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A PRELIMINARY STUDY OF OCCUPATIONAL NOISE EXPOSURE AMONG LEAF BLOWER AND GRASS CUTTER WORKERS IN PUBLIC UNIVERSITY

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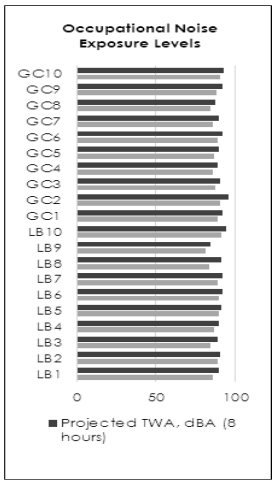
Graphical abstract



Abstract

Many occupational noise exposure studies have been conducted in various occupational sectors. However, in Malaysia, there are limited numbers of study on grass cutter workers and there is no study on leaf blower workers. Thus, this preliminary study was conducted to assess both occupational noise exposure among leaf blower and grass cutter workers by measuring occupational noise exposure, determining sound power level of the machines and conducting interview session. A total of 20 workers were selected from a public university as study subjects. Noise dosimeter and sound level meter were used to measure the occupational noise exposure and sound pressure level of all machines in determining their sound power levels respectively. Most of the workers were exposed to daily noise dose and time-weighted average (TWA) noise level which exceed the permissible limits. All machines recorded a high sound power level and several workers showed prevalence symptoms of hearing loss. This preliminary study revealed that most of the workers are exposed to excessive occupational noise exposure and at high risk of acquiring noise-induced hearing loss (NIHL).

Keywords: Noise, occupational noise exposure, leaf blower, grass cutter, hearing loss

1.0 INTRODUCTION

Over the past years, occupational noise exposure has remained a problem in all the regions of the world, which becomes a widespread risk factor of hearing loss [1]. Basically, noise is an unwanted sound. It is an audible acoustic polluting element which has been considered as the most physical urban pollution and one of the environmental and occupational hazards listed in the Factory and Machinery Act (FMA) 1967 [2]. Meanwhile, noise-induced hearing loss (NIHL) is a form of sensor neural hearing loss, major hazard in most of work places and continues to be a serious health problem throughout the industrialized world [3].

Factories and Machinery (Noise Exposure) Regulations (FMR) 1989 under Factories and Machinery Act (FMA) 1967 is used to protect workers from hearing loss or impairment in Malaysia [4-5]. The Noise Exposure Regulations came into force in early 1989 where it requires all workers who are exposed to the noise levels exceeding 85 dBA to be protected [6]. Based on these regulations, the Time-Weighted Average (TWA)

for action level is 85 dBA or daily noise dose is 50%, the TWA for permissible exposure limit (PEL) is 90 dBA or daily noise dose is 100% and maximum exposure limit (MEL) is 115 dBA.

Several studies reported a significant result of NIHL in various countries and sectors such as 60% out of 623 operating engineers from the construction industry in the United States of America [3], 76% of the 269 steel factory workers in the Eastern Saudi Arabia [7], 78.4% of the 545 miners from large and small-to-medium scales mining sector in the South Africa [8] and 26% of the total workers in the Indian oil mills [9] were exposed to high noise level which is higher than 85 dBA. It means that the risk of hearing loss and detrimental health effects among workers are higher. In Malaysia, the toll teller workers are at high risk of NIHL and imperilled from excessive noise exposure [1].

In Malaysia, grass cutting and leaf blowing works are considered as landscape care and maintenance service activities under the small-to-medium enterprise (SME) [10]. There is an effective support for formal and large enterprises; however, more works and efforts need to be implemented for the SME workers in order to ensure better protection from occupational exposures and hazards. This may help the Social Security Organization (SOCSO) to capture and record more occupational problems among the SME workers. SOCSO and private insurance company are two main bodies which are responsible to handle occupational cases in Malaysia including the hearing loss among workers [11].

Leaf blower machine is a powered machine, widely used for cleaning, routine maintenance of paths and clearing leaves on the streets, ways or lawns [12]. The leaf blowing works will be carried out by means of high velocity air flow which produces noise. The use of leaf blower machine especially the gasoline-powered was considered as a major source of high noise level [13]. Noise is one type of hazards that can be produced by the leaf blower machine [14] and it has been identified as a source of adverse health effects. Other than that, the use of gasoline-powered machine also can cause vibration exposure among workers [5, 15].

Meanwhile, grass cutter machine is widely used in various tropical countries including Malaysia and India for grass cutting on the roadsides, facility locations and other landscape areas [5, 16-17]. The climate characteristics of Malaysia are uniform temperature and high humidity with abundant rainfall. The grass cutting service is compulsory at least once or twice a month for the tropical areas with fast growing grass. Leaf blower and grass cutter machines among other machines such as chainsaw, scarifier, shredder or chipper, high pressure water jet and cooling equipment on vehicles are categorized under the highest ranking of high noise level [18]. These two machines are man-carried machines which are mainly powered by two-stroke engine in close proximity to the worker [19].

Currently, although limited in numbers, there are several studies of occupational noise exposure among the grass cutter workers in Malaysia. However, there is no study of occupational noise exposure among the leaf blower workers in our local context as compared to other developing countries. Thus, this study was carried out to assess both occupational noise exposure among the leaf blower and grass cutter workers in Malaysia by measuring the occupational noise exposure among the workers, conducting interview session with the workers and determining the sound power level of the leaf blower and grass cutter machines.

2.0 METHODOLOGY

2.1 Subjects

One of the public universities in Malaysia, Universiti Teknologi Malaysia, Johor Bahru has been selected as the measurement location for this study. An official permission to carry out the measurement around the university area was obtained from the Office of Assets and Development prior to the measurement of this study. The whole area of this university was divided into 11 working zones namely Zone 1 until Zone 11. The university has hired 11 private contractors for the cleaning and maintenance services for each zone. Usually, each contractor is under contract with the university for two years contract period. This study has focused on the leaf blower and grass cutting workers who are exposed to the high noise levels produced from the machines.

A total of 10 leaf blowers and 10 grass cutters were selected out of the 11 working zones. All workers are male and full-time contract. Most of the workers are working for seven days and some of them are working for six days a week. They will start working at 8.00 in the morning and finish at 5.00 in the evening. During the working hours, they will have three break periods which include 10.00 to 10.30 in the morning, 12.00 to 1.30 in the afternoon and 3.00-3.30 in the evening. There are two types of leaf blower machine and two types of grass cutter machine used by the workers as shown in Figure 1 (a-d). The specifications of each machine are summarized in Table 1.

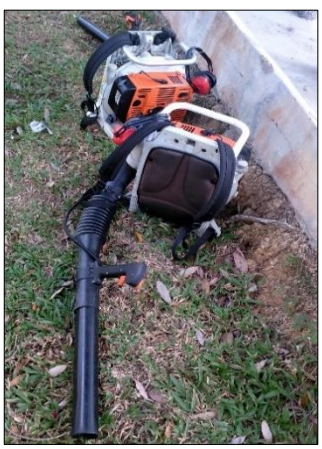


Figure 1 (a) STIHL BR 420

Figure 1 (b) STIHL BR 500

Figure 1 (c) Mitsubishi TB 43

Figure 1 (d) Ogawa BG 430

Table 1 Specification of leaf blower and grass cutter machines

Model	Power Source	Weight, kg	Sound Power ,dB	Fuel Capacity, liter	Speed , RPM
BR 420	Gasoline 50:1	9.1	108	1.5	Idle 3100
BR 500	Gasoline 50:1	10.1	100	1.4	Idle 2500
TB 43	Gasoline 30:1	10.3	N/A	1.3	Max. 7000
BG 430	Gasoline 25:1	10.5	N/A	1.2	Max. 6500

N/A = Not Available

2.2 Instrumentations

There are two types of instruments used to measure the occupational noise exposure among workers and sound pressure level of machines such as personal noise dosimeter and sound level meter as in Figure 2 and Figure 3 respectively. Occupational noise exposure among leaf blower and grass cutter workers was measured using 3M The Edge 4 personal noise dosimeter which complied with ANSI S1.25-1991 (R1997) and IEC 1252-1993-Electroacoustic. The Department of Safety and Health (DOSH), Malaysia has established a standard procedure of personal noise monitoring assessment. The dosimeter was set up prior to the measurement with threshold level of 80 dB, criterion level of 90 dB, sampling rate is slow and exchange rate of 5 dB as specified in FMR 1989 [6].

In this study, the personal noise dosimeter was clipped on the workers' shoulder as a close position to the workers' ear as in Figure 4. The measurement was conducted for four working hours and was projected to eight working hours. The data was retrieved by using the Detection Management Software (DMS), a data logger of 3M instruments. The instrument was also calibrated prior and after the measurement at 114 dB in order to control the measurement errors and uncertainties to acceptable levels. The measurement was carried out based on BS EN ISO 9612: 2009, Acoustics-Determination of occupational noise exposure- Engineering Method [20].

Type 1 Pulsar Model 33 calibrated data logging sound level meter was used to measure the sound pressure level of the machines. Model 106-Class 2 acoustic calibrator with reference sound of 94 dB ± 1 dB @ 1 kHz was used to calibrate the SLM before and after measurements. The calibration readings are in the range of 93-93.2 dB before and after the measurements. The most common method used is BS EN ISO 3746: 1996 Acoustics-Determination of sound power levels of noise sources using sound pressure survey method using an enveloping measurement surface over a reflecting plane [21]. In this study, the sound pressure level was measured at six points around the working area for 15 second per point at 1 meter distance. However, there are some measurements taken at a distance more than 1 m to avoid any interruption to the workers as in Figure 5.

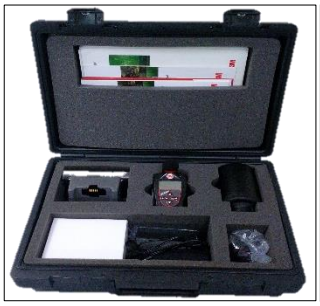


Figure 2 Personal noise Dosimeter

Figure 3 Sound level meter

Figure 4 Attachment of personal noise dosimeter

Figure 5 Measurement of sound pressure level

Then, the measurement values were converted using Equation 1.1 for hemispherical radiation where machines were considered near or on the ground. It is an equation of relationship between the sound power

level, L_w and sound pressure level, L_p. By using this equation, the sound power levels of machines were obtained.

$$L_w = L_p + 20 \log_{10} (r) + 8 \quad 1.1$$

where, L_p = sound pressure levels measured from each machine
r = distance between measurement point and the machine
8 = constant used for hemispherical Radiation, measured in dB

Other than the measurement of occupational noise exposure and sound pressure level, interview sessions with the leaf blower and grass cutter workers were conducted. The purpose of the interview is to determine the demographic background of the workers, symptoms of hearing loss and awareness of occupational noise exposure. Other than that, it helps to observe the hearing capability among workers in responding to the questions asked.

3.0 RESULTS AND DISCUSSIONS

3.1 Occupational Noise Exposure Monitoring

Table 2 summarizes the results of occupational noise exposure monitoring which includes noise dose (4 hours), projected noise dose (8 hours), TWA (4 hours), projected TWA (8 hours), L_{peak} and L_{max} values. The workers were exposed to noise dose of 22.5 to 122.9% for four hours and 59.0 to 380.2% for eight hours. The range of TWA for four hours is 81.0 to 90.8 dBA and 84.4 to 95.8 dBA for eight hours. GC2 may experience the highest noise dose of 380.2% and TWA of 95.8 dBA for eight hours which exceeded permissible noise dose of 100% and TWA of 90 dBA respectively. Meanwhile, the ranges of L_{peak} and L_{max} are 116.3 to 143.2 dBA and 96.9 to 118.1 dBA respectively.

Table 2 Summary of occupational noise exposure among leaf blower and grass cutter workers

Type of Worker	Noise Dose, % 4 hours	Projected Noise Dose, % 8 hours	TWA, dBA 4 hours	Projected TWA, dBA 8 hours	Lpeak, dBA	Lmax, dBA
LB1	40.8	85.7	86.1	89.3	122.3	102.9
LB2	74.1	104.8	88.7	90.2	132.5	107.7
LB3	29.7	76.4	84.7	88.8	125.7	101.2
LB4	46.0	89.6	86.6	89.5	124.1	103.1
LB5	98.8	127.4	89.9	91.0	120.8	102.4
LB6	93.3	162.3	89.7	92.1	143.2	118.1
LB7	73.1	159.9	88.6	92.0	116.3	101.0
LB8	24.3	127.6	83.8	91.0	122.2	97.3
LB9	22.5	67.9	81.0	84.4	120.8	96.9
LB10	122.9	264.1	90.8	94.2	125.7	108.6
GC1	80.4	165.7	89.0	92.1	130.8	103.6
GC2	115.4	380.2	90.6	95.8	127.9	102.1
GC3	53.6	103.8	87.2	90.1	129.1	106.0
GC4	41.3	80.2	86.1	89.0	129.5	100.5
GC5	49.9	98.1	86.9	89.9	128.1	103.3
GC6	73.3	147.2	88.6	91.6	132.3	105.4
GC7	39.4	99.0	85.9	89.9	130.2	97.9
GC8	26.5	59.0	84.2	87.7	128.5	97.7
GC9	72.2	151.7	88.5	91.8	129.9	100.6
GC10	110.6	191.1	90.4	92.8	131.4	102.1

LB= Leaf Blower, GC= Grass Cutter, TWA=Time-Weighted Average

Figure 6 shows the comparison of occupational noise exposure among workers with action level of 85 dB(A), permissible exposure level (PEL) of 90 dB(A) and maximum exposure level (MEL) of 115 dB(A) as specified under FMR 1989. Any TWA of the workers which fall below action level of 85 dB(A) is consider as a safe working environment. All workers should not expose to PEL of 90 dB(A) without wearing any HPDs. Based on the Figure 6, only one worker, LB9 (84.4 dBA) may expose to noise level less than action level and PEL for 8 hours. There are 12 out of 20 workers (LB2, LB5, LB6, LB7, LB8, LB10, GC1, GC2, GC3, GC6, GC9, GC10) who may expose to noise level exceeded PEL of 90 dB(A) for 8 hours. None of the workers may expose to noise level which exceed MEL of 115 dB (A).

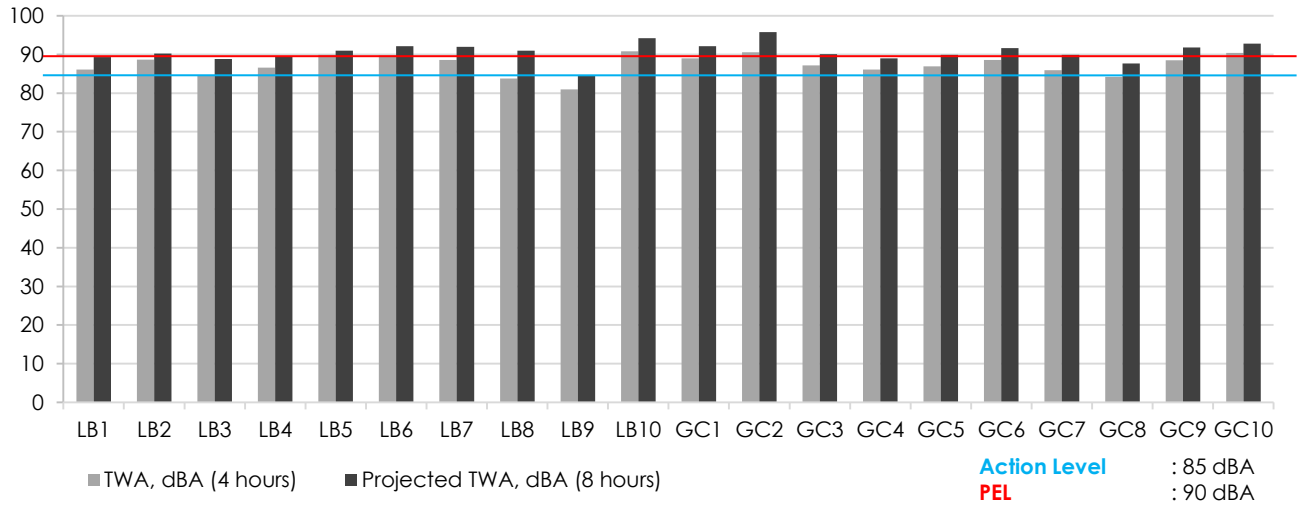


Figure 6 Comparison of noise exposure (TWA) with limits

3.2 Sound Power Level Evaluation

For this study, 20 machines were measured for the sound pressure level to determine their sound power levels. Table 3 summarizes the type of machine, model of machine, working zones and sound power level. There are two models of machines for both leaf blower and grass cutter machines. The range of sound power level for all the machines is between 106.2 to 116.8 dBA. The lowest and highest sound power level are produced by GC8 and GC10 respectively.

Table 3 Summary of sound power levels of leaf blower and grass cutter machines

Type of Machine	Model of Machine	Working Zones	Sound Power Level, dB (A)
LB1	STIHL BR420	2	108.0
LB2	STIHL BR420	4	107.1
LB3	STIHL BR420	4	110.4
LB4	STIHL BR500	5	107.7
LB5	STIHL BR420	6	109.0
LB6	STIHL BR420	7	110.4
LB7	STIHL BR420	8	112.6
LB8	STIHL BR420	9	107.5
LB9	STIHL BR500	10	107.5
LB10	STIHL BR420	11	107.3
GC1	MITSUBISHI TB43	1	108.8
GC2	MITSUBISHI TB43	2	113.0
GC3	MITSUBISHI TB43	3	106.6
GC4	MITSUBISHI TB43	5	109.5
GC5	MITSUBISHI TB43	6	110.1
GC6	MITSUBISHI TB43	7	111.5
GC7	MITSUBISHI TB43	8	106.5
GC8	MITSUBISHI TB43	9	106.2
GC9	MITSUBISHI TB43	10	108.9
GC10	OGAWA BR430	11	116.8

LB= Leaf Blower, GC= Grass Cutter

Based on Table 3, the sound power levels for the leaf blower and grass cutter machines are almost similar. The lowest and highest sound power levels of the leaf blower machine are 107.1 and 112.6 dBA respectively. Meanwhile, the lowest and highest sound power levels of the grass cutter machine are 106.2 and 116.8 dBA respectively. The difference in sound power levels may be due to the specification and age of the machine, working condition and maintenance factor.

The measured sound power levels of leaf blower machines were compared with the guaranteed sound power level. The specified sound power level of STIHL BR 420 and BR 500 leaf blower machines are 108 and 100 dBA respectively. Some of the sound power levels obtained exceeded the guaranteed sound power level specified by the manufacturer. LB3, LB5, LB6, LB7 and LB8 of STIHL BR 420 exceeded the guaranteed sound power level. Meanwhile, both LB4 and LB9 of STIHL BR 500 also exceeded the guaranteed sound power level.

3.3 Interview Feedbacks Evaluation

Based on the interview feedbacks, all workers do not undergo any audiometry test. The employers or supervisors of the workers have supervised all the workers during working period. Table 4 summarizes the other information obtained from the interview sessions with 10 leaf blower and 10 grass cutter workers. Demographic information of the workers shows that the age range of all workers is from 20 to 45 years old. Meanwhile, the range of working experience among them is from one month to 19 years. Other than that, all leaf blower workers were wearing hearing protection devices (HPDs). However, only one grass cutter worker who was wearing ear plugs and the rest of them did not have any.

In terms of awareness and perception of noise among the workers, three of them are not aware with noisy working environment and some of them are not aware with the effects of noise on hearing capability. Quarter of the workers reported that they have health problems which include migraine, frequent fever and high blood pressure. The rest of them are in good condition. Only four workers have experienced other health problems such as shoulder numb, hearing interruption and tinnitus. The grass cutter workers were not provided with any HPDs by the employers as compared to the leaf blower workers. All workers do not attend any workshop on occupational noise hazard, they only have regular meeting with staff from the Office of Assets and Development.

Table 4 Summary of interview feedbacks among leaf blower and grass cutter workers

Type of Worker	Age (Year)	Working Experience (Month/Year)	Hearing Protection Device	Noisy Working Environment	Effect of Noise on Hearing	Health Problems	Other Health Problems after Working	HPD Provision	Workshop on Noise Hazard
LB1	40	7 years	Yes[1]	Yes	Yes	Yes[3]	Yes[6]	Yes	Yes[10]
LB2	28	8 years	Yes[2]	Yes	Yes	Yes[4]	Yes[7]	Yes	Yes[10]
LB3	20	1 year	Yes[1]	Yes	No	No	No	Yes	No
LB4	24	1 month	Yes[1]	No	No	No	No	Yes	No
LB5	35	2 years	Yes[1]	Yes	Yes	Yes[5]	No	Yes	Yes[10]
LB6	27	1 month	Yes[1]	Yes	No	No	No	Yes	No
LB7	20	2 years	Yes[1]	Yes	No	No	No	Yes	Yes[10]
LB8	37	4 months	Yes[1]	Yes	Yes	No	Yes[8]	Yes	No
LB9	20	1 month	Yes[1]	No	No	No	No	Yes	No
LB10	45	8 years	Yes[1]	Yes	Yes	Yes[5]	No	Yes	Yes[10]
GC1	30	8 months	No	Yes	No	No	No	No	No
GC2	26	1 year	Yes[2]	Yes	No	No	No	Yes	Yes[10]
GC3	39	6 years	No	Yes	Yes	No	No	No	Yes[10]
GC4	40	8 years	No	Yes	No	No	No	No	Yes[10]
GC5	22	6 months	No	No	No	No	No	No	No
GC6	31	2 months	No	Yes	No	No	No	No	No
GC7	38	16 years	No	Yes	Yes	No	No	No	Yes[10]
GC8	30	10 years	No	Yes	No	No	No	No	Yes[10]
GC9	37	19 years	No	Yes	No	No	No	No	Yes[10]
GC10	40	8 years	No	Yes	Yes	Yes[4]	Yes[7, 9]	Yes	No

[1]Ear Muff, [2]Ear Plug, [3]High Blood Pressure, [4]Migraine, [5]Frequent Fever, [6]Hearing Interruption, [7]Headache, [8]Shoulder Numb, [9]Tinnitus, [10]Meeting with staff from Office of Assets and Development

Some of the older workers reported prevalence symptoms of NIHL such as hearing interruption and tinnitus. Based on the feedbacks, age and working experience can be associated factor of noise-induced hearing loss. Several previous studies agreed that age is the contributing factor of NIHL [2,22,23]. On top of that, grass cutter workers have higher risk of acquiring NIHL as compared to leaf blower workers because they were not provided with any HPDs by the employer. As previously stated, the sound power levels of both leaf blower and grass cutter machines are high and almost similar in values. Thus, the risk of acquiring NIHL of both works is the same. Hence, all workers need to be provided with necessary HPDs during working.

The two common hearing protection devices (HPDs) are ear plugs and ear muffs. Ear plugs are disposable, inexpensive, single use items and more comfortable than ear muffs in the heat and humidity. Meanwhile, ear muffs cover the whole external ear part and provide more predictable noise attenuation level. The provision of HPDs somehow may reduce the risk of acquiring NIHL among the workers. On the other hand, NIHL burden can be minimized by the use of engineering controls to reduce the generation of noise at its source since occupational noise is a significant cause of adult-onset hearing loss.

There are several effects of occupational noise exposure among workers such as primary effects (acoustic trauma and tinnitus), communication and performance effects (annoyance and absenteeism) and other effects (cardiovascular problem, stress and high blood pressure). Based on the interview feedbacks, some of the workers showed the prevalence symptoms of NIHL and tendencies to have hearing impairment, but there are insufficient evidence to indicate that these symptoms are caused by excessive noise exposure at their working environment. However, it can be concluded that the workers are at high risk of acquiring NIHL because most of them are exposed to excessive noise dose and TWA for eight hours and high sound power level of the machines.

4.0 CONCLUSION

Most of the workers were exposed to the excessive noise exposure within 4 hours of working period and they may have higher noise exposure level within eight hours of working period. Besides that, both machines produced similar high sound power level and some of measured sound power levels exceeded the guaranteed sound power levels specified by the machine's manufacturer. Interview feedbacks from the workers also indicate high risk of acquiring NIHL. Although the results obtained only from a small sample of workers, this study revealed that most of the workers are exposed to excessive occupational noise exposure and at high risk of acquiring NIHL.

NIHL can be prevented by implementing effective hearing conservation program. The workers who are exposed to the excessive noise exposure need to undergo audiometry test annually to identify any hearing impairment. It is the duty of the employer to provide required HPDs to the workers. The workers must be separated within 15 meters from each other to avoid combined noise level exposures while working in group. Thus, it is very essential to carry out occupational noise exposure assessment in order to

identify occupational noise exposure levels among workers and to determine necessary corrective actions such as hearing conservation program and noise control.

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