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A NOISE CONTROL FOR A ROOF BOLTING MACHINE: COLLAPSIBLE DRILL STEEL ENCLOSURE

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ABSTRACT

The National Institute for Occupational Safety and Health (NIOSH) at the Pittsburgh Research Laboratory (PRL) is conducting research to reduce the noise exposures of roof bolting machine operators and to prevent additional cases of Noise Induced Hearing Loss (NIHL) thru the development of engineering noise controls. This paper describes and evaluates an engineering noise control for the roof bolting machine, namely the collapsible drill steel enclosure. The results of the evaluation demonstrated that using the collapsible drill steel enclosure provided a 7 dB(A) reduction in sound pressure level at the operator's position of a roof bolting machine.

1. INTRODUCTION

The drilling of rock in a confined work environment contributes to high levels of noise exposure in the mining industry. The Mine Safety and Health Administration (MSHA) coal data from 2000 to 2005 has shown that roof bolting machine operators were second among all underground coal mining equipment operators who exceeded 100% dosage, per the MSHA Permissible Exposure Limit (PEL) [1]. According to the Bureau of Labor Statistics (BLS) approximately 3,930 roof bolting machine operators are employed in coal mining [2].

Roof bolting machines are underground drilling machines used to implement a mine roof control plan. All underground coal mine operators are required to develop and submit roof control plans to MSHA for evaluation and approval. These plans provide the necessary requirements and placement of roof supports to eliminate any potential ground control issues [3]. A common method used in a roof control plan for attaching lower level rock strata to upper layers is to use a roof bolt and epoxy resin to seal the layers of rock strata. A roof bolting machine trams to the required location and drills a hole several feet into the mine roof, as described by the roof control plan. After a hole is

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placed in the roof, a plastic tube with epoxy resin is inserted into the hole. A roof bolt is then inserted in the hole and rotated by the roof bolting machine tearing the plastic tube of epoxy resin and mixing the resin to the bolt and the surrounding rock layers. The epoxy resin typically "sets up" or hardens within a couple of seconds; attaching the bolt and rock layers to each other. In most underground mining situations, a roof bolt is placed approximately every four feet in the mine. The roof bolt and epoxy combination are a conventional mean to provide primary roof support. The roof bolting machine operator will repeat this process as needed to comply with the requirements of the underground roof control plan for a respective mine.

The roof bolting machine operator is exposed to several noise sources from two processes, one is drilling and the other is bolting. The dominant noise sources are a result of the drilling process [4].

To reduce noise exposure caused by roof bolting machines generated during the drilling process a collapsible drill steel enclosure has been developed. Specifically, this paper describes the collapsible drill steel enclosure, the measurement method used to evaluate the enclosure for noise reduction, and the results.

2. COLLAPSIBLE DRILL STEEL ENCLOSURE

The collapsible drill steel enclosure, Figure 1, consists of a round aluminum coated fiberglass bellows with a spring enclosed inside the bellows.

Figure 1: The collapsible drill steel enclosure installed on a roof bolting machine

Fiberglass was chosen because it provides good acoustical absorptive properties, has excellent heat resistance and is incombustible. In addition the aluminum coated fiberglass can not absorb moisture so it will not decay and is resistant to acids, oils, many solvents, and corrosive vapors. Fiberglass with an aluminum cover allows the material a 95% reflective heat property that makes it a very good material in high heat use. The fiberglass bellow is 1.905 cm thick by 19.685 cm outside diameter and the extended length is 1.2192 m; however, diameters up to 1.8288 m and extended lengths up to 6.096 m can be procured (Figure 2).

Figure 2: Fiberglass bellows used in the collapsible drill steel enclosure

The spring is a straight cylindrical compression spring made of .635 cm of round wire with a load of .303 kN. Also, the spring is 1.0668 m in length with a total of 16 coils. The outside diameter is 15.8242 cm for each coil (Figure 3).

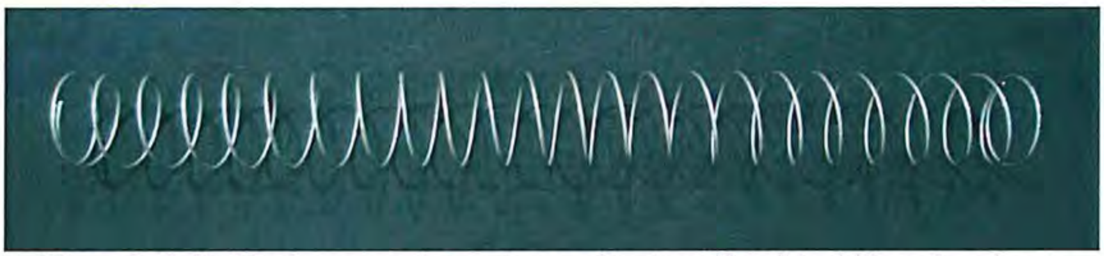

Figure 3: Cylindrical compression spring used in the collapsible drill steel enclosure

3. MEASUREMENT METHOD

To effectively develop and evaluate engineering noise controls for large mining equipment, such as a roof bolting machine, the NIOSH / PRL has a large reverberation chamber that is designed and equipped to determine sound power level emissions (Figure 4). The Acoustic Test Chamber (ATC) is at the PRL and yields scientifically valid and reliable testing of engineering controls because the influences of varied equipment and operator underground environments can be controlled in the chamber. The ATC has been NVLAP accredited for sound power level testing per the ISO 3741 / ANSI S12.51 standard for broadband precision grade measurements [5].

Figure 4: The ATC facility was designed to determine the sound power level emissions of large mining equipment.

The nominal room dimensions are 18.3 meters long by 10.3 meters wide with a height of 6.7 meters. The chamber volume is 1,286 cubic meters. These dimensions are important, as few reverberation facilities are not large enough to test large mining equipment.

A Bruel & Kjaer Pulse system serves as the data acquisition system for the sound power level determinations. One-third octave band sound pressure levels are collected by the Pulse system at fifteen microphone locations within the reverberation chamber and these data are dynamically linked to an Excel spreadsheet in real time. In Excel, these data are logarithmically averaged to calculate an average sound pressure level for the test. These measurements are conducted for a calibrated reference sound source and then for the device under test. These sound pressure level data are then used to calculate the sound power level emissions for the device using the comparison method [5].

4. MEASUREMENTS

Testing was conducted in the ATC with a Fletcher HDDR roof bolting machine, shown in Figure 4. Since the dominate noise sources are a result of the drilling process, the measurements were conducted while drilling. Granite blocks were used as the drilling media for the tests because prior experience has shown that using granite reduces test-to-test variability [4]. Also, a low rotation speed of 200 rpm and a low thrust of 9.4 kN. was used. The lower thrust was used so a longer drill time could be obtained. A new drill bit was used for each hole also to reduce test-to-test variability.

Drill bits and drill steels that were representative of industry usage were used for testing. Commonly used drill steels are either round or hexagonal in shape and are available to be used with either 2.54 cm or 3.49 cm drill bits (Figure 5).

Figure 5: Hex and round drill steels for a 3.49 cm diameter drill bit (upper) and two examples of drill bits (lower).

Because the roof bolting machine measurements require a rather large drill media (granite), a steel support apparatus had to be constructed to hold the drilling media. This large steel support stand is comprised of rectangular tubes to hold the drilling media, shown in Figure 6. To prevent the support stand from radiating significant amounts of sound, sand was used to fill the hollow tubes except for the diagonal tubes and the horizontal tubes along the short direction at the top of the structure. This was performed to create a vibration impedance mismatch in the structure to reduce vibration transmission. Two layers of a urethane material were bonded to the rock support tubes to break direct contact between the rock and the structure. Finally, a layer of urethane was placed between the rock and the chain used to support the rock media.

Figure 6: A large steel support stand comprised of rectangular tubes to hold the drilling media.

The test plan was to compare the sound power results generated by drilling into granite and comparing the sound power results when using the collapsible drill steel enclosure under the same conditions. In addition, tests were conducted with varying gaps between the top of the collapsible drill steel enclosure and the bottom of the drill media. The varying gaps would determine how tight of a seal was needed between the collapsible drill steel and the rock media in reducing sound power levels. Gap lengths of 15.24 cm, 10.16 cm, 7.62 cm, 5.08 cm and no gap were tested. This resulted in 6 different combinations of test parameters, including the baseline test, with 3 measurements for each combination totaling 18 measurements.

5. RESULTS

Sound power gives a direct comparison of noise generated by any device tested under the same conditions. Therefore, determining a sound power level is an effective way of evaluating the collapsible drill steel enclosure as a noise control.

Baseline results for drilling in granite demonstrated that the sound power was at 111 dB(A). Figure 7 illustrates the one-third-octave-band spectrum for drilling in granite at 200 rpm and a thrust of 9.4 kN. The frequency content of the noise radiated is dominated by the 1250 Hz through 8 kHz bands.

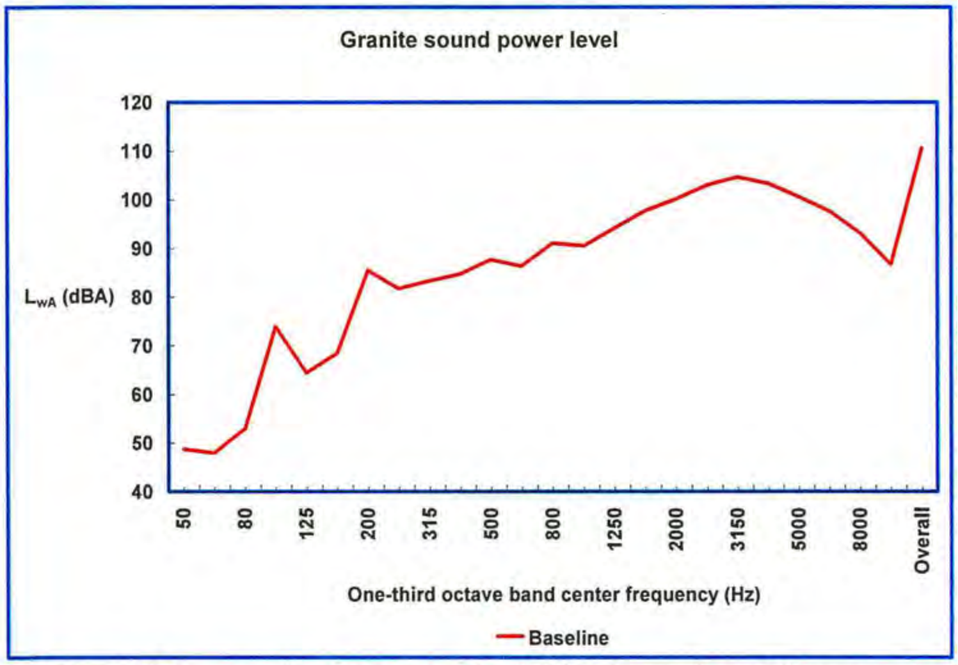

Figure 7: One-third-octave-band spectrum for drilling in granite at 200 rpm and a thrust of 9.4 kN.

Results when using the collapsible drill steel enclosure indicate that the sound power level was reduced by 6 dB(A) with gaps of 10.16 cm, 7.62 cm, 5.08 cm, and no gap. However, with a 15.24 cm gap the sound power level was only reduced by 5 dB(A). Figure 8 illustrates the one-third-octave-band spectrum for drilling in granite at 200rpm at a thrust of 9.4 kN for all configurations. It can be seen from Figure 8 that all configurations were effective in reducing the dominant frequencies bands from 1250 Hz through 8 kHz.

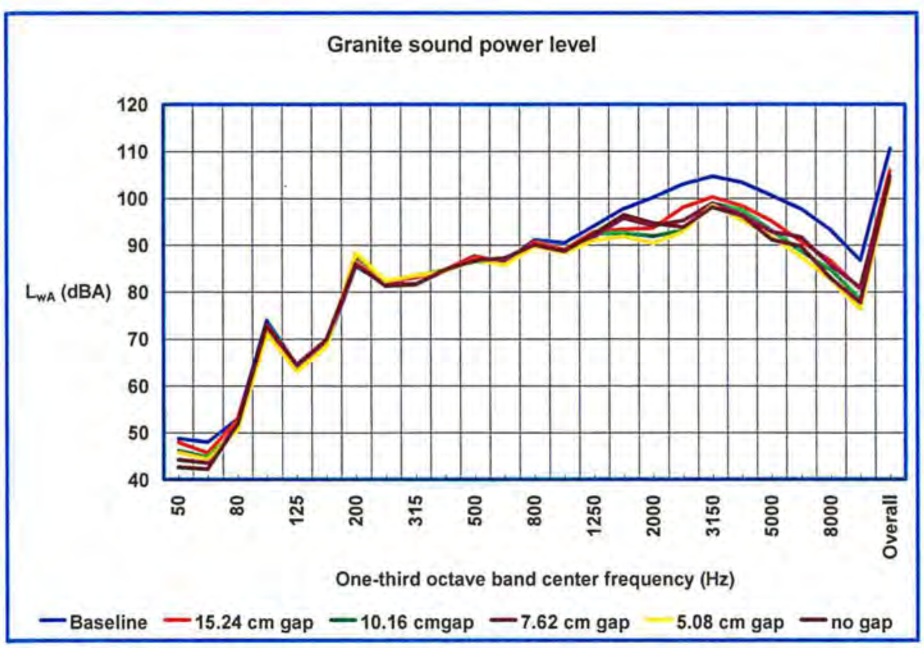

Figure 8: One-third-octave-band spectrum for all configurations while drilling in granite at 200rpm and a thrust of 9.4kN.

Since the collapsible drill steel enclosure displayed promise in the laboratory, the next step would be to conduct an underground field evaluation for durability and noise exposure reduction. Recommendations for the underground field evaluation would be to use dosimeters to determine the amount of acoustic noise that a roof bolting machine operator is exposed to during a work shift with and without the collapsible drill steel enclosure.

6. CONCLUSION AND RECOMMENDATIONS

NIOSH laboratory results showed that the collapsible drill steel enclosure had a significant influence on lowering the sound power level of the roof bolting machine. The one-third-octave-band spectrum for drilling is dominated by the 1250 Hz through 8kHz bands and the collapsible drill steel enclosure was effective in reducing these frequencies bands. In addition, the gap from the top of the collapsible drill steel enclosure to the bottom of the rock media did not have to be a good seal. With a gap of 15.24 cm, the collapsible drill steel enclosure was still an effective noise control. The sound power level for the collapsible drill steel enclosure was consistently 5 to 7 dB(A) below that of baseline levels of the roof bolting machine without any noise controls and the same operating conditions. It appears that the collapsible drill steel enclosure is potentially a viable engineering noise control for roof bolting machines.

REFERENCES

[1] Title 30 CFR Part 62, 2000-2005, U.S. Department of Labor, Mine Safety and Health Administration, Information Resource Center, Denver Co.

[2] U.S. Department of Labor Bureau of Labor Statistics, May 2006, web site http://www.bls.gov/oes/current/oes475061.htm

[3] U.S. Department of Labor, Mine Safety and Health Administration, web site http://www.msha.gov/regs/fedreg/informat/2006icr/e6-97.asp

[4] Peterson JS, Kovalchik PG, Matetic RJ [2006]. A Sound Power Level Study of a Roof Bolter. In: Yernberg WR, ed. Transactions of Society for Mining, Metallurgy, and Exploration, Inc. Vol. 320. Littleton CO: Society for Mining, Metallurgy, and Exploration, Inc., pp 171-177.

[5] Peterson JS, Bartholomae RC [2003]. Design and instrumentation of a large reverberation chamber. In: Proceedings of NOISE-CON 2003. Ames, IA: Institute of Noise Control Engineering of the USA, pp. 8.