Noise Control in a Sample Preparation Room

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ABSTRACT

Workers were exposed to excessive noise when working in the sample preparation room of ALCOA Kwinana Refinery. The noise was mainly from the four BICO disk mills located side by side in the centre of the room. High noise level from each mill affected its operator and operators of other mills. The airgun used for cleaning sample residues further increased the workers' noise exposure level. The sample preparation practice also generates dust. Workers had to use earmuffs on top of other bulky safety equipment, which made the job quite awkward. A simple noise control solution involving noise absorption treatment, noise transmission blockage and vibration damping, was proposed and implemented for this noise problem. After the treatment, the noise exposure level was significantly reduced to the level below the exposure standard for ten-hour shift, making the use of hearing protection unnecessary.

Introduction

The Sample Preparation Room in an ALCOA refinery has four BICO disk mills located side by side in the centre of the room, as shown in Fig. 1. Noise exposure assessments indicated that mill operators exposed to the noise level exceeded the occupational noise standard, especially when four mills were running simultaneously. They were likely exposed to the daily noise exposure level between 89 dB(A) in their 10-hour shift (N.D. Engineering 1999; Alcoa Kwinana Refinery 1998 and 2000). As such, according to WA Occupational Safety and Health Regulations 1996, measures that would practically reduce the mill noise and the operators' noise exposure should be pursued.

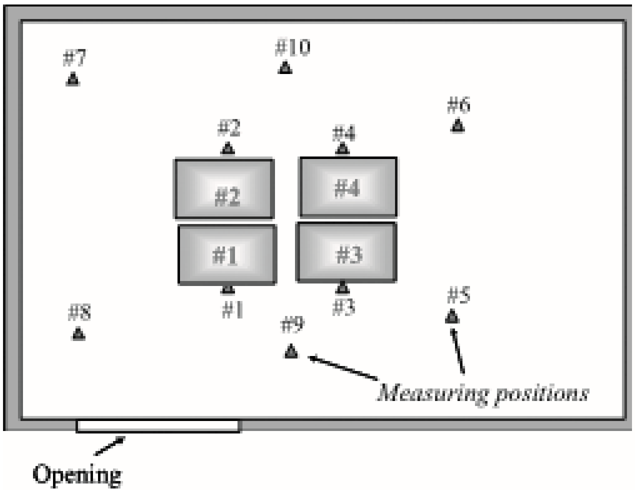

Figure 1: Noise Measuring Locations

The operation of disk mills also generated other workplace hazards, such as dust. As such, mill operators were required to put various personal protective equipment on, such as face masks, safety glasses, gloves, protective apron, and safety boots. A pair of hearing protectors became an extra burden to the mill operator. All these considerations had made the noise control a priority task. The control goal of this project was to reduce the operators' daily noise exposure down to the level below the occupational noise standard for 10-hour shift, making the use of hearing protectors unnecessary.

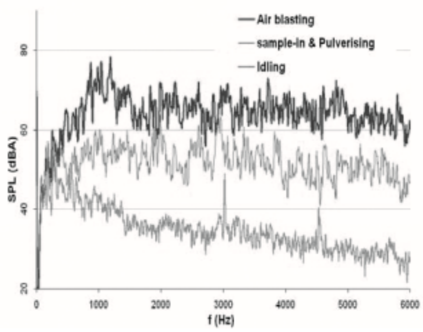

Figure 2: Noise Spectra at #2 When Mill 2# Operates Alone

Noise Source Identification

The operation of each mill involves four distinct operating phases - idling, sample in (pulverising), sample out, and mill cleaning with an airgun. The motor of the mill is the only noise source during the idling and sample-out phases, while the noise during the pulverising stage involves motor noise and sample crushing noise of the mill. The major noise when cleaning the mill after the pulverising phase is from the airgun, though the motor noise also contributes to it.

A-weighted noise levels and noise spectra were measured at 10 measuring locations around four mills. Data were recorded and analysed for different operating phases and different operating combinations of the four mills.

Figures 2 shows the noise spectra of three operating phases at #2 position when the #2 mill was operating alone. It is obvious that the air gun noise was the most dominant noise to the mill

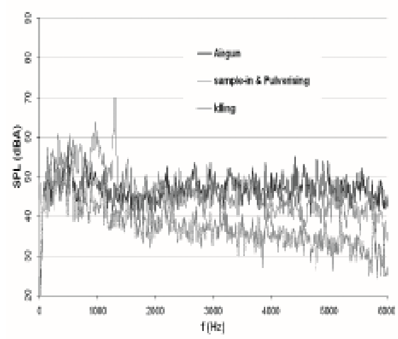

Figure 3: Noise Spectra at #2 When Mill 1# Operates Alone

operator, which was about 10dB higher than the second dominant noise - the sample pulverising noise - when it was in its peak value. However, the measurement also demonstrated that the blasting noise varied significantly during the operation. It was highly dependant on the location and direction of the airgun when cleaning. The variation of the blasting noise level could be up to 20 dB. Figure 2 also shows that the level of idling noise was the lowest in the whole cycle, which was several decibels quieter than that of the noise from pulverising samples.

The cross-affecting noise, which is defined as the noise level on one operator due to operations of other mills, was also measured. Figure 3 shows the noise spectra at location #2 when only the mill #1 was operating. Comparing Fig. 3 with Fig 2, it can be shown that the noise from other mills had much lower high-frequency components (>1000Hz). This was because the airgun noise from other mills, as a point source with mainly high-frequency components, decayed significantly during transmission. As a result, the blasting noise from other mills was not the number one dominant noise any more and became comparable to the pulverising noise.

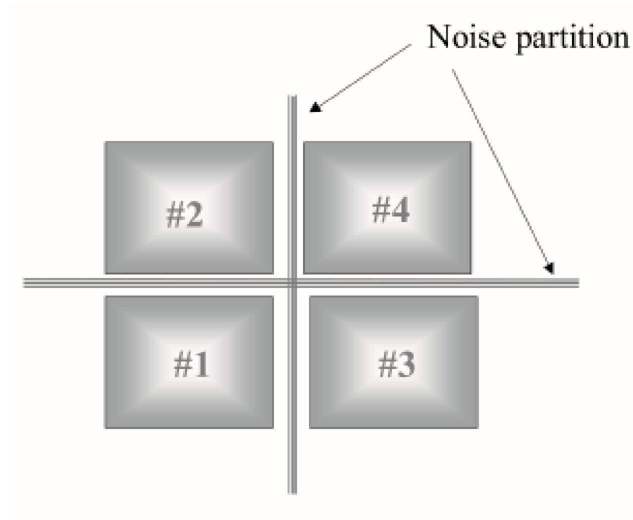

Figure 5: Noise Partition for the Stations

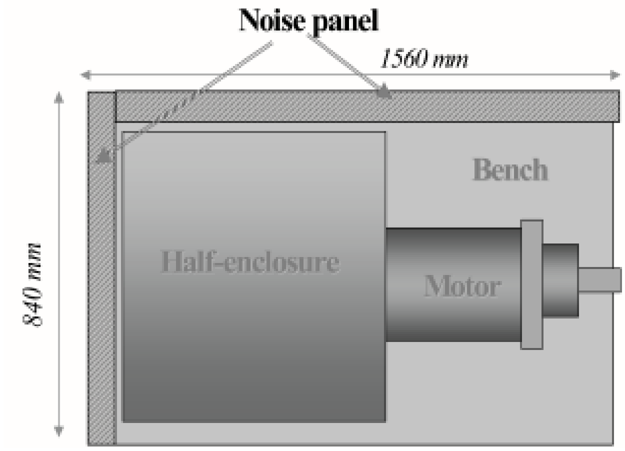

Figure 6: Noise Partition for the Stations

The reverberation time of the sample preparation room was measured at three locations, in order to assess the acoustical properties of the room. The estimated average sound absorption coefficients of walls with octave frequency bands are listed in Table 1. Table 1 indicates that the diffuse degree of the room was not very high. This demonstrates that noise levels around mill operators were able to be significantly reduced, if the direct noise from the mills was controlled by acoustical treatment, such as noise insulation and absorption.

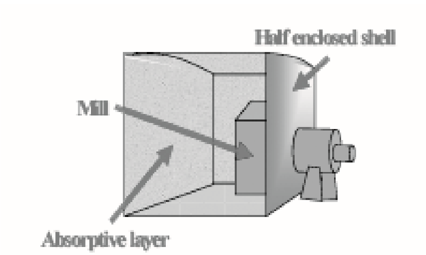

Figure 4: Noise Absorption Layers in the Inner Surface of the Shell

Noise Control System Design

From the noise source identification and measurement, it is obvious that the reduction of an operator's noise exposure level could be achieved in three areas. They were: (1) reducing the blasting noise from the airgun used by the operator; (2) blocking the pulverising noise and blasting noise transmitted from other mills; and (3) damping the vibration of radiating structures.

Absorption treatment on the enclosure shell

The experimental study of the airgun noise control indicated that the airgun noise was highly dependent on the location and direction of the gun over the mill to be cleaned. The difference could be as high as 20 dB. The result of the study also indicated that the blasting noise was directly proportional to the air pressure. The blasting noise level might be significantly reduced by using jet noise mufflers. However, this proposal was not accepted by operators, due to the concern of the efficiency of the blasting cleaning.

It was found from the study that the blasting noise from the airgun was amplified by the non-absorptive half-enclosed shell, which reflected the noise and focused it to the operator's location. The absorptive treatment on the half-enclosed shell would reduce the reflection and then this noise-focusing effect, and the noise exposure of the operator due to airgun noise, as well as the pulverising noise.

A noise absorption layer was designed to cover the four inner surface of the enclosure shell, as shown in Fig. 4. The purpose of this design was to (1) absorb the blasting and pulverising noise; (2) reduce the noise-focusing effect of the shell to the mill operator; and (3) damp the vibration of the shell, which would reduce the structural-borne noise from the sample processing.

Noise absorptive materials to be used in this treatment should have very high absorptive coefficient covering the broad frequency band of air-blasting noise starting from around 400Hz. From laboratory tests, a double-layer combination arrangement (two materials – a 22mm metal-film-foam as bottom layer and an 11mm perforated foam as top layer) was

f(Hz)	125	250	500	1k	2k	4k
Alpha	0.26	0.29	0.33	0.41	0.32	0.35

Table 1: Average Sound Absorption Coefficients of the Walls

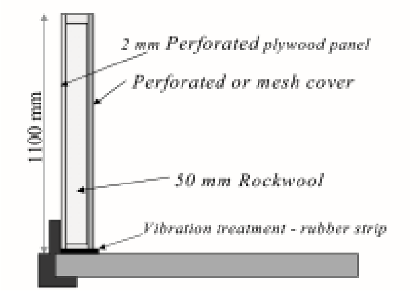

Figure 7: Noise Partition for the Stations

identified to provide very high sound absorption (~80%) at all frequencies of interests. The reduction of blasting noise level at the location of the airgun operator was expected to be by at least 5 dB with this treatment. The pulverising noise of the mill should also have noticeable reduction.

Absorptive Noise Partition Installation

The noise from other mills could be reduced by blocking the noise transmission path, or by absorbing the noise through its transmission. Partition panels were designed for this purpose, as shown in Fig. 5. Our study indicated that this design was mostly effective for the sample pulverising and motor noise, as the airgun noise from other mills was not the major noise, especially after the absorptive treatment of the half-enclosed shell. The design of the partition panels is shown in Figs. 6 and 7. Each panel is 1100 mm high, with its lower ends fixed on the bench. It is a sandwich panel with a 2 mm perforated plywood laminate on one surface and a perforated or mesh cover on other side. The core layer is made by 50 mm rockwool, which is very absorptive from 400 Hz upward. A wooden frame of 50 mm in thickness is a core part of this panel. To prevent the vibration induced noise from the panel, vibration insulation was also designed for the panel - a rubber strip in between the panel bottom and the station bench. The installation of the noise partition was designed to reduce the sample pulverising noise by about 3 dB.

Vibration Treatment

Vibration measurement results

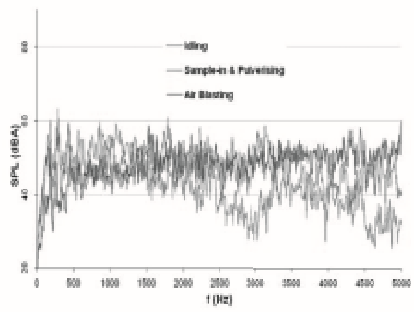

Figure 9: Noise Spectra at #2 when the Mill #2 was Operating Alone

indicated that the vibration levels on the surface of the motor and the outer surface of the half-enclosed shell were high, making them noise sources that could not be ignored. In the design, the surface of the motor was covered and wrapped by a rubber layer, while the outer surface of the half-enclosed shell was adhered with a layer of acoustical foam.

The overall view of these three designed treatments is shown in Fig. 8. It was expected that with the completion of these treatments, daily noise exposures levels of the mill operators' would be significantly reduced down to below the occupational noise standard, making the use of hearing protectors not necessary.

Achieved Noise Reductions

To test the effectiveness of the design, Mill #2 was chosen to be installed with the control system.

Noise spectra measured at #2, the operator's position of Mill #2, under

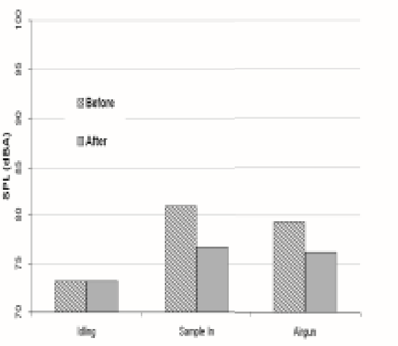

Figure 10: Noise Levels Before and After Control at #1 Due to the Operation of Mill #2 Only

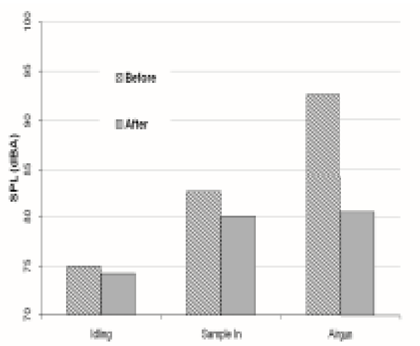

Figure 11: Noise Levels Before and After Control at #2 Due to the Operation of Mill #2 Only

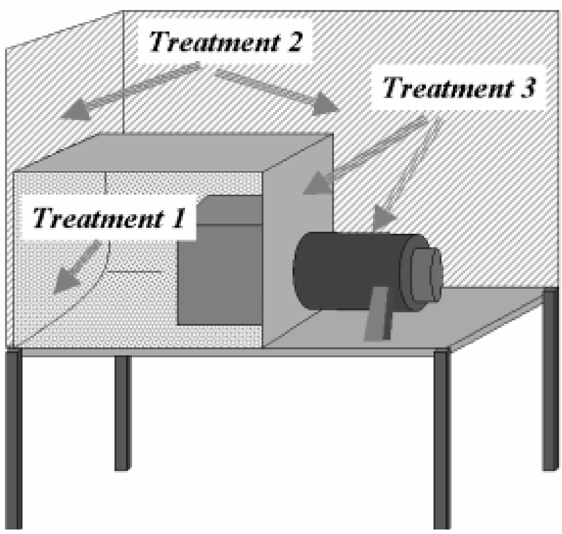

Figure 8: Noise Partition for the Stations

three distinct operating conditions when Mill #2 was working along are shown in Fig. 10 at the same location under same working conditions before the installation of the control system shown in Fig. 2, it is obvious that this treatment was most effective to air-blasting noise, which has been significantly reduced to the level comparable to that of the pulverising noise. Figure 10 also indicates that this treatment is also effective to high frequency components of the pulverising noise – an obvious reduction of this noise can be seen in the high-frequency range.

The reduction of the airgun noise level of Mill #2 at its operator's position can be as high as 10 dB. Figure 11 compares the A-weighted noise level at Mill #2 before and after the installation of the noise control system. It is demonstrated that the reduction of air blasting noise level is over 10 dB due to the noise control

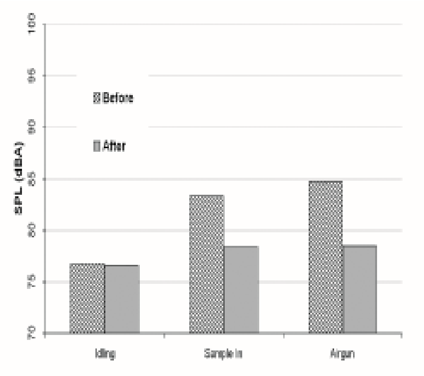

Figure 12: Noise Levels Before and After Control at #2 Due to the Operation of the Three Other Mills

system. Figure 11 also demonstrates that noise levels under idling and sample-in conditions are also reduced after the installation of the control system, though not as much as that of the air-blasting noise. The high effectiveness of this treatment on the airgun noise is due to the fact that the airgun noise, as a point noise source, is generated exactly within the half-enclosed shell. This is an indication that noise absorptive treatment on the inner surface of the shell is very effective to minimise the noise-focusing effect of the shell.

Figure 12 shows the change of noise levels at the measuring location of Mill #1 due to the operation of Mill #2 only. Both the noise levels from pulverising and air-blasting are reduced after the installation of the noise control system. This proves that the installation of the noise panel also reduces the noise transmission from Mill #2 to other three mills.

The installation of the control system does reduce the cross noise pollution among four mills. Figure 13 shows the noise levels at Mill #2 when the other three mills - Mills #1, #3, and #4 - were operating together. It is obvious that the partition panels successfully reduce the noise transmission from other three stations to the Mill #2 operator by about 6 dB for the airgun noise and about 5 dB for the pulverising noise.

Conclusions and Discussion

The noise control experiment on Mill #2 meets the expectations of the design, which significantly reduces the noise under the noisiest working condition - air-blasting noise. The reduction level can be as high as 10 dB.

The control system is also able to reduce the noise under idling and pulverising working conditions, though the reduction is not as big as that of the air-blasting noise. It can be estimated that the control system can reduce the idling and pulverising noise by at least a couple of decibels.

The noise control system also successfully blocks the noise transmission among four mills. The noise panel reduces the noise level transmitted to Mill #2 from other three mills by about 5 dB under pulverising condition and about 6 dB under air-cleaning condition. It also reduces the noise transmission from Mill #2 to other three mills by about 2 dB under pulverising and air-blasting conditions.

The daily noise exposure of mill operators varies with each day's operating pattern. Under comparable operating conditions, it can be calculated that the daily noise exposure level of the Mill #2 operator is reduced by at least 5 dB, making it below the occupational noise standard for 10-hour shift and the use of hearing protectors not required.

It can be estimated that further noise reduction will be achieved when the control system is installed on all other three mills. The full installation of the control system on all mills will have at least 1~2 dB further reduction at the position of the Mill #2 operator, which will make the use of hearing protectors unnecessary for all mill operators.

The observation of the operating conditions and measurements indicated that the regular maintenance of mills played very important role in the noise control. During a follow-up measurement, one mill generated abnormally high level of noise in both idling and pulverising conditions, which were several decibels higher than previous readings.

This was due to the bearing failure of that mill. Regular maintenance that keeps all mills in good working order is critical for a good noise management system.

Acknowledgment

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