THE INEXPENSIVE NOISE CONTROL METHOD – A CASE STUDY

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1. INTRODUCTION

Stack exhausts are one of the worst radiators of noise levels from major industrial sites, due to their height as well as the loss of directivity corrections due to the large propagation distances. In addition, oven stacks from major process operations suffer from strong load variations such as temperature and flow changes. The complexity of the stack noise generation and its attenuation is discussed through one atypical example. The stack under investigation is located downstream of a pollution control systems used to control the effluent from four ovens of a major industrial facility. Unlike typical exhausts that produce steady sound levels around its azimuth, strong variations were identified. Implementing a typical stack silencer would not have guaranteed noise attenuation success. The details of this case study and the inexpensive modifications are presented in this paper.

2. SITE DESCRIPTION

Most major industrial plants such as paper and pulp mills, process plants, auto manufacturers, auto-parts manufacturers, and chemical plants have large exhaust stacks on their roof. They contain mostly fans that are used to exhaust effluents at large heights above the plant roof. Most of these stacks generate (mostly fans) broadband hum. If the adjacent sensitive receptors are more than 300 m or more away from the plant, the resulting noise levels are insignificant. However, there are exceptions to the general separation guideline applied in many locations. In Ontario, as contained in the Municipal Act, the separation distance between major industrial sites and residential receptors is of the order of 300 m.

The plant under study is a large industrial facility with a myriad of exhaust stacks on its roof. New paint facilities were added near one corner of the plant. Residential receptors were at a distance of about 300 from the plant. The present study was instituted as part of the audit noise measurements requested by the regulatory agencies. The plant layout is shown in Figure 1. The line of stacks is shown in Figure 2.

Four of the exhaust stacks from the new facility were connected to a pollution control system. The output from the pollution control system was exhausted through a single stack. The stack, around 110 cm in diameter was 10 m above the top roof of the new extension. The audit measurement program indicated the major concern is the noise output from the single stack. The details of the measurement program and the resulting analysis are described below.

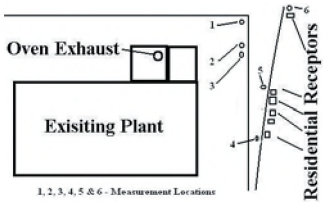

Figure 1. General Layout of the Plant and the Oven Exhaust.

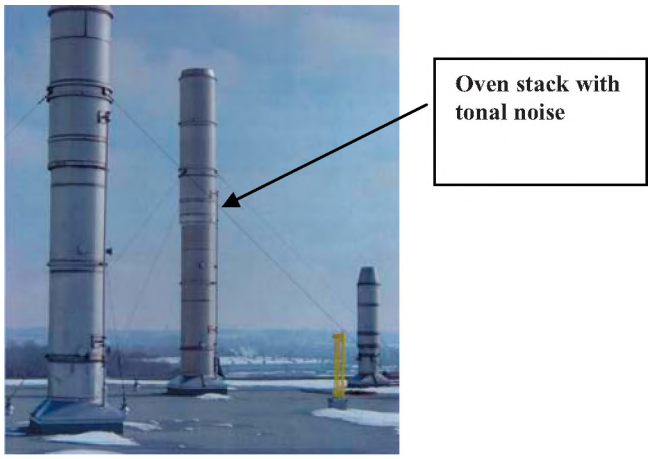

Figure 2. General Layout of the Plant and the Oven Exhaust.

3. PLANT NOISE AND MITIGATION

The new extension had to satisfy the noise emission limits. Since the plant is located in an urban setting, the ambient noise is set by local traffic and any other industry. As per the Provincial guidelines the noise limit to be satisfied by the extension is 45 dBA or the combined noise from the ambient road traffic and the existing plant, which ever is higher. In addition, if the source has any special characteristics such as a tone, a penalty of 5 dB must be added to the source level, before evaluating the noise impact. These levels are expressed as

one-hour energy averaged sound level, L_{eq}, in dBA. The existing ambient levels were evaluated through measurements. The lowest noise level was measured to be 48 dBA.

The plant, as part of its approval conditions, had to perform audit noise measurements of the extension. During the measurement program, a strong tonal noise was noticed. Narrow band analysis showed that the tone was centred at 266.5 Hz. The noise signature exhibited strong variation, both temporally and spatially. The measured noise levels are summarized in Table 1 below. The offending tone was barely audible at Location 5 (Figure 1 and Table 1).

Location	Before		After	
	250 Hz Band	dBA	250 Hz Band	dBA
1	42/64	49/59	44	48
2	62/70	57/63	57	55
3	57/50	56/49	57	54
4	-	-	48	49*
5	44/43	50/51*	45	48*
6	-	-	47	50*

*** - Dominant Noise - Road Traffic.**

Table 1. Summary of Measured Noise Levels.

Measurements were also conducted close to the sources of the new extension on two roof levels. The spectra of the rood top measurements are shown in Figure 3 below. These measurements indicated the exhaust stack of the pollution control system generated the offending tonal noise. Table 1 and Figure 3 shown results conducted at a number of locations as well as at different time periods. The 'before' measurements show the results, before any modifications to the stack were implemented. The results indicate strong variations of the order of 20 dB of the 266.5 Hz tone. The spatial variations can be seen from Figure 3 and Table 1.

The temporal variations can be seen from the results at Locations 1, 2 and 3 (Table 1). The residential receptor noise level, including the tonal penalty, was estimated as 57 dBA at the 2nd Storey bedroom window. The noise impact was of the order of 9 dB. A simple solution would have been to install a circular silencer with a minimum insertion loss of 10 dB in the 250 Hz band. However, due to the strong spatial and temporal variations, the successful performance of the silencer was in doubt. Any mitigation measure can be useful, only after the reasons for the variations can be established. Closer inspection of the stack revealed that the top 3 m of the pipe was slightly larger than the bottom 7 m pipe, thus creating a short annulus. The above prevents any condensed fluid from trickling back to the fan. The annulus creates an entrained flow, which provides tuning of the 266.5 Hz tone of the fan. The plant decided to close the annulus. The modification is described as well as highlighted in Figure 4. The results are shown as 'After' in Table 1 and Figure 3. The strong reduction of the tone level, between 8 and 10 dB, can be seen from Figure 3.

Finally, the residential noise levels showed the plant was within 1- 2 dB of the guideline limits.

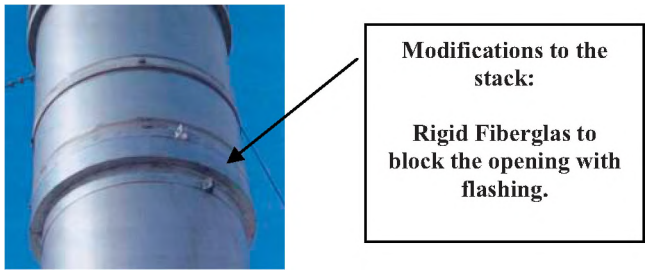

Figure 4. General Layout of the Plant and the Oven Exhaust.

REFERENCES

Model Municipal Noise Control By-Law, Ministry of the Environment, Ontario, Canada, 1978.

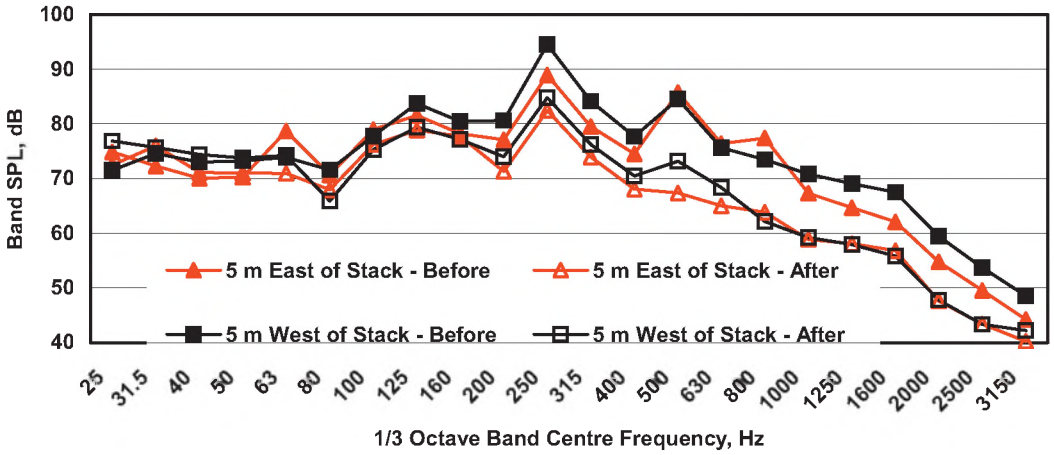

Figure 3. Noise Spectra of the stack exhaust, on the rooftop.