Collaborative Noise Control – A Case Study

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1.0 INTRODUCTION

Acoustic and noise control consulting covers a wide spectrum of potential projects. The noise control engineer is expected to provide the complete package of services in noise control from analysis, design and actual implementation even though some aspects may be outside his/hers area of specialty. One such instance will be explored and described through the following case study.

2.0 SITE DESCRIPTION

Dust collector fans are ubiquitous in any process industries that emit reasonably sized particulates into the atmosphere. These fans, usually centrifugal in designs, come in various sizes and specifications. A schematic detail of one such design in a cement plant in Northern USA is shown in Figure 1. The design is an ID fan, centrifugal, located downstream of the large dust-collection system. The fan's specifications are: 44,000 CFM, 1800 RPM, 250 HP, Pressure rise of 26" H_2O. The outlet is a 38" diameter circular pipe and the exhaust stream temperature is 200° F. The fan produces a strong blade passing tone (around 296 Hz), which is further amplified by the constricted outlet design of the ID fan. The amplified tone of the fan is clearly audible at residences located, approximately, a kilometre away, depending on the wind directions. The residents lodged strong complaints and the local municipality issued orders to the industry to remove the offending noise.

The ID fan noise was measured at four locations, three (Locations A, B and C) in the plant and the fourth locations was in the yard of one of the residents. The plant measurement locations are identified in Figure 1. The results of the measurements are shown in Figures 2 and 3. The data shows that the noise is highly tonal and is purely from the outlet duct. Location C level in the 315 Hz band is 103 dB and is at least 20 dB more than the 315 Hz band levels for the other two locations. The narrowband spectrum of Figure 3 shows that the tone is clearly audible at the residential receptors.

The plant installed a short lined expansion as a possible passive silencer, also shown in Figure 1. The measure provided no noise attenuation. A simple solution would have been to install bullet silencer to provide a noise reduction of about 15-20 dB in the 315 Hz band. However, the fan did not have any headroom for the pressure drop of the silencer. Instead, the plant would have to redesign the fan without the noise concerns. However, the new fan design was not practical due to the large lead time, in excess of a year or so, required for the implementation of the new design.

Another possible solution was to install active noise control. However, one of the manufacturer of HVAC active noise control systems was unable to provide a suitable solution for the following reasons: the offending source produces a higher order duct mode (the cut-off frequency of the second mode inside the 38" diameter outlet duct at 200° F was less than 250 Hz); and the temperature of 200° is too high for the active noise control system components. Even though the first author has a strong theoretical understanding of active noise control, he has no actual design experience. Further, we were convinced an active noise control system can be suitably designed. Hence, we approached our colleagues in the consulting field with design expertise and requested their assistance. The resulting collaboration resulted in resolving the noise concerns of the ID fan. The details of the active noise control system implementation are described below.

3.0 ACTIVE NOISE CONTROL

The noise control objective was a substantial reduction of the fan blade passage tone. The nominal frequency of 300 Hz as well as the duct diameter put this at the upper limit of the capabilities of an active noise control system. In order to assure a high degree of stability a conventional dissipative silencer was interposed between the sensing microphone and the noise cancelling loudspeakers. In this manner the controller can be configured to operate in a 'feed-forward' mode wherein the signal to be controlled is measured by the sensing microphone and phase and amplitude adjustments are made based on feedback from the error microphone that is positioned well away from the duct discharge opening. The system details are shown in Figure 4.

The first configuration used a sensing microphone that was located close to the fan discharge. The sensing microphone was configured in a manner similar to that of a turbulence screen. Because of the hot environment a Knowles high temperature microphone was used. Unfortunately, the signal level blade passage frequency was not dominant, and the controller did not lock onto the reference signal. This interference problem was eliminated when the sensing microphone was moved further away from the fan. A sketch of the installed system is shown in Figure 5.

The performance of the active control is illustrated in Figure 6. The system reduces the blade passage tone by 12 dB. The system was first run during the evening hours. When the morning shift arrived for work, they through that the plant was shut down, since the audibility of the familiar fan tone was greatly reduced. They were however disappointed when they found out that there was no provision for a parallel signal input so that the loudspeakers could play their favourite music.

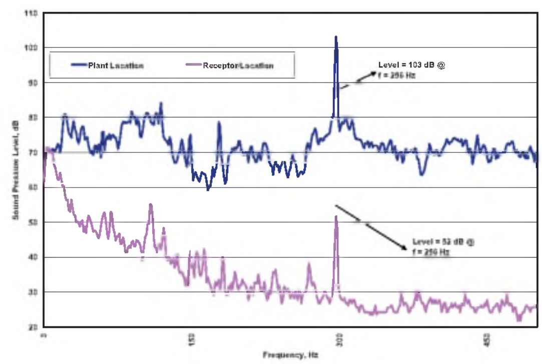

Figure 2. Narrow Band Spectra of ID Fan Noise.

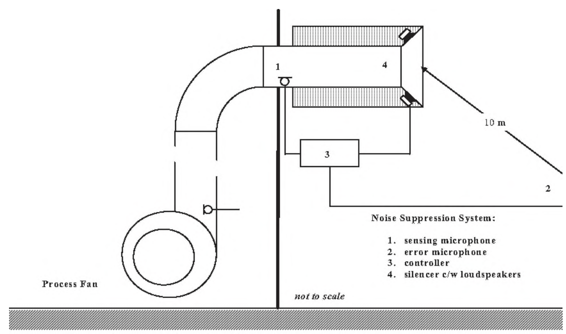

Figure 4. Active System Components

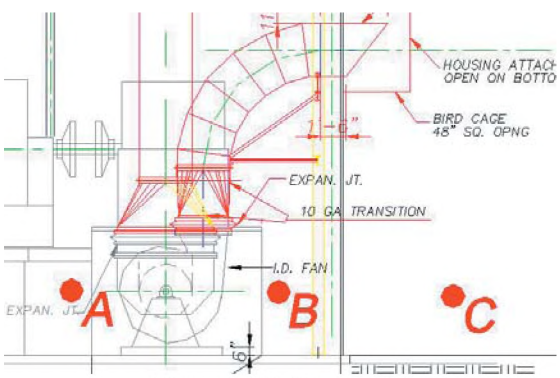

Figure 1. ID Fan Details

Figure 5. Active Noise Control Silencer

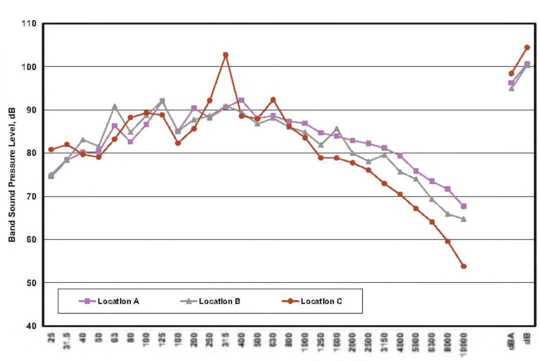

Figure 2. 1/3 Octave Band Spectra of ID Fan Noise.

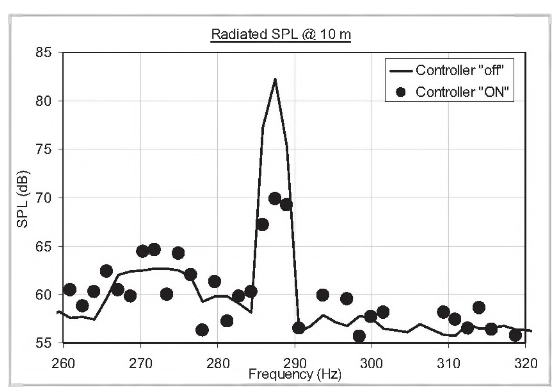

Figure 6. Performance of Active Noise Control System.