APPENDIX H. REVERBERATION TIME

H.1. Introduction

In every room (besides an anechoic chamber) in which the sound source emits acoustic power the acoustic waves of two origins are presented. The waves which are emitted by the sound source are the **original waves.** The second type are the **reflected waves** which become due to the reflection of the original waves from the room boundaries. The propagation time of the original and reflected acoustic waves in the room since the moment when the sound source has been switched off to the moment when certain sound level pressure is achieved is called the **reverberation time**. Usually the reverberation time is defined as the number of seconds, counted since the sound source has been switched off, in which the sound pressure level in the room decreases by 60 dB. The graphs below present the reverberation time nature (in the case when only one frequency is emitted):

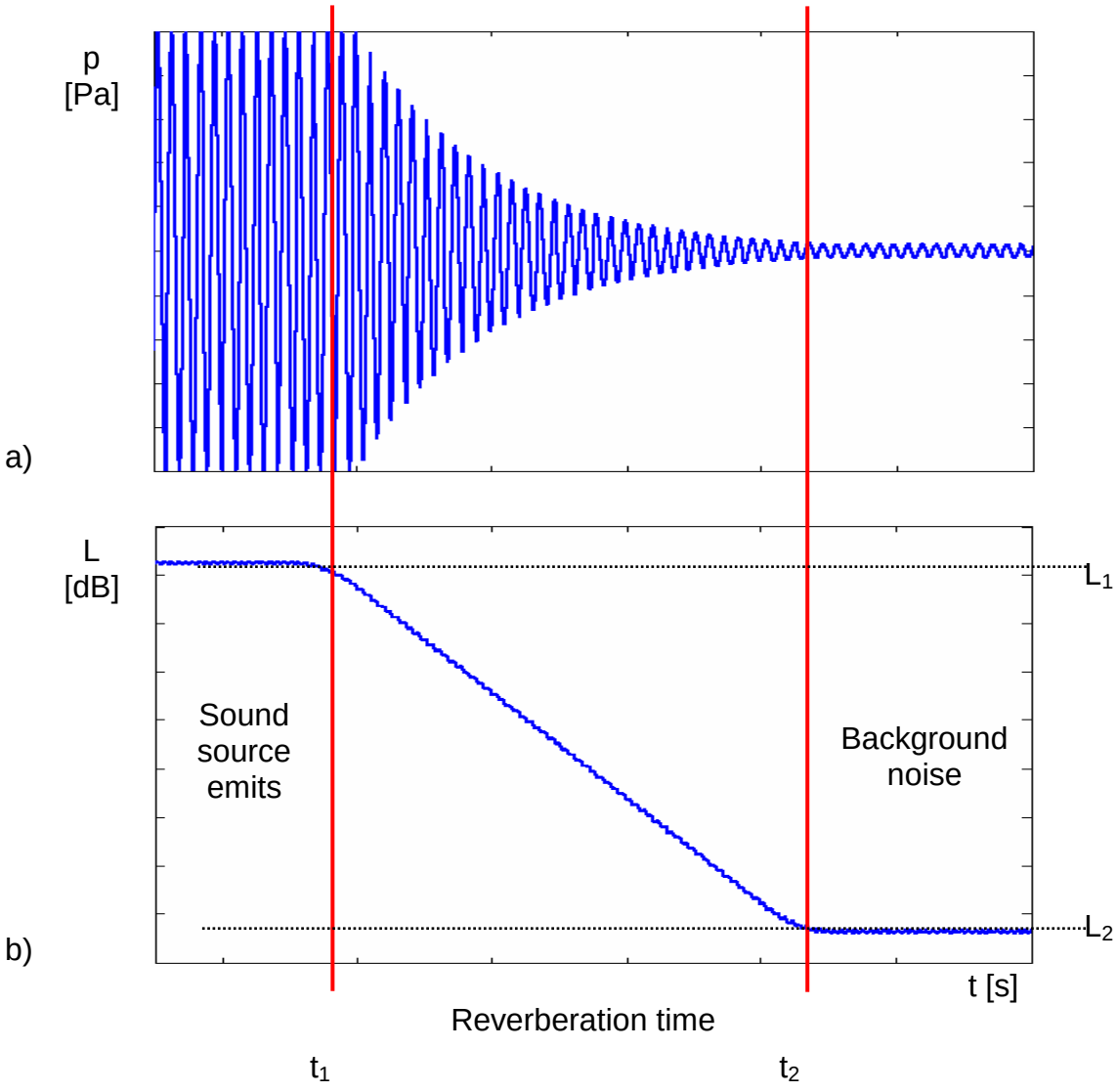

Fig 1. The acoustic pressure versus time (a) and the value of the sound pressure level versus time so-called decay curve (b)

The marker t_1 indicates the moment when the sound source was switched off. From this moment the acoustic sound pressure / acoustic power (reflected waves propagate in the room) decreases till the moment indicated by the marker t_2. The lower graph presents so-called **decay curve**. The reverberation time value is equal to $t_2 - t_1$ when the difference between sound pressure levels L_1 and L_2 is 60 dB. The

60 dB dynamic condition is impractical in real measurements (very difficult to fulfil) hence the reverberation time (RT 60) is obtained using the slope coefficient of the decay curve. The type of the definition from which slope coefficient is calculated (EDT, T 20, T 30 or user defined) depends on the difference between levels L_1 and L_2 (the difference between background noise level and sound source level) of the decay curve and it depends significantly from the acoustic source ability. If the level difference is larger than 45 dB, the RT 60 parameter can be calculated using three definitions: EDT, T 20 and T 30.

The real measurement results are not so smooth as the curves presented on graphs in Figure 1. In order to point out the interesting decay curve region (the position of the markers t_1 and t_2) some measurement data processing (in general signal smoothing by averaging) need to be applied.

H.2. The definition and the calculation process of the RT 60 reverberation time

- **EDT (early decay time):**
  - The EDT decay curve region is pointed out by markers t_1 and t_2 (Fig. 2).
  - It is checked whether the selected decay curve region has proper dynamics for the EDT calculation:

    $L_1 - L_2 > 5$ dB + noise margin

    It is recommended by the ISO-3382 standard to set 10 dB value for noise margin.
  - If above condition is fulfilled, the sound pressure level values between points t_1 (with L_1 level) and t_{EDT} (first L value which has $L_1 - 5$ dB level) are approximated with the straight line ($y = a \cdot x + b$) by the linear regression.

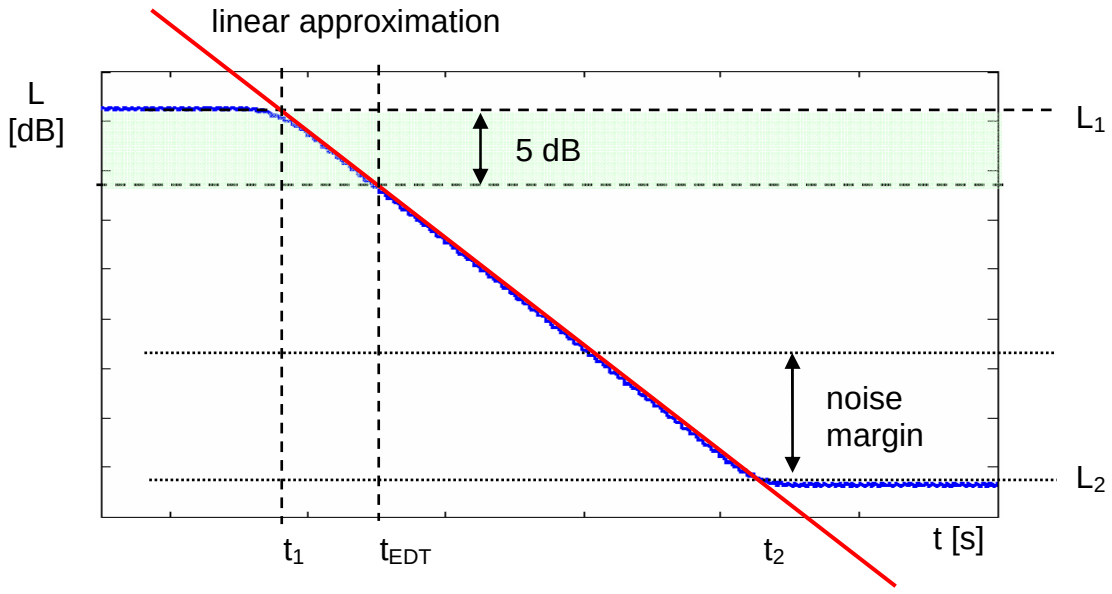

Fig 2. The EDT evaluation

  - Then the RT60 value is calculated using the slope coefficient 'a' obtained from the linear approximation of the EDT decay curve region, according the formula:

    EDT = - a / 5

    RT 60 = 12 · EDT

- **T 20 (reverberation time calculated with 20 dB dynamics):**
  - The T 20 decay curve region is pointed out by markers t_1 and t_2 (Fig. 3).

- It is checked whether the selected decay curve region has proper dynamics for the T 20 calculation:

$$\mathbf{L_1 - L_2 > 5\ dB + 20\ dB + noise\ margin}$$

It is recommended by the ISO-3382 standard to set 10 dB value for noise margin.

- If that condition is fulfilled, the sound pressure level values between points t_{20a} and t_{20b} are approximated with the straight line ($y = a \cdot x + b$) by the linear regression.

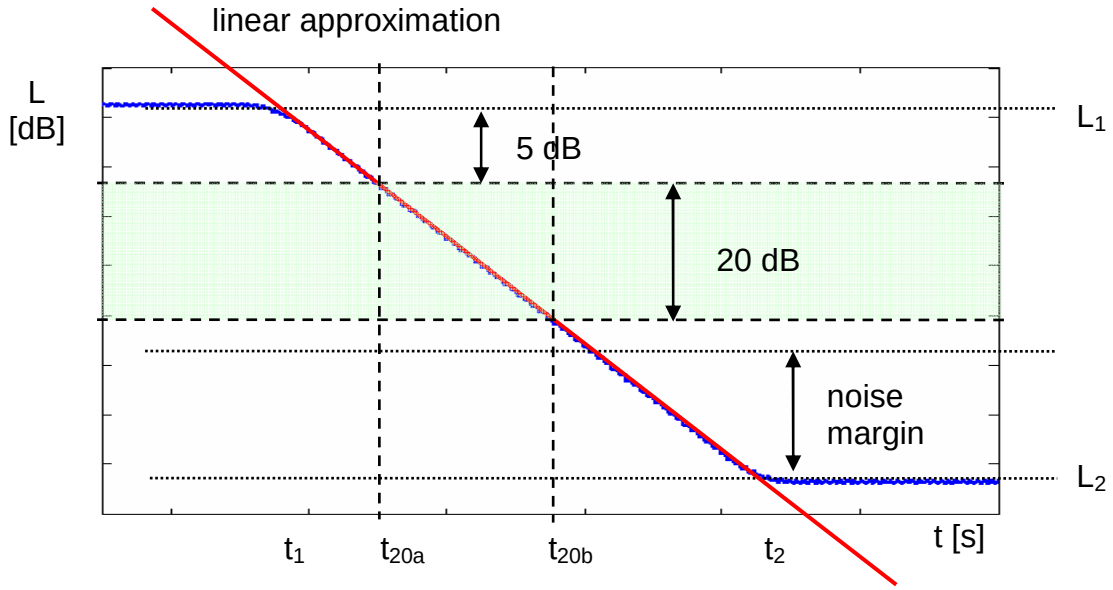

Fig 3. The T 20 evaluation

- Then the RT 60 value is calculated using the slope coefficient 'a' obtained from the linear approximation of the T 20 decay curve region, according to the formula:

$$\mathbf{T\ 20 = - a / 20}$$

$$\mathbf{RT\ 60 = 3 \cdot T\ 20}$$

➢ **T 30 (reverberation time calculated with 30 dB dynamics):**

- The T 30 decay curve region is pointed out by markers t_1 and t_2 (Fig. 4).
- It is checked whether the selected decay curve region has proper dynamics to the T 30 calculation:

$$\mathbf{L_1 - L_2 > 5 + 30\ dB + noise\ margin}$$

It is recommended by the ISO-3382 standard to set 10 dB value for noise margin.

- If above condition is fulfilled, the sound pressure level values between points t_{30a} and t_{30b} are approximated with the straight line ($y = a \cdot x + b$) by the linear regression.
- Then the RT 60 value is calculated using the slope coefficient parameter 'a' obtained from the linear approximation of the T 30 decay curve region, according to the formula

$$\mathbf{T\ 30 = - a / 30}$$

$$\mathbf{RT\ 60 = 2 \cdot T\ 30}$$

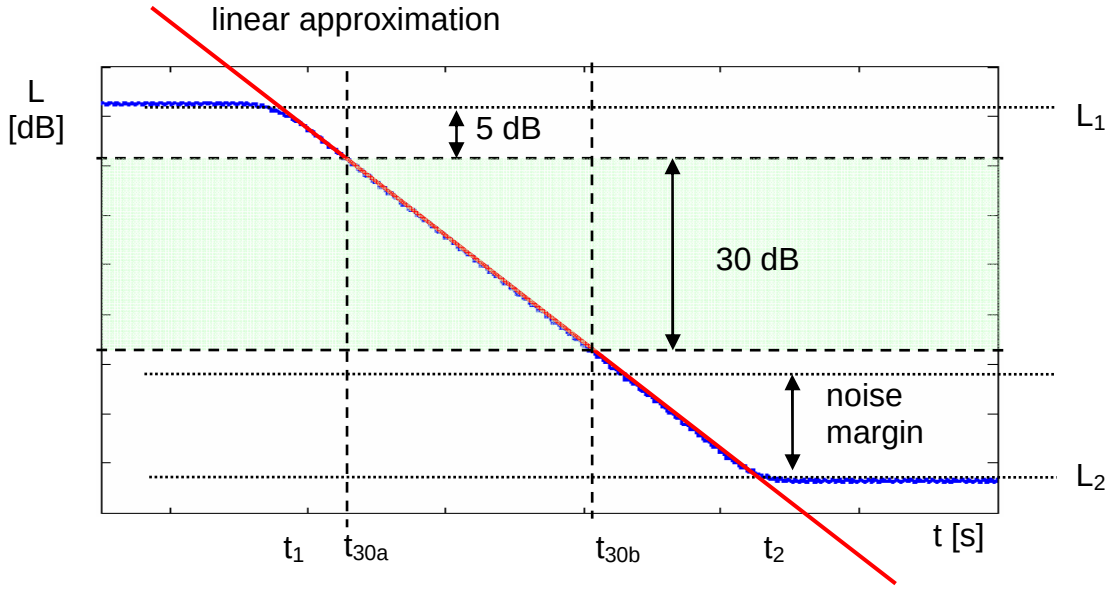

Fig 4. The T 30 evaluation

H.3. Description of the decay curve recording in different measurement methods

- **DECAY method**

This RT 60 measurement method requires omnidirectional sound source which emits pink noise in appropriate frequency band. The most critical parameter of the omnidirectional sound source is emitted sound pressure level as it was mentioned in the beginning of the appendix.

The graphical illustration of the data recording in this method is presented in Figure 5.

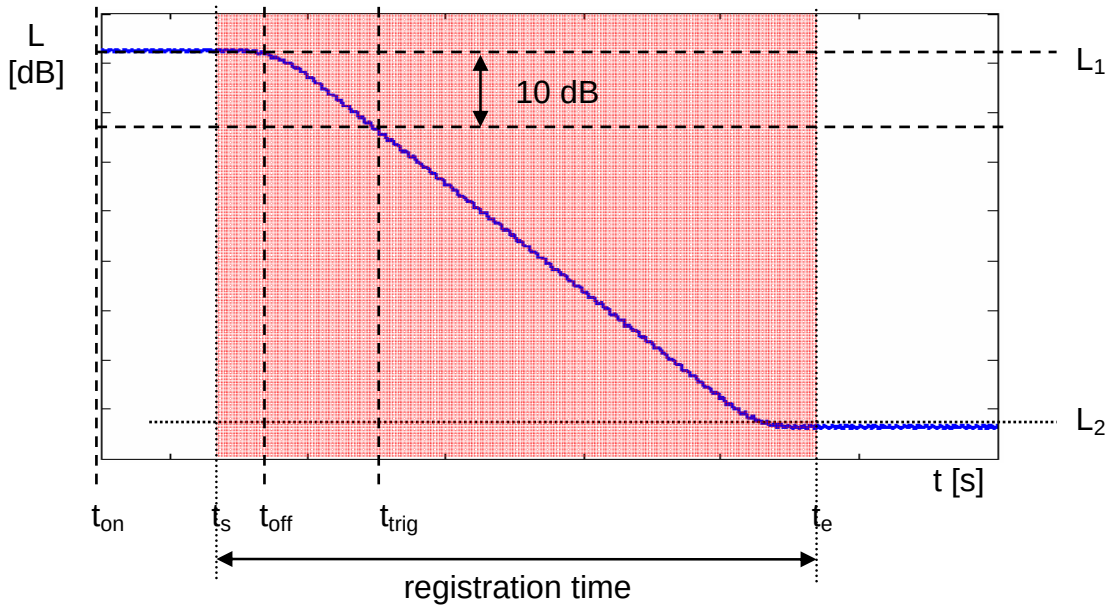

Fig 5. Data recording in the decay method of the reverberation time evaluation

The measurement time in this method consists of:

- The time between markers t_{on} and t_{off} in which the omnidirectional sound source emits acoustic power and the SVAN xxx analyser measures the actual sound pressure level.
- The time between markers t_{off} and t_{trig} in which the omnidirectional sound source is switched off and the SVAN xxx instrument waits for trigger condition fulfilment.
- The period of time between markers t_s and t_{trig} registered since the trigger condition fulfilment back till point t_s to allow recognising the beginning of the decay region. In the SVAN xxx instruments this period of time is equal to **TIME STEP** (*path: MENU/INPUT/MEASURE SETUP*) parameter value multiplied by 50.
- The time between markers t_{trig} and t_e registered since t_{trig} forward to record whole decay curve together with significantly long period of the noise level. This period of time in SVAN xxx instruments is adjusted by the **RESPONSE TIME** (*path: MENU/INPUT/MEASURE SETUP*) parameter.

The above graph shows that the proper setting of the **RESPONSE TIME** value is very important. The registration time has to be long enough to acquire sufficient number of background noise level values. In other case the decay curve region could not be properly analysed or decay region could not fulfil the dynamic condition mentioned above. It is recommended to set **RESPONSE TIME** parameter two times longer than expected reverberation time.

➢ **IMPULSE method**

This RT 60 measurement method requires impulse sound source like pistol, petard or other sound source which emits impulse signal with very high sound pressure level.

The graphical illustration of data registering in this method is presented in Figure 6.

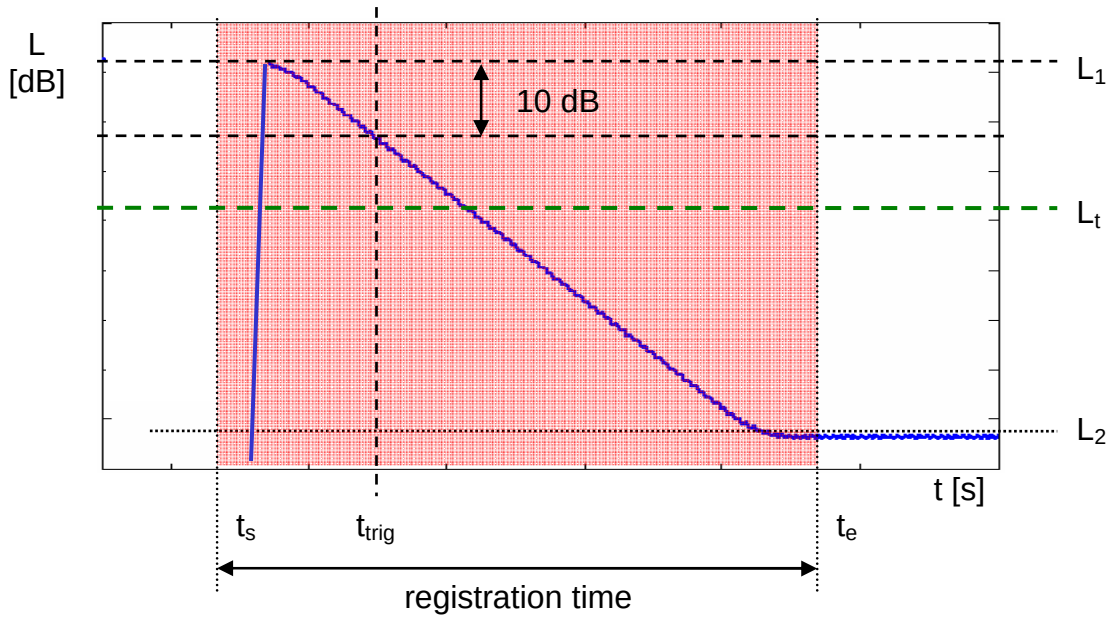

Fig 6. Data recording in the impulse method of the reverberation time evaluation

The measurement time in this method consists of:

- The time before marker t_{trig} in which the SVAN xxx analyser measures the actual sound pressure level and waits for the very high impulse sound pressure level which will fulfil the trigger condition. The trigger conditions will be fulfilled only when emitted impulse has maximal sound pressure level higher than L_t level (see Figure 6). The Lt level in SVAN xxx analyzer is adjusted by parameter **LEVEL** (*path: MENU/INPUT/TRIGGER SETUP*).

- The period of time between markers t_s and t_{trig} registered since the trigger condition fulfilment back till point t_s to allow recognising the beginning of the decay region. In the SVAN xxx instruments this period of time is equal to **TIME STEP** (*path: MENU/INPUT/MEASURE SETUP*) parameter value multiplied by 50.
- The time between markers t_{trig} and t_e registered since t_{trig} forward to record whole decay curve together with significantly long period of the noise level. This period of time in SVAN xxx instruments is adjusted by the **RESPONSE TIME** (*path: MENU/INPUT/MEASURE SETUP*) parameter.

The above graph shows that the proper setting of the **RESPONSE TIME** value is very important. The registration time has to be long enough to acquire sufficient number of background noise level values. In other case the decay curve region could not be properly analysed or decay region could not fulfil the dynamic condition mentioned above. It is recommended to set **RESPONSE TIME** parameter two times longer than expected reverberation time.