Selecting Suitable Noise Control for Mine Return Air Raise Systems

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1 Introduction

The above ground fresh air and return air fans used to ventilate underground mines have the potential to be the greatest sources of noise at mines. These fans often have direct exposure to the outdoors via the air intake or exhaust duct openings, they are often situated closer to sensitive points of reception than other sound sources such as the supporting infrastructure surrounding a headframe, and they can therefore have a significant impact on the communities surrounding the mine. Accordingly, noise control measures, such as intake and outlet silencers, are often incorporated within the design of the ventilation system.

Recent measurements and observations conducted in response to a residential noise complaint suggest that moisture and particulate drawn through the return air ventilation systems can cause rapid clogging and degradation of the outlet silencers, if not properly accounted for in the design of the system. The implications of this are multifaceted, and include significant economic, environmental, and residential annoyance concerns. This paper will present measured sound level data collected as part of a complaint investigation and silencer maintenance program, outline elements which can be considered when designing a return air system to optimize the potential of the noise control equipment, and examine the feasibility of implementing nontraditional noise control methods.

2 Noise Complaint Investigation

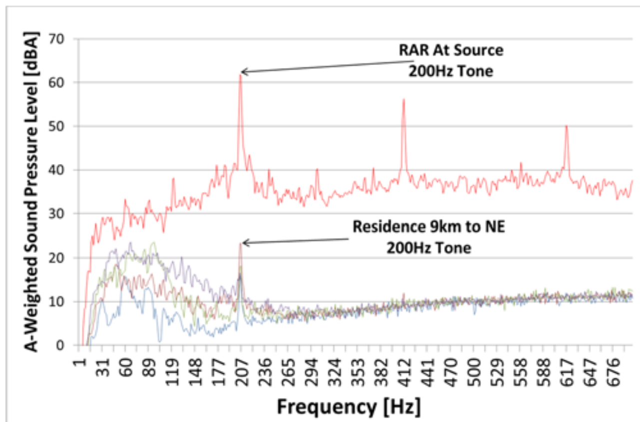
2.1 Residential Measurements

An initial series of sound level measurements were conducted in response to a noise complaint from a resident situated approximately 9 kilometres to the northeast of a mine in northern Ontario. In general, natural sounds dominated the acoustical environment, however a characteristic tonal frequency signature was evident during lulls in the background sound. Accordingly, narrow-band (Fast Fourier Transform, or "FFT") sound levels were measured as a means of discerning the tonal frequency, which resulted in a clear peak at 200 Hz.

It was suspected that the fans associated with the main return air raise ventilation system ("RAR") were responsible for the audible tone at the residence. To confirm this, additional FFT sound levels were measured near to the RAR to quantify the acoustic signature unique to the fan sound. The audible tone associated with ventilation fans are a function of the blade pass frequency ("BPF"), which in this case, was used to verify the source of the sound at the residence. The measurements were conducted using a Norsonic Nor140 precision sound level meter, which was within its annual laboratory calibration period. Correct calibration was field-verified.

The results of this comparison indicated that the acoustic signature of the primary tone measured and observed at the residence matched the acoustic signature of the RAR. Figure 1, below, shows the A-weighted narrow-band sound levels measured at the residence, and near to the RAR.

Figure 1: Narrowband Frequency Analysis



2.2 RAR Silencer Cleaning

Inspections of the RAR silencers suggested that the perforations in the baffle casing had become significantly clogged, due to the abundance of moisture and particulate being drawn through, and discharged from the silencers. Figure 2, below, shows a picture of a clogged silencer.

Figure 2: Clogged Perforations in Baffle Casing

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As a temporary means of minimizing the sound of the RAR, attempts were made to clean the silencers using water and a pressure washer. Because the silencers were not designed to facilitate routine cleanings, the perforated casing was not removed from the silencers, thus the degree of damage incurred by the baffle fill was not known.

Measurements of the RAR outlets were conducted prior to and after the cleaning of the outlet silencers, on three occasions, to quantify the benefit of the cleaning activities. Measurements were conducted in third-octave bands using a Brüel & Kjær Hand-held Analyzer Type 2270, equipped with Sound Intensity software BZ-7233, a Brüel & Kjær model 3654 Sound Intensity Probe and a pair of phase-matched model 4197 microphones. All instrumentation was calibrated correctly before and after the measurements. Sound levels were measured at a distance of 50 metres, at various angles from the outlets, and converted to the overall A-weighted sound power levels listed in Table 1, below.

Table 1: Sound Power Levels [dB re. 10^{-12} Watt] Silencer Outlet Before and After Cleaning

Silencer Condition	dBA
March 4, 2015 - Before Cleaning	128
April 7, 2015 - After Cleaning	119
Sound Level Reduction	**9**
November 3, 2015 Before Cleaning	124
November 6, 2015 After Cleaning	116
Sound Level Reduction	**8**
April 11, 2016 – Before Cleaning	124
April 14, 2016 – After Cleaning	118
Sound Level Reduction	**6**

The results outlined in Table 1 indicate that the cleaning of the RAR outlet silencers in April of 2015, November of 2015, and April of 2016 provided sound level reductions of 9 dBA, 8 dBA, and 6 dBA, respectively. The decreasing improvement in silencer performance afforded by the successive cleanings suggested that the absorptive fill within the acoustic baffles of the silencers was damaged and continuing to degrade with time, and that future cleanings would not mitigate the future audibility and potential for disturbance at the residence of the complainant.

In addition, when the system was designed, the sound power levels specified by the manufacturer for the silenced and unsilenced RAR outlets were approximately 97 dBA and 120 dBA, respectively, under a similar operating speed (750 RPM). Therefore, it was evident that the sound level reduction of the silencers, after becoming clogged, was negligible, and that the fans were louder than specified.

3 Alternative Considerations & Discussion

Considering the results outlined above, it was determined that the noise control equipment on the RAR system would need to be retrofitted or replaced.

To address the issue, the most straightforward method will be to install new rectangular dissipative silencers, to avoid the reconstruction of the outlet ducting. Silencers which have easily accessible, removable and/or replaceable acoustic baffling should be considered, to allow for cost effective cleaning and/or replacement in the future.

Because the reason for the degradation and clogging of the silencers is the moisture and particulate being drawn through the RAR system from underground, the addition of a moisture dropout chamber/trench will be beneficial toward preserving the internal silencer media. An added benefit of this will also be minimizing the release of water contaminated from the underground mining operations, into the surrounding environment.

Consideration can also be given to investigating reactive silencers. These can be tuned to attenuate sounds at specific frequencies, such as the BPF (and harmonics thereof) of the RAR fans. Further, as demonstrated in Figure 1, the acoustic energy measured and observed at the residential location is concentrated at the BPF of the fans; by specifically targeting the BPF, rather than a more typical broadband approach, the efficiency of the silencer could be maximized. Conversely, this approach is not advisable for ventilation systems which utilize variable speed fans, when the BPF (and associated acoustic signature) will also be variable.

4 Conclusion

The noise complaint investigation outlined above has indicated that incorporating typical, or "off-the-shelf" noise control measures on equipment which require extra considerations can result in noise control measures which need significant maintenance, and do not work as intended.

Specifically, it has been determined that mine return air fans have the potential to draw moisture and particulate from underground, and this can degrade a dissipative silencer to a state of being nearly entirely ineffective. The consequence of this has been the unforeseen annoyance of neighbouring residents, the need for costly routine maintenance, and the need to replace the ventilation equipment and/or noise control equipment. Moreover, this has the potential to contribute to sound levels which exceed the regulatory sound level limits enforced by a governing body.

Therefore, it is prudent that RAR systems are fully understood during the design phase of a mine, and the appropriate noise control measures are incorporated.