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PREDICTION AND DESIGN OF NOISE BARRIERS FOR STATIONARY NOISE SOURCES

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Abstract

Last years noise barriers find wider application to reduce noise emitted by outside stationary equipment, for instance by ventilation equipment, chillers, compressors and other types of energy installations. New theoretical approach is elaborated to predict noise reduction level provided by noise barriers. Developed method takes into account shape of the barrier, its geometrical size, acoustical properties and features of barrier location around the noise source. Barrier design criteria and practical issues are discussed. Efficiency of barriers installed outside around ventilation equipment and compressors obtained from experimental study is in the range 7-15 dBA for a set of specified receivers. Features and principals of noise barriers prediction and design are considered in the paper.

INTRODUCTION

Excessive noise emissions were found at a large plant manufacturing construction materials. Nearby community is located in close vicinity to the plant (Fig. 1). In order to select noise mitigation strategies noise sources identification was carried out. Parameters and exploitation features of each noise source were studied. Equipment of plant divisions such as furnaces, cooling towers, compressors, electric motors and drives, ventilators and others causes significant disturbance in nearby residential areas. A-weighted sound pressure levels measured in urban areas were in the range 60-64 dBA while permissible A-weighted sound pressure level for day time is 55 dBA.

ANALYSIS

Taking into account planned increase of power stations and installation of additional equipment sets at the plant territory complex noise reduction measures were required. Prediction of expected noise levels emitted by additional equipment being operated together with already used apparatus was done (for point noise sources) using the following equation:

$$L = L_w - 20\lg r + 10\lg \Phi - \frac{\beta_a r}{1000} \qquad (1)$$

where

L_w is the A-weighted sound power level, dBA,

r is the distance from the acoustical center of the noise source to the specified receiver, m,

Φ is the noise source directivity factor,

β_a is sound attenuation in the atmosphere, dB/km, equal 6 dBA per each 1000 m, β_a is neglected for distances $r \leq 50$ m.

a) *b)*

Fig. 1. Location of nearby community (a) and noise sources (b)

Total sound pressure level emitted by several noise sources (dBA) is estimated as follows:

$$L_{\Sigma A} = 10\lg \sum_{i=1}^{n} 10^{0.1 L_{A_{eq_i}}} \qquad (2)$$

where

$L_{A_{eq_i}}$ is A-weighted sound pressure level in receiver position, dBA, emitted by a particular sound source.

Acoustical characteristics of noise sources (Fig. 2) were measured in the near sound field. Results of noise sources characteristics measurements are presented in Table 1. Estimation of expected sound pressure levels in community was carried out using Eq. (1-2). As follows from prediction reduction of noise levels in urban areas is in the range from 9-18 dBA.

Results of measurements of noise emitted by ventilators and compressors at 1 meter distance from a source

Table 1

Noise source	Sound pressure levels, dB, octave frequency bands, Hz									dBA
	31,5	63	125	250	500	1000	2000	4000	8000	
vent #1	85,7	88,1	90,3	86,4	87,5	86,0	80,6	80,4	75,9	90,2
vent #2	82,1	92,3	89,5	87,0	91,0	87,0	81,8	80,8	76,0	91,9
compr #1	113,6	95,3	84,9	85,1	82,9	81,3	81,7	81,3	81,2	88,8
compr #2	114,5	96,0	86,1	82,7	77,6	72,4	69,7	68,2	61,8	80,5
compr #3	115,1	100,9	86,0	87,8	76,8	73,2	72,6	71,0	64,2	82,6

(a) *(b)*

Figure 2. Ventilators (a) for a plant division an filters and compressors (b) at the compressor station

Noise barriers are recommended for noise reduction [1, 2]. Efficiency of noise barriers was estimated using elaborated equation [2] as follows:

$$\Delta L_b = \frac{2\pi h_b r^2}{R^2(5-\alpha_{gr}-\alpha_s-2\alpha_b)\lambda(1-\alpha_b)\beta_b arctg\frac{l_b}{2R}}, \quad \text{dB}, \quad (3)$$

where

r is the distance between the barrier and specified receiver, m,

R is the distance from the noise source to the barrier, m,
λ is the wave length, m,
α_b is the barrier sound absorption coefficient,
α_{gr} is the underneath ground sound absorption coefficient,
α_s is the nearby surfaces sound absorption coefficient,
h_b is the barrier height, m,
l_b is the barrier length, m,
β_b is the diffraction coefficient.

Developed method takes into account barrier geometrical size, its shape, acoustical properties and features of surfaces located around the barrier.

Predicted efficiency of 6m height barriers to be installed around the plant is in the range 7-15 dBA for a set of specified receivers. Additional noise mitigation measures for each significant noise source are considered taking into account that required noise reduction level for some receiver positions is higher than efficiency of a barrier located around the plant. П-shaped noise barrier (4 m height) is recommended for noise reduction of two ventilators presented in Fig. 2a. Separate noise wall (6 m height) is recommended for noise reduction of a compressor station shown in Fig. 2b. Sound absorption lining and mufflers are recommended for ventilation ducts. Sound-proofed enclosures are recommended for small installations.

CONCLUSION

Noise reduction measures for a plant manufacturing construction materials are considered. Efficiency of barriers is predicted using elaborated analytical method. Geometrical size and design features of noise barriers are recommended.

REFERENCES

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