LOW FREQUENCY SOUND INSULATION

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Session: BAG
Tbilisi, Georgia, Company AKUSTIKO
Speaker: Avtandil Avtua Kraveishvili

1 INTRODUCTION

I am Avtandil Avtua Kraveishvili, Co-founder and chief acoustic consultant in company AKUSTIKO, which is located in Tbilisi, the capital of Georgia. This paper describes case study of low frequency noise problem of one object, which is located in Tbilisi as well. Noise sources were 16 pieces of HVAC outdoor units on rooftop of dwelling building. The goal of this project was that Tbilisi City Hall Monitoring Service Agency declared that there is no violation of Outdoor Noise Law, but subjectively, residents were disturbed by noise during day and night.

In next chapters I will describe more details, how works monitoring of outdoor noise violations in Georgia, what kind of Government Regulation we have, what is difference in technology and knowledge between Government and Private sector in acoustic field and how I manage with that process.

2 NOISE SURVEY AND RISK OF MISTAKE

As I mentioned, noise sources were located on rooftop, and flats as noise receivers were located 1 floor below. When I received first call from City Hall Monitoring Service Agency and resident of that building, they explained that their acoustic analyzer does not shows any deviations from Noise Limit, but resident and even City Hall inspector confirmed that subjectively noise is really annoyance.

For your information: According to the Resolution #398 of the Government of Georgia, the limit of intrusive noise from outside in living spaces is 35 decibel during the day and 30 decibel during the night, with one remark: if noise source has tonal character, then these limits should be reduced by 5 dB.

Just for technical information: We have Acoustic Analyzator with Class 1 Microphone and with Class 1 Precision Calibrator. We don't have Vibration Meter, but we always have on hand glass of Georgian water. Please see our technical staff below on Picture #1:

So, we placed first acoustic measurement, measured background noise level in conditions when all HVAC Rooftop Units were turned off: We got LAeq 28.5 decibel (5 positions in receiver room).

After that we asked to turn on all Rooftop Units and made another measurement: We got LAeq 31.1 decibel (5 positions in receiver room). As you see, difference between conditions Turned Off and Turned ON is 2.6 decibel.

After that I interested to measure the noise source itself on roof, because I was afraid that noise source had tonal character. But no result, because of noise masking from street. Please see below Picture #1, where is shown how was installed all Rooftop Units on roof floor.

Picture #1 – Rooftop Installation before acoustic treatment:

Then I came back to flat and measured the noise in frequency range. Results showed us that problem is in so VERY low frequency, that can't be even covered by Government Law – Problem was at 31.5-40 Hz. Please see below figures #1, #2 and Table #1, which shows RTA results of Rooftop Units in Turned OFF and Turned ON conditions.

Figure #1 - RTA of Rooftop Units in turned on, 1/3 octave band

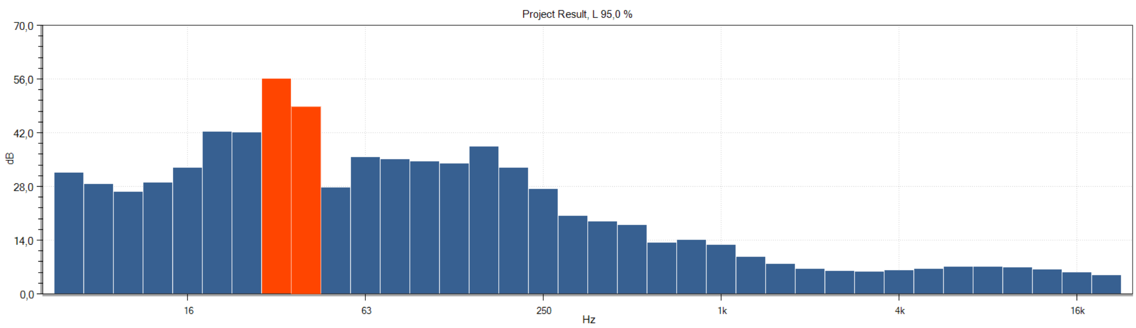


Figure #2 - RTA of Rooftop Units in turned off, 1/3 octave band

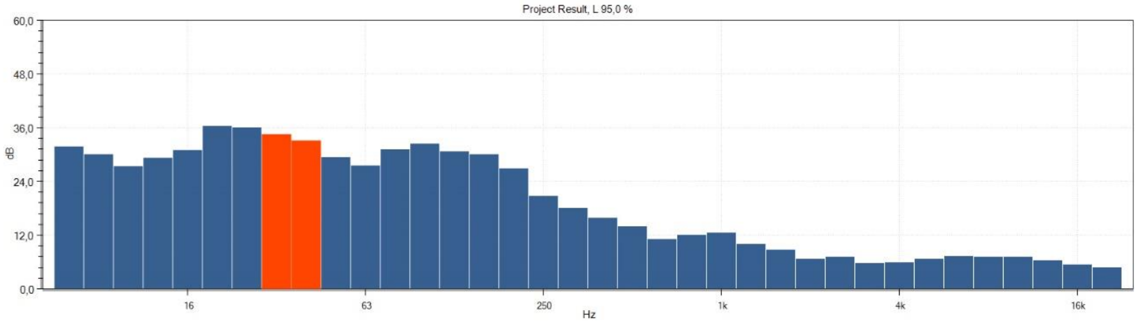


Table #1 – Level differences in Low Frequencies between Turned ON and Turned OFF conditions

Rooftop Units Condition / Levels at Low Frequencies	31.5 Hz	40 Hz
Rooftop Units Turned ON	56.2 dB	48.8 dB
Rooftop Units Turned OFF	34.6 dB	33.2 dB
Level Difference	21.6 dB	15.6 dB

We also measured dBC and dBA during Turned ON condition, and there is difference: dBA 31.1 dB – dBC 55.5 dB = **24.4 dB**

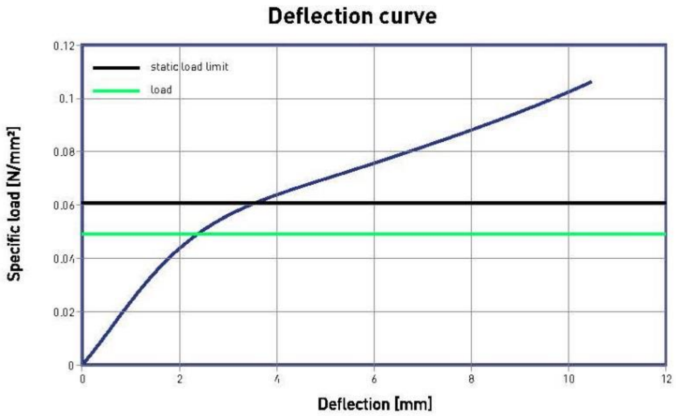
The question from customer about desired Sound Insulation Index is in Offside, because even DnTw+Ctr can't be relevant because of limit in frequency range (50 Hz). So, that's why decided to go through the Vibroacoustic calculations instead of Sound Insulation Calculations. I made it based on Weight distribution on each support point of Rooftop Units and researched exact PUR Elastomer with thickness of 50mm, but also, I raised up all Rooftop Units from Roof level to Metal Pedestal with 50 cm and then used Vibro Supports. Please see below Picture #2, where is shown Rooftop Units after acoustic treatment and on next page please see vibroacoustic calculation report #1 and #2, which is made in WEB based single calculator:

Report #1 – Vibroacoustic calculation for VRF Outdoor Unit #1

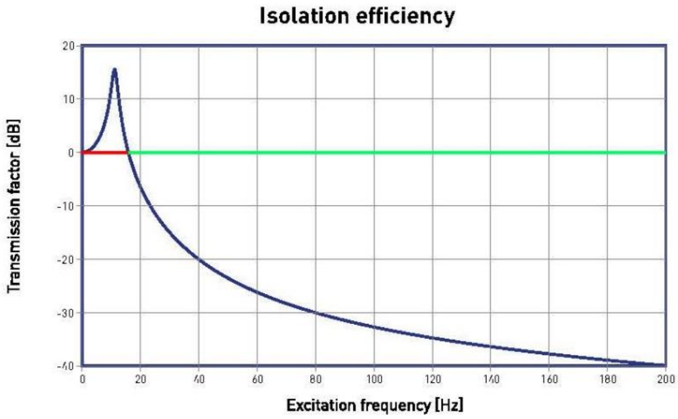
Shape	Rectangle
Length	300 mm
Width	300 mm
Thickness	50 mm
Area	90000 mm²
Form factor	1.50

Mass	450 kg
Load	0.049 N/mm²
Capacity	80.7 %
Deflection	2.37 mm

Natural frequency	11.2 Hz
Dyn. modulus of elasticity	1.245 N/mm²
Dyn. bedding modulus	0.025 N/mm³



Frequency	Isolation efficiency
4 Hz	1.2 dB / -15 %
5 Hz	1.9 dB / -25 %
6.3 Hz	3.3 dB / -46 %
8 Hz	6.0 dB / -100 %
10 Hz	12.0 dB / -299 %
11.2 Hz	15.5 dB / -497 %
12.5 Hz	10.3 dB / -228 %
16 Hz	-0.3 dB / 4 %
20 Hz	-6.5 dB / 53 %
25 Hz	-11.5 dB / 73 %
31.5 Hz	-15.9 dB / 84 %
40 Hz	-20.1 dB / 90 %
50 Hz	-23.6 dB / 93 %
63 Hz	-26.9 dB / 95 %
80 Hz	-30.1 dB / 97 %
100 Hz	-32.7 dB / 98 %
125 Hz	-35.2 dB / 98 %
160 Hz	-37.8 dB / 99 %
200 Hz	-40.0 dB / 99 %



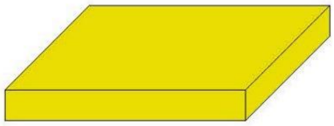
Comments: 4 vibro support, eash vibro support dimensions 150x150mm, total thickness for each vibro support 50mm

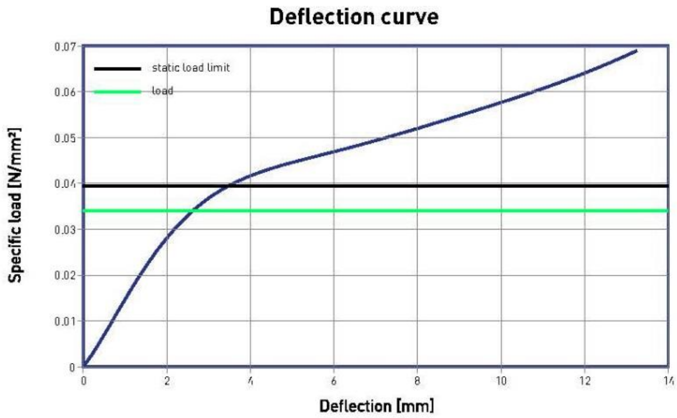
Report #2 – Vibroacoustic calculation for VRF Outdoor Unit #2

Shape	Rectangle
Length	400 mm
Width	400 mm
Thickness	50 mm
Area	160000 mm²
Form factor	2.00

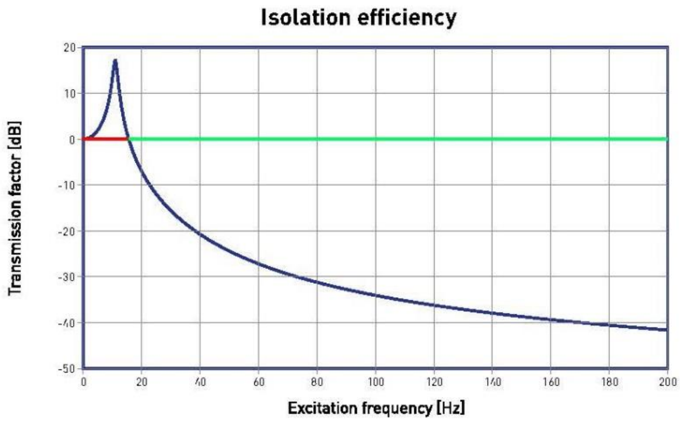
Mass	550 kg
Load	0.034 N/mm²
Capacity	86.3 %
Deflection	2.62 mm

Natural frequency	11 Hz
Dyn. modulus of elasticity	0.826 N/mm²
Dyn. bedding modulus	0.017 N/mm³





Frequency	Isolation efficiency
4 Hz	1.2 dB / -15 %
5 Hz	2.0 dB / -26 %
6.3 Hz	3.4 dB / -48 %
8 Hz	6.4 dB / -109 %
10 Hz	13.4 dB / -368 %
11 Hz	17.2 dB / -621 %
12.5 Hz	9.7 dB / -205 %
16 Hz	-0.9 dB / 10 %
20 Hz	-7.0 dB / 56 %
25 Hz	-12.0 dB / 75 %
31.5 Hz	-16.5 dB / 85 %
40 Hz	-20.8 dB / 91 %
50 Hz	-24.4 dB / 94 %
63 Hz	-27.9 dB / 96 %
80 Hz	-31.2 dB / 97 %
100 Hz	-34.1 dB / 98 %
125 Hz	-36.7 dB / 99 %
160 Hz	-39.4 dB / 99 %
200 Hz	-41.6 dB / 99 %



Comments: 4 vibro support, eash vibro support dimensions 200x200mm, total thickness for each vibro support 50mm

As you saw above on vibroacoustic calculation reports, we used two type of vibro support and it is because of difference in Outdoor Unit dimensions and weight:

Type A: vibro support with dimensions 150x150mm, thickness 50mm
Type B: vibro support with dimensions 200x200mm, thickness 50mm

Effectiveness of the vibro support starts from 20 Hz for both types. At our desired frequencies results are given in Table #2:

Table #2 – Acoustic results (calculated) on desired frequencies using vibro support

Vibro Support Type	31.5 Hz	40.0 Hz
Type A	-15.9 dB	-20.1 dB
Type B	-16.5 dB	-20.8 dB

Unfortunately, because of COVID-19 restrictions and residents prudence and fear, they did not gave me the chance to measure it again to record results. But, our measure unit were residents itself, they said that can't detect when Rooftops are Turned On or Turned Off. So, it means that we received good results.

3 SUMMARY

That kind of cases gives me more and more chance and area to talk with Government bodies for future upgrade in Georgian Law for noise monitoring and limitation, to minimize biggest negative difference between Government and Private sector possibilities and knowledge in acoustics. Below is given several topics on that direction:

1. Upgrade of acoustic analyzers (change for new one) for several Government Bodies which are responsible for noise monitoring. Reason is to measure the noise level in frequency range, not only in dBA.
2. Changes in Noise Monitoring Guidelines - measuring not only dBA, but also in dBC to detect if there is potential low frequency problem. If the difference between dBC and dBA is at least 20 dB (I wish to upgrade it to 15 decibel difference, because LFN is very sensitive problem), necessary call obligation to acousticians for next acoustic analyze and treatment works.
3. Planning some basic training courses for Government employees who are involved for noise monitoring.
4. Increasing awareness in acoustics, outdoor noise and Low Frequency Noise.

4 REFERENCES

1. DIN 45680-1997 Measurement And Evaluation Of Low-Frequency Environmental Noise.
2. N. Broner. A Simple Criterion for Low Frequency Noise Emission Assessment. JOURNAL OF LOW FREQUENCY NOISE, VIBRATION AND ACTIVE CONTROL, VOLUME 29 NUMBER 1 2010
3. Ian Rushforth, Andy Moorhouse, Peter Styles. A Case Study of Low Frequency Noise Assessed using DIN 45680 Criteria. SAGE journals, Published December 1, 2002.