Bâtiment de Grenoble) and the work of J.P. JULLIEN and A.C. SEVERNE from IRCAM in Paris.
- The thesis realised by V. FAVRE pour l'Ecole Supérieure de Mécanique de Marseille (1998)

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