ROOFTOP NOISE IMPACT INVESTIGATION TO THE COMMUNITY

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1 Introduction

Based on an investigation of rooftop equipment noise, the methodology described in this paper was developed to isolate the noise contribution from a subset of noise sources from a set of noise sources (including urban hum) that contribute to the sound pressure level at a given community receptor location. Results comparing the projected noise impact from the rooftop equipment to community measurements based on this method are presented.

2 Methodology

The following parameters are considered in developing the methodology:

1. The modeled partial sound pressure level contribution for each source; and
2. The measured sound pressure levels at Reference Receptor locations that surround the sources of interest.

The term “Reference Receptor” refers to the noise monitor location that captures specific sources of interest. Typically, multiple reference receptors are used to surround the area of interest, and are located between the sources and community receptor but comparatively closer to the sources, such that the reference receptor is not influenced by extraneous noise such as urban hum.

Figure 1 presents a graphic overview of this method in terms of the main relationships between sources, reference receptors and community receptors.

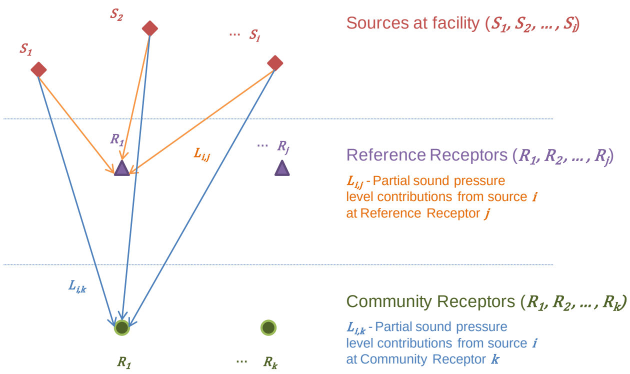

Figure 1: Relationship between Sources, Reference Receptors and Community Receptors

In terms of the method the attenuation that occurs during propagation is considered constant. It is not dependent on the source sound power level, but is related on factors such as a) source-receptor geometry including heights and elevations; b) attenuation due to geometrical divergence; c) screening effects of the building and surrounding topography; d) attenuation due to atmospheric absorption; e) attenuation due to ground effects; and f) meteorological correction factors favourable for propagation from the sound source to the receptors. This means that any increase or decrease of the source sound power level will have a direct and proportional effect on the reference and community receptor partial sound pressure level. This is better illustrated in Figure 2, where a single source, multiple reference receptor and single community receptor is presented.

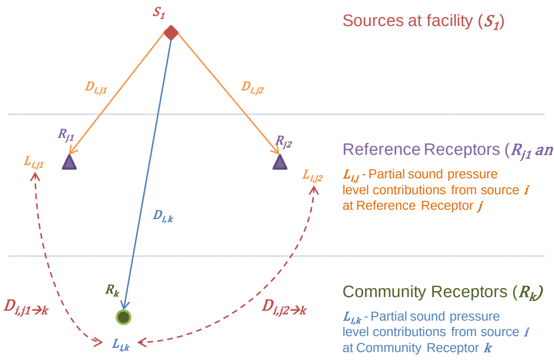

Figure 2: Single Source Overview of Relationship between Partial Sound Pressure Contribution, Source Sound Power and Attenuation Factor

Acoustic modeling provides the partial sound pressure level contribution from each source at community and reference receptor locations, and provides the relative contribution from each source at a given reference receptor location j. Assuming that the urban hum contribution at the reference receptor location is insignificant, any variations of the sound pressure level at the reference locations is then dependant only on variations of the sound power level of the sources contribution to the reference receptor. The approach taken here assumes the following:

a) All the sources identified from the facility that are captured by the reference receptor are continuously operating; and

b) The background noise levels due to urban hum at the reference receptor location are negligible.

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The following equation can be written when noise level contributions are considered in terms of sound pressure in Pa (instead of sound pressure level in dB):

$$\frac{p_{i,j}^{2}{}'}{p_0^2} = \langle p'_{i,j} \rangle = 10^{\frac{L'_{i,j}}{10}} \textbf{ [1]}$$

And the total sound pressure level at reference monitor location *j* becomes:

$$\langle p'_j \rangle = 10^{\frac{L'_j}{10}} = \sum_{i=1}^{\#Sources} \langle p'_{i,j} \rangle \textbf{ [2]}$$

From partial $\langle p'_{i,j} \rangle$ and the total $\langle p'_j \rangle$ sound pressure, apparent weighting for each partial sound pressure to the total sound pressure can be determined from the formula:

$$X'_{i,j} = \frac{\langle p'_{i,j} \rangle}{\langle p'_j \rangle} \textbf{ [3]}$$

The following is assumed in developing this methodology:

1. The apparent weighting factors (Equation 3) from the model are transferable to the measured values at the Reference Receptor Locations.

2. The method provides long term average sound levels. As such any differences between measured total sound pressure levels at the Reference Receptor Location *j* (L_j) and modeled total sound pressure levels at the Reference Receptor Location *j* (L'_j) can be attributed only to the sources. Since all the sources are considered to be continuously operating, the difference in sound pressure level is distributed according to the apparent weighting.

For each source *i* under consideration and based on the assumptions above, multiple partial sound pressure level contributions $L_{i,j\to k}$, based on different Reference Receptor Location *j*, should provide similar values of $L_{i,j\to k}$.

In reality, different sources of error in both measurements and varying background sound pressure level may lead to slightly different partial sound pressure level contribution $L_{i,j\to k}$ than provided in the acoustic modeling. Multiple sound pressure level contributions from various Reference Receptor Locations $L_{i,j\to k}$ are logarithmically averaged for each source to adjust for this.

$$\overline{L_{i,k}} = 10 \times \log_{10}\left(\frac{1}{\#j} \times \sum_{j=1}^{\#j} 10^{\frac{L_{i,j\to k}}{10}}\right) \textbf{ [4]}$$

From the individual average source contributions $\overline{L_{i,k}}$ the total sound pressure level at Community Receptor Location *k*, can be determined by adding the individual source sound pressure level contributions at the receptor.

$$L_k = 10 \times \log_{10}\left(\sum_{i=1}^{\#S} 10^{\frac{\overline{L_{i,k}}}{10}}\right) \textbf{ [5]}$$

3 Results

Rooftop equipment on a facility was surrounded with four noise monitors, and compared to measurements at three community locations. To determine rooftop noise contribution to the community monitor locations, the measured rooftop noise levels were projected using the methodology described above to the community monitor locations on a 1-sec Leq basis. A sample one hour comparison is shown in Figure 3.

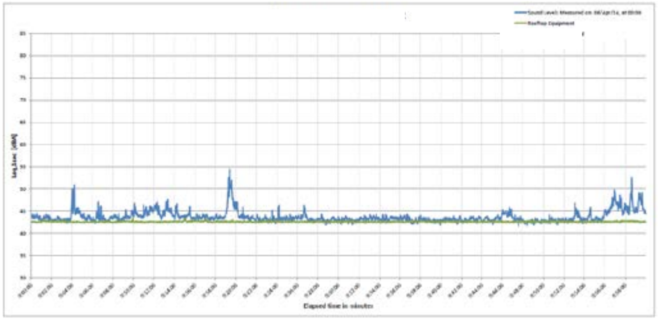

Figure 3: Rooftop Equipment Projected Noise Levels at the community vs Community Measured Noise Levels

Comparison over the long term monitoring at the community locations showed a good correlation to the community measurements. In this case, rooftop noise was typically steady state, and did not contribute to peak noise levels at the community as confirmed by audio recordings.

4 Conclusion

By comparing projected noise and measured community noise, the following conclusions were drawn: 1) rooftop noise is within acceptable noise guidelines, 2) peak sound levels experienced in the community were not contributed by the rooftop equipment, and 3) the rooftop equipment is a contributing factor to the ambient noise in the community.

This methodology was developed to project facility noise to the community and isolating it from urban hum. The methodology outlined in this paper allows for the reference monitoring around a set of noise sources, and projecting the noise levels from these reference monitors.

References

[1] ISO 9613-1 Acoustics – Attenuation of sound during propagation outdoors – Part 1 Calculation of the absorption of sound by the atmosphere. *International Organization for Standardization*.1993

[2] ISO 9613-2 Acoustics - Attenuation of sound during propagation outdoors – Part 2 General method of calculation. *International Organization for Standardization*.1996