NOISE CONTROL FOR HIGH PLUME EXHAUST FANS: A CASE STUDY

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1 Introduction

High plume exhaust fans, also known as air induction exhaust fans, are commonly used for exhausting fume hoods. By their nature this type of fan has above-average sound level. Close proximity of these fans to sensitive points of reception can result in requirements for large sound reduction.

2 Background

The intent of air induction exhaust fans is to get contaminated exhaust away from areas that are sensitive to air quality. This includes fresh air intakes that are located on or near the rooftop, where air tends to recirculate. Historically, contaminated exhaust has been removed by the use of stacks that reach high enough that the dispersion is away from the building. More recently, specialty fan systems that have shorter stacks and specialized exhaust nozzles with high exit velocities have been used with the same intent as tall stacks.

The concept of keeping exhaust stacks out of sight appeals to the architectural aesthetic demands on institutions. Tall stacks rising from the roofs to exhaust research or diagnostic testing fume hoods conflict with the intended public image. However, in practice institutions bring the public into closer proximity with air emission sources.

Similarly, institutions have noise sources that are in closer proximity to sensitive areas. Universities, colleges and hospitals are located close to noise sensitive residential areas. Institutions themselves can also be noise sensitive, or have noise sensitive spaces. The proximity of sources to sensitive areas results in more frequent application of abatement, and larger abatement measures to achieve the required criteria.

In this case study the equipment sound levels required more abatement than what was available from the manufacturer in order to achieve the Ontario Ministry of Environment and Climate Change criteria for the facility. A custom-built solution was required to mitigate sound from this complex source. This case, however, required reductions that were more modest that are required elsewhere because the points of reception were 100 m or more away.

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3 Source Description

The air induction fan in this case is a multi-component system. Exhaust from a number of fume hoods is ducted together, passes through a heat recovery system associated with an air handling unit, and then enters the fan system. The exhaust flow enters the base of the system, which is a plenum. The fans that draw from the plenum achieve a constant airflow, despite variable flow from the fume hoods, by taking additional air into the plenum through bypass dampers. In this case three fans are connected to the plenum. The fans discharge vertically through a special tapered nozzle whose tip is enclosed in a wind band. The nozzle has a high exit velocity. The nozzle and wind band are together intended to induce additional diluting airflow to the exhaust air stream. A diagram of the system prior to the installation of noise abatement is provided below.

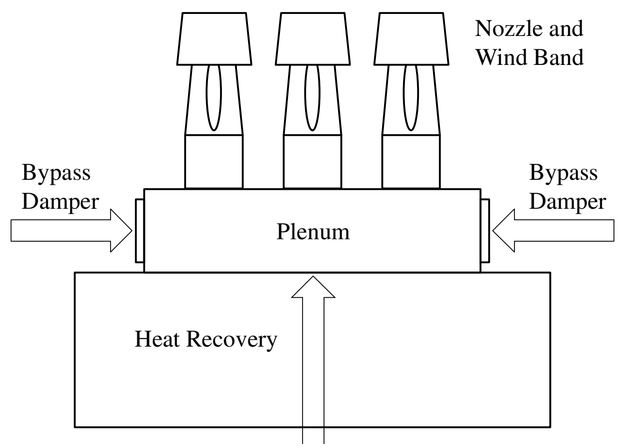

Figure 1: Diagram of an Air Induction Exhaust Fan

The system in this case study uses axial fans. Several other manufacturers use centrifugal fans. Despite the variability in design, the systems have similar key sources of sound emission to the outdoor environment: the nozzle outlet, the bypass louvre(s), and radiation from the casing. Inherent to the design is the high flow velocity at the exit and the resultant higher sound levels.

Sound level data provided by the fan manufacturer was supplemented by measurements of the system components, as installed. Manufacturer data and measurements provided nozzle outlet and bypass louvre sound levels, but were not able to isolate casing-radiated sound.

4 Criteria

Motivation for implementing sound level reductions was primarily driven by the regulator. This installation is in Ontario, where the Ministry of Environment and Climate Change specifies criteria which must be met to receive an operating approval. It is the cumulative sound level from all sources at the facility which is required to meet the applicable criteria at nearby sensitive locations. Because numerous sources at the facility contribute to the cumulative sound level, the individual contribution of each source must be significantly below the criteria. Each individual emission point was therefore limited to a contribution between 30 and 35 dBA.

5 Analysis

Modelling of the sound level contributions at points of reception was done in the Cadna/A software package. The influence of buildings between the sources and points of reception was thus considered.

Minimum sound level reductions of approximately 15 dB were required on the nozzle outlets, and 10 dB on the bypass louvres. This level of reduction is towards the upper limit of what could be achieved by acoustic barriers. The negative influence of barriers on the air dispersion as well as the structural loading from such large elevated surfaces further discouraged the use of barriers.

The casing radiated sound was expected to become a secondary source once sound from the nozzle outlets was reduced. The casing was therefore also identified for mitigation.

6 Mitigation Measures

The specified sound level reductions exceeded the reductions that could be provided by standard abatement equipment supplied by the fan manufacturer. A firm focussed on design, construction and installation of custom noise abatement solutions was retained to complete the project. The package of equipment provided by Parklane Mechanical Acoustics included outlet silencers, bypass silencers, and an enclosure to address the casing noise.

To ensure that the function of the nozzles and wind bands would be unchanged, the decision was made to install the outlet silencers between the fans and nozzles. This placement meant that the silencers would address sound generated by the motor and fan but not any sound caused by the nozzle and wind band. Achieving an overall reduction of approximately 15 dB would therefore require the motor noise to be mitigated more in compensation for the nozzle source that could not be addressed. In-situ measurements were not able to separate motor noise from that of the nozzle. Silencer dynamic insertion losses were therefore planned to be significantly more than the requested 15 dB reduction.

At the same time, the silencers' internal construction was not allowed to degrade the performance of the fans or the function of the nozzles and wind bands. They were therefore designed to ensure that flow to the nozzles was uninterrupted and that there was only a very small pressure drop across the silencers.

The additional weight introduced by the mitigation measures was supported independently of the fan and plenum structure. A photo of the installation is provided in Figure 2.

Figure 2: Noise Abatement Measures Installed on an Air Induction Exhaust Fan System

7 Verification

Sound levels with the noise abatement equipment in place were verified once the system was back in operation. Casing radiated noise from the fans was inaudible. Sound levels at the nozzle were 15 dB quieter, as specified. The bypass louvre sound was reduced by more than the minimum, with the silencers achieving 15 dB.

In addition to the achievement of regulatory compliance requirements, these mitigation measures improved the acoustic environment for pedestrians in the area.

8 Conclusions

An air induction fan, also known as a high plume exhaust fan, is a more complex type of noise source that frequently needs mitigation when installed at locations that are close to sensitive locations. In this case a mitigation strategy was developed to provide more modest reductions of 15 dB without the use of acoustic barriers. In-situ measurements verified that the design developed for this application achieved the required reductions.