MŰEGYETEM 1782

Technical Acoustics and Noise Control

Measurement Report - Reverberation Room

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Introduction:

The propose of this measurement is to get acquainted with an FRF measuring technique and apply that technique to determine the efficiency of three noise protection covers.

So basically, we used three covers with different sizes and wall structures to silence a noise source. In order to have the perfect environment to do the measurement, we use a reverberation room. During this measurement we will compare the naked sound source with the covered one. The sound pressure spectrum with and without cover are going to be measured in the reverberation room.

When we create a reverberation room we have to exclude the external noise and vibration. The room is like a box made of reinforced concrete. To separate the box from the other part of the building there is an air gap around it. The box is placed on many steel springs where the natural frequency is approximately 3 Hz. The walls of the room are coated with hard, smooth, non-porous artificial resin paint. There are also two large globes hanged in the room in order to make the sound reflections irregular, what means that the sound after the birth will mix up with itself faster than without the globes. In a good reverberation room, the sound field has to be homogenous and the sound cannot have directionality.

To determine the sound power of a source we have to place it together with the microphone at any place. In order to get a sound pressure stable independently of the place and the direction of the sound source or the microphone we have to keep a safe distance from the walls and between the source and the microphone. After this, we can calculate the sound power of the source using the sound pressure.

After switching off the sound source in a room the sound pressure or the sound energy decays exponentially.

To get the best measurement results we have to use specific instrumentation such as power amplifier BK 2706, a small sound source (a loudspeaker with closed box), reverberation room, condenser microphone and preamplifier BK 4366 + BK 2619, a measuring amplifier BK 2636, a data acquisition board (+ PC via USB), an analog output NI 9263 4ch±10V 16bit 100kHz and an analog input NI 9239 4ch±10V 24bit sigma-delta.

Aim and procedure of the Measurement:

The aim of this measurement was to introduce ourselves to the various Acoustics measuring devices such as the Accelerometers, Calibrators and Loud Speaker configurations.

The Reverberation Room was a sound preserving room with uneven surfaces and round objects that could reflect the sound waves in order to increase disorder and unevenness of the sound waves which caused us to experience sound very loudly.

The Anechoic Room was the exact opposite. It was a room with basically No flat surfaces upon which sound could reflect its self! The walls were built by numerous “pyramid” like objects with unstable surface made from rockwool that absorbed almost all sound and reflected none back to us.

The Experiment:

For the experiment in the reverberating room we used the loud speaker and 3 different insulating boxes with different covers and sizes in order to determine which has the best noise insulation technique. Then, we switched off the loud speaker and we measured again in order to have a perfect insulation.

What we measured was basically the frequency of the sound waves from within the boxes which we then put through software to apply the so called “Frequency Response Function” between the loudspeaker excitation and the microphone signal. The FRF measurement is a “self-cleaning” process which tries to eliminate the disturbing noises.

The dimensions of the boxes that used to cover the microphone are shown below:

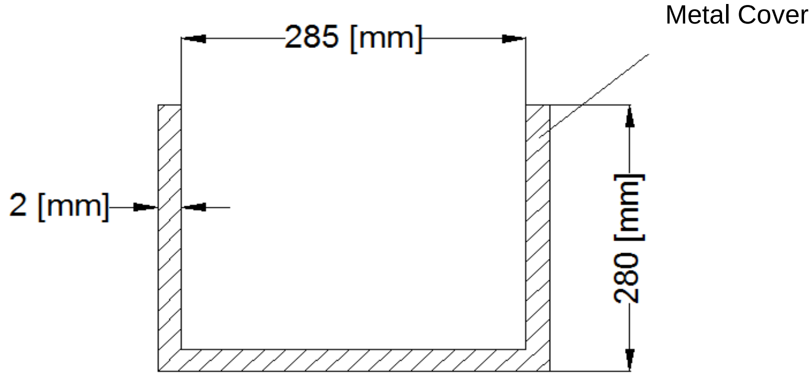


Figure 1: Box 1- Non-insulated, Steel

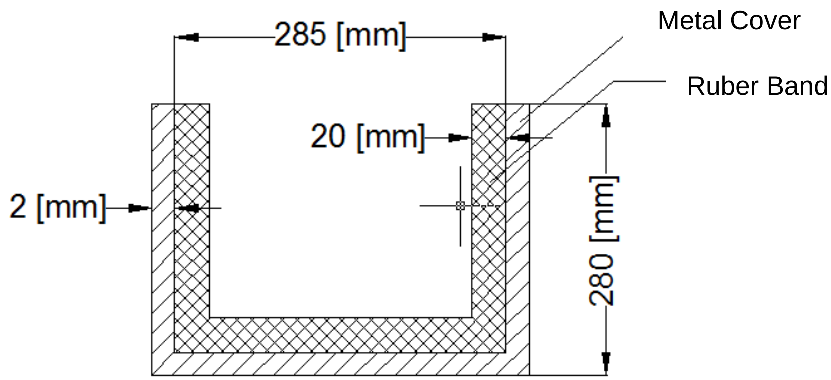


Figure 2: Box 2 - Semi-insulated: Just with

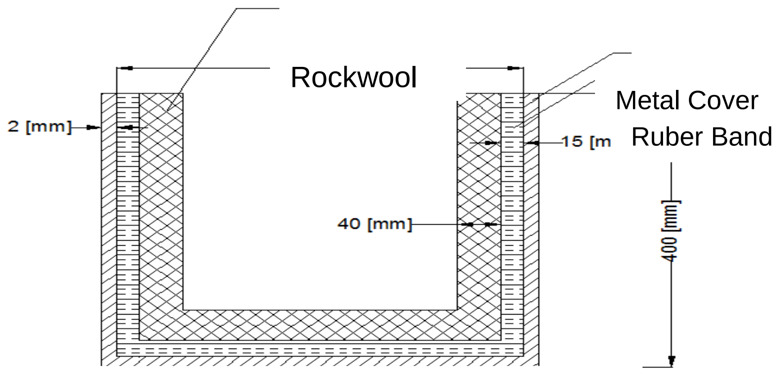


Figure 3: Box 3 - Fully Insulated – Rockwool +

The Data saved was the Frequency of the sound wave measured in Hertz at the Microphone and the logarithmic value of the Frequency Response Function measured in decibel.

For the result, we evaluate the boxes isolation efficiencies, taking in consideration the difference of the sound level, in respect with 1/3 Octave, for the sound with no isolation and with the boxes simulating an isolator. It is good to highlight that the graph represents the amount of the sound level that was absorbed by the isolation. It is also important do say that is not so relevant to analyze the value below 150Hz and Above 15000Hz due the quality of loudspeaker, but it was plotted anyway.

Measurement and results:

1 Without any isolation

The first analysis was measured without any box isolation to have an initial reference for the others measurement. And it is important to highlight that in this case the collected measurement data corresponds to a free sound exposure.

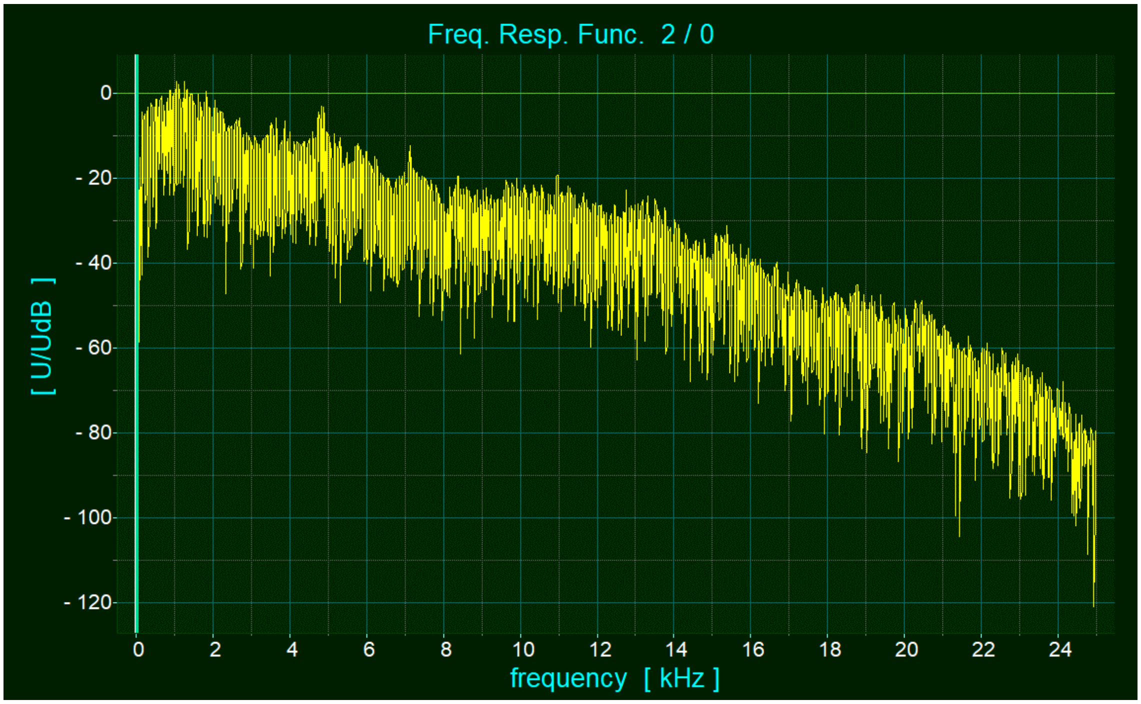


Figure 4: Sound level measurement – without any box.

Here we can see the sound wave in the reverberation room emitted by a loudspeaker. In this case the sound is not isolated by anything so we will take this graph as an example to compare with the others.

2 Simple Steel box

This analysis was taken in consideration the simple case of isolation, consisting in a simple steel box with the dimensions shown in a below table. With that measurement we can compare how a simple thin material is able to reduce the external sound from an inner sound source. A simple analogous example to this case can be an active loudspeaker inside a room and the reference listener outside the room.

Table 1: Dimensions box 1.

Height [mm]	Length [mm]	Depth [mm]	Thickness of steel [mm]
280	290	280	2

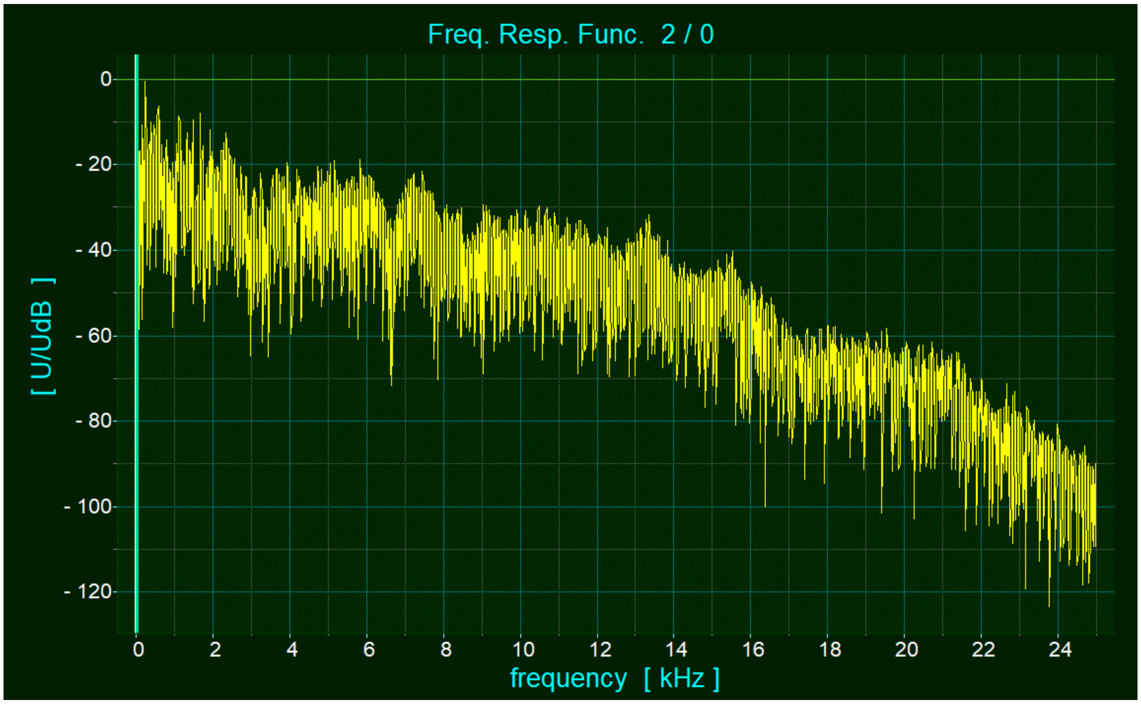
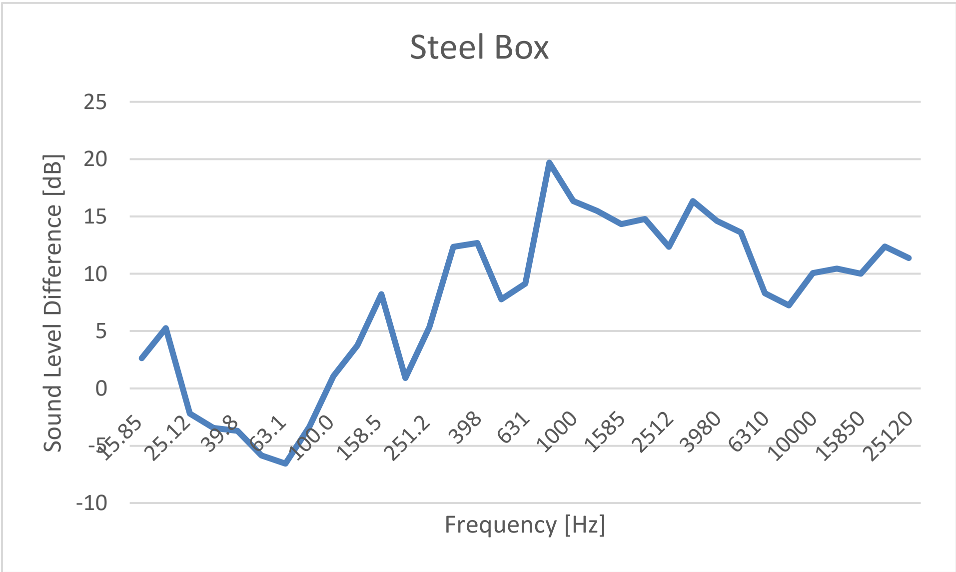


Figure 5: Sound level measurement – simple steel box



Graph 1: Sound level difference in dB.

It is possible to see a big difference with only a simple box made of steel for the perception of the frequency range between 750Hz to 6310Hz. This can be considered as low efficient isolation for mid frequencies sound.

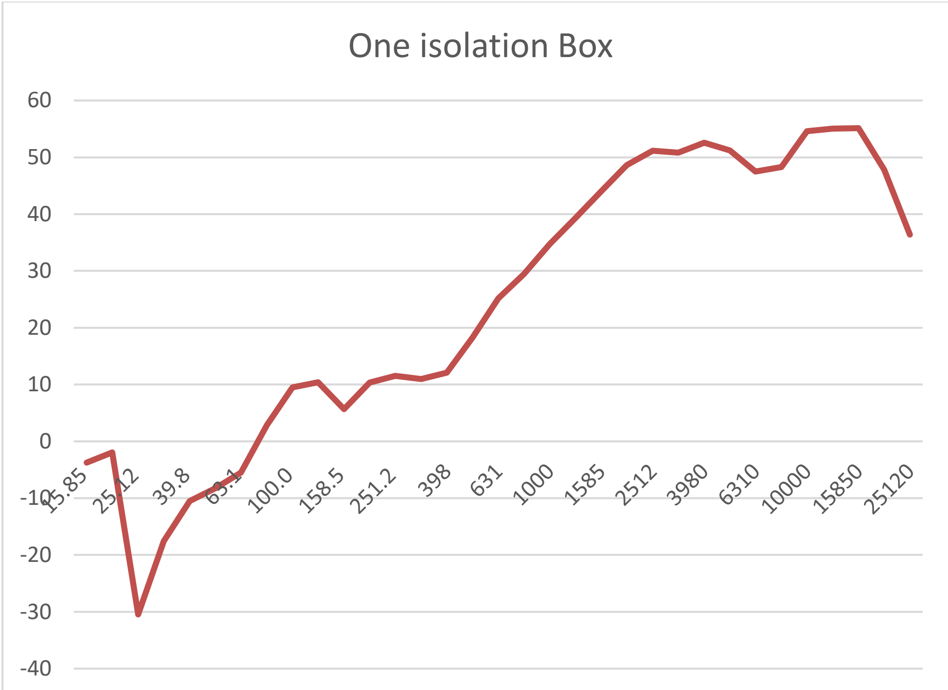
3 One isolation box

In this case, one single isolation layer was assembled inside the previous box case. The dimensions of the layer added and of the steel box can be seen in a table below. An analogous case can be demonstrated as a room with a sound isolation with an active loudspeaker inside the room and the observatory outside the room.

Table 2: Dimensions box 2

Height [mm]	Length [mm]	Deepth [mm]	Thickness of steel [mm]	Thicknes of the isolation [mm]
280	290	280	2	20

Figure 6: Sound level measurement – steel box with one layer or isolation.



Graph 2: Sound level difference in dB.

It is possible to see that with only one layer of isolation material the range of the frequencies of the sound that was isolated was much higher and the sound level difference is much higher. It can be characterized as a medium efficient isolation.

4 Double isolation box

In this case, one more isolation layer was assembled inside the previous box case, totalizing two layers of isolation and one layer of steel, the one that constitute the box. The dimensions of the layer and of the steel box can be seen in a table below. An analogous case can be demonstrated as a room with a double sound isolation with an active loudspeaker inside the room and the observatory outside the room. This case is applied usually when the material of isolation it is too thin or bad quality or even though when a better acoustic isolation is required.

Table 3: Dimensions box 3

Height [mm]	Length [mm]	Deepth [mm]	Thickness of steel [mm]	Thicknes of the isolation [mm]
280	290	280	2	55

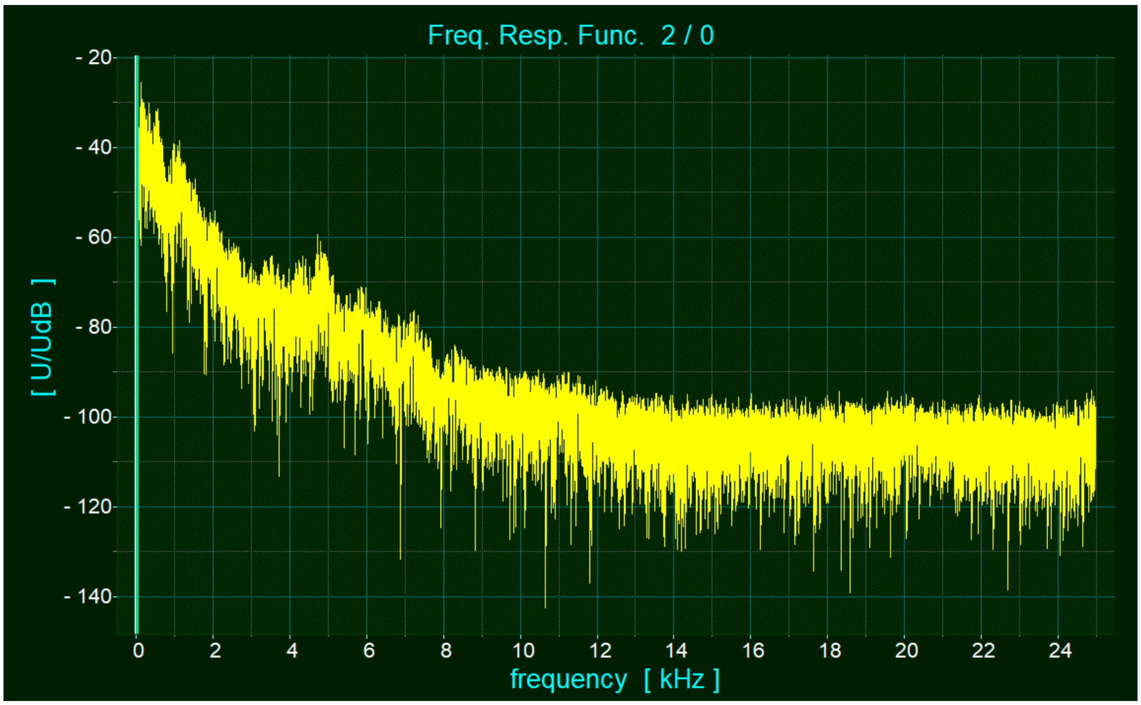
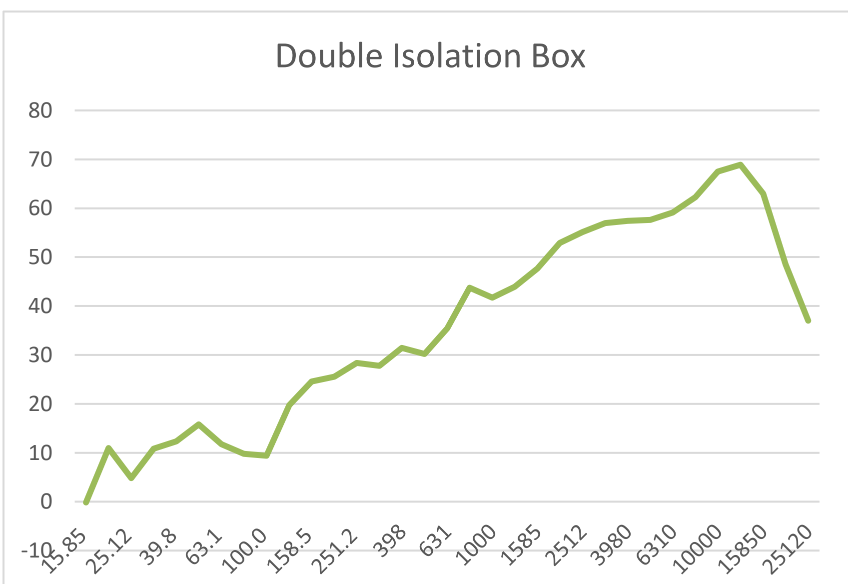


Figure 7: Sound level measurement – steel box with two layers of isolation



Graph 3: Sound level difference in dB.

With two layers of isolation material, the difference compared with the only steel box is tremendous. It was possible to reduce the sound level for more than 60dB, in the peak and for the general frequencies, between 600Hz and 10KHz, the sound was reduced by 40 or 50dB. This conjunct of the isolation materials and the steel box can characterize as a very efficient isolation.

5 Perfect isolation box

In this case the measurement taken place should be done by a perfect isolation box, this means that the box should filter all the sound provide by the loudspeaker and block all the frequencies from the interior to the exterior. As this is a very complicated procedure, it is possible to say that is almost impossible to create a box with the same dimension as the previous one with an enough amount of layer the can characterize a perfect acoustic isolation. To achieve a very good isolation, it is required a very thick wall made of various materials to absorb the most as possible plus a large wall made of brick and concrete with the intention to isolate more. But even this case is not the perfect one but can be represented as an ideal one in terms of sound isolation. A curiosity about the most silent room in the world is an Anechoic chamber, at Microsoft's headquarters in Redmon, Washington. The official world record for silence when the background noise level inside was measured at an ear-straining -20.6 dB.

So, in our case we applied the reverse engineer and made the assumption that a perfect isolation box will provide us the same result as if there is not any active sound source in the room, so the cable was unplugged from the sound device and the measurement was realized.

Figure 8: Sound level measurement – perfect box condition

Here we want to simulate the perfect isolation box, to do that we turned off the sound source and started the measurement. With the graph we can see a huge difference comparing with the Fig.1, the sound power is much lower since the beginning and the stabilization of the wave is occurring since 4[HZ].