Evaluation and Analysis of Noise Pollution in the Manufacturing Industry

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M Subramaniam1, M Z Hassan*1, M F Sadali1, I Ibrahim1, M Y Daud1, S A Aziz1, N Samsudin1 and S Sarip1

1 UTM Razak School of Engineering and Advanced Technology, Universiti Teknologi Malaysia, Jalan Sultan Yahya Petra, 54100 KUALA LUMPUR.

*Corresponding: mzaki.kl@utm.my

Abstract. In the past few decades, a rapid of industrialization increasing the noise pollution and provides a people awareness to combat this issue. Here, apart from providing employment opportunities to worker, manufacturing industry also produce disturbing noise that is generated by various sources especially from the machineries. The aim of this study is to estimate the maximum working hours due to the over exposure of the noise hazard in the industry. Initially, the reading of noise exposure was obtained using the dosimeter. Then, criteria for a recommended standard occupation noise exposure based on NIOSH (1998) and OSHA (1989) noise working safe condition was measured. The results indicate that there is high risk of noise-induced hearing loss (NIHL) among workers that come from the noise exposure was obtained. The critical is CAM & CNC department with less than 0.125 hours and 1.33 hours following NIOSH and OSHA regulation respectively. In addition, the proposedly related noise exposure working period are also included.

1.Introduction

Noise is generally well-defined as any undesirable or unattractive sound. The general effect of noise pollution has been a topic of debate among the researchers for a number of years [1-5]. In order to combat this issue, developed countries such as Japan had enacted such legislation in 1972, the Health and Safety at Work Act 1974 (United Kingdom) and United States of America with the Occupational Health & Safety Act in 1970. In Sweden and Norway, the Act was called Internal Control Regulation. The overview of wide-ranging Occupational Safety and Health Act (OSHA) was updated in 1994 to the need of wider employee base and newer hazardous act in the workplace. Here, OSHA states that the maximum working hours for industrial workers shouldn't been exposed to noise level of 90 dBA for 8 hours of period.

The ordinary human ear and nervous system have their own maximum volume to accept and perceive level of sound. Depending on period, level of noise exposure and distance from the source typically effect of the human nervous system and comfortable. The effect of noise to human health is divided into four groups: physiological effect (high blood pressure, irregularity of heart rhythms and ulcer), psychological effect (stress and irritability), performance effect (reduction in productivity) and physical effect (hearing loss). Sensor neural hearing loss is one such disease that occur which hair cells of the inner ear (stereocilia) lose their ability to transmit sound information to the brain. This noise-induced hearing loss is the most common aetiology hearing loss caused by exposures to hazardous levels of noise in a manufacturing plant [2]. In addition, Babish *et. al.* [3] found that physiological cardiovascular effects is due to over exposure to level of noise. They suggested that acute of noise can cause increases in blood pressure, heart rate and cardiac output resultant by release of stress hormones including catecholamine. Thomas *et. al.* [4] reviewed the cardiovascular effect on overexposed of environmental noise exposure.

The auditory system, noise causes annoyance and disturbs sleep, and it impairs cognitive performance. Furthermore, evidence from epidemiologic studies demonstrates that environmental noise is associated with an increased incidence of arterial hypertension, myocardial infarction, and

stroke. This study al so show studies indicate that in particular night-time noise can cause disruptions of sleep structure, vegetative arousals and increases in stress hormone levels and oxidative stress, which in turn may result in endothelial dysfunction and arterial hypertension.

Many attempts have been made in order to investigate the hazardous level of noise in a workplace. Atmaca *et. al.* [5] conducted an industrial noise exposure at concrete traverse, iron, cement and textile factories located in Sivas, Turkey. It has been shown that the noise level in all the above industries are much above the noise level of 80 dBA. The degree of disturbance from noise amongst the employees employed for 5-10 years is 74 % and increase to 100% among worker occupied for more than 21 years was recorded. In addition, it is conceivable to state that the weightiest disturbance produced by noise is uneasiness. Investigations made on the type of hearing complications designate that 31% and 35% of the employees are commonly complaining about pollutions like hearing loss and distressed from noise hearing complications respectively. Nadya *et. al.* [6] investigated occupational noise for the toll tellers employed at toll plaza that extensively over contact to noise. The greatest dangerous was disclosure that the peak level of sound produced from the heavy vehicles such as buses and trailers. In spite, the overexposure of noise also affected the health including hearing loss, the level of noise also informed significantly annoyance and had troubled the job of toll tellers. It also suggested that a toll tellers are at risk unprotected to high level of noise which significantly exceeded threshold limit values, and majority of the toll tellers apparent noisy and getting irritated by the sources of noise at toll plaza.

In addition, the discussion of the study regarding to occupational noise hazard which extracted from Voorhees *et. al.* [7] indicates lower noise stages from different tank rooms has been reported, however the highest value 83.2 dBA recorded immediately when the pavilion tanks was been adjacent to the power washer. Attarchi *et. al.* [8] indicates that shift operational and separate noise contact have preservative result on incidence of hypertension in rubber manufacturing. Other than that Ismail *et. al.* [9] conducted a noise level awareness amongst the workers in quarry industry. They said that noise is one of the occupational hazard and it may lead to higher prevalence of noise induced hearing loss. Based on Kisku *et. al.* [10] recently suggested the benefit of power plant to adopt precautionary procedures and safety approaches in thermal power plant to reduce the noise level. The noise monitoring was carried out using sound meter level for 30 min at a height of 1.5 m and 1 m away covering 73 locations of small scale power plant. The noise level was found at control, compressors and fan rooms were recorded more than 85 dBA. They concluded that noise may not jeopardize employee's life immediately but might be the cause of neurobehavioral change, psychological stress and unhappiness in daily life without showing the symptoms of chronic diseases. Oyedepo *et. al.* [11] found that there is no significant different of hazardous noise level between community and industrial. They show that the noise pollution levels in Ilorin metropolis exceeded the recommended level by WHO at 34 of 47 measuring points. It can be concluded that the city is environmentally noise polluted and road traffic and industrial machineries are the major sources of it. In 2015, Anjorin *et. al.* [12] found that there is high hazard of rising noise induced hearing loss in manufacturing and processing businesses. The average noise equivalent level (LAeq) was studied to identify the noisy machines and generate baseline data. A precision grade sound level meter was used to determine the various pressure levels of sound at thirty minutes interval for five days. It was observed that noise limit values were exceeded at almost all machines regarding to regulation criteria and international standard. Also, the results of this study shows that noise control measures were not adequate in the industries surveyed.

This particular study was attempted to investigate the noise pollution level at different department of a manufacturing industry. The result will be useful for related workers as their awareness and for the industry management to implement mitigation strategy. This study was adapting NIOSH and OSHA guidelines for data experiment and collection procedure.

2.Material and method

Sound Level Mater (SLM) is a device that used to obtain the level of noise in the unit decibel (dBA). The Impulse Integrating Sound Meter model Quest SoundPro SP SE-2SLM was selected and able to take readings in fast and slow mode. This SLM is obtained the reading of sound pressure level in a

particular period. During the data reading, SLM when the small air molecule mixed the vibration of sound and give an impact to the surface of microphone. The energy then transform into electrical signal and it appear as a sound value in unit of decibel (dBA).

In order to provide constantly reading, the CASELLA Calibration model was used for each measurement sequence. This type of measurement accurateness is compulsory for observing within noise exposure standards following the Noise at Work and environmental noise regulations. Data obtained from the QUEST Soundpro SP SE-2 through area sound monitoring were transferred to a computer using the 3M™ Detection Management Software (DMS). Data were scrutinized on the basis of corresponding constant sound pressure level (Leq), and peak sound pressure level (SPL). Octave band data were documented for Leq at each dimension site during selection events. Both one-third and full-octave bands were documented.

Figure 1 show the SLM and calibrator were used in this study. Those measurement devices were installed at the four potential areas of hazard including polishing site, surface treatment site, CAM & CNC machine area, and quality control area. The monitoring process was continuously carried out for seven days within 8 hours per day. The factory operates at 8 hour per shift and 3 shift per day.The SLM were statically positioned near by the noise sources at approximate 1 meter height.

Sound Level Meter: Impulse Integrating Sound Level Meter.
Made : QUEST
Model : SoundPro SP SE-2
(JKKP PSLM 50/06)
Serial No : BA109005

(a)

Calibrator-Made : CASELLA
Model : CEL-110/2
Serial No : 049113

(b)

Figure 1 Noise monitoring (a) SLM and (b) calibrator devices

3.Results and discussion

Figure 2 shows a noise level against time traces at Polishing Department for two days. The recording was taken between 7am to 4pm. It can be seen that the peak noise values occurred at 8.30am and 3.30pm for those days. In other hand, the peak values of noise level at 12.00pm on Tuesday was also been recorded. The values are reached above than 90 dBA. Here, the communication between operators that associated with the polishing machine noise is primary annoyance at this time. As can be seen from Figure 2, the noise levels were constantly found to be exceeding 85 dBA at 14% and 27% for those Monday and Tuesday respectively.

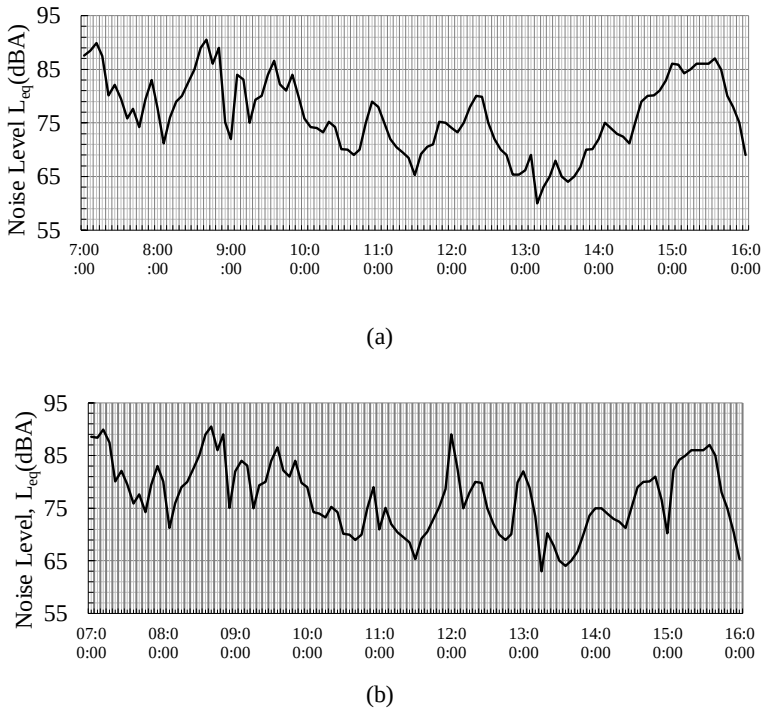

Figure 2 Typical noise level - time traces for (a) Monday and (b) Tuesday at Polishing Department

Figure 3 shows noise level (dBA) against time traces at Surface Treatment department. The noise level was recorded from 8am – 5pm on daily basis for a week. The noise level at peak value, 90 dBA at 8.30 am for every day and the average noise levels approximately at 76 dBA were recorded. The noise levels in this section were somewhat less severe with 5% of time exceeding the 85 dBA. From the result indicated in Figure 3, most of the occurrence of noise that contributed from the surface treatment machine may contributed to the level that exceeded 65 dBA and interrupt the normal conversation between operators especially those who work in this section.

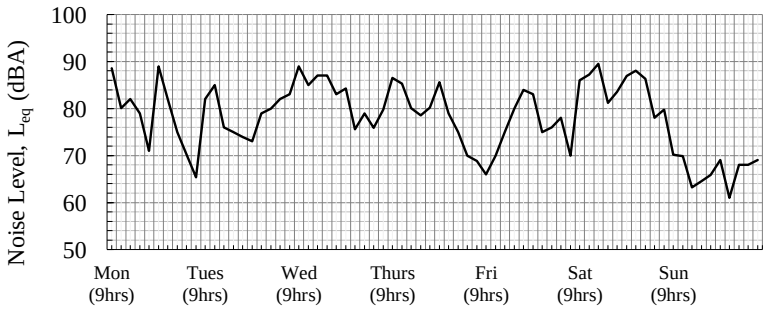

Figure 3 Typical noise level (dBA) – time for a week at Surface Treatment Department

Another high-risk noise exposure within the factory is the area of CAM & CNC. Figure 4 shows noise reading recorded in this area at the average of 103.27 dBA which much higher than the allowable limits by NIOSH and OSHA. The noise level recorded seem to be fluctuated between day to

day and hour by hour. In addition, Thursday and Friday recorded the highest noise level at 120 dBA, however Monday recorded the lowest values. Whereas on the hourly basis, it is observed that maximum sound level reading in the early morning and the level slightly reduced toward afternoon. The level is significantly regained in the afternoon and declined again toward the end of the shift. There are many possibilities to influence the sound level in this area. It is expected that all machines fully operate in the early morning and many other production activities such as conveyor movement, material handling activities during this period may contribute the higher noise reading. This intolerable noise level could harm the workers within this area. A special attention need to be done by the factory management to mitigate noise risk.

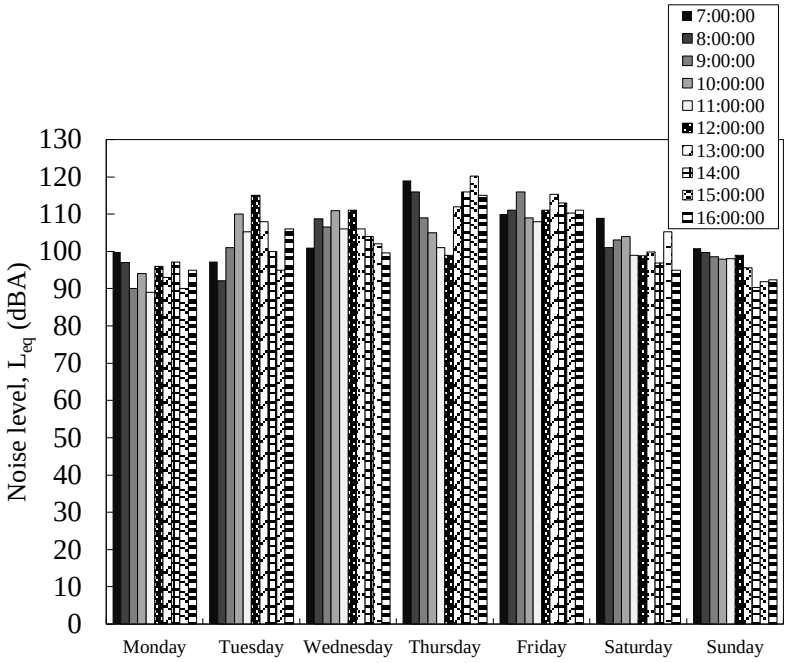

Figure 4 Daily and hourly noise level at CAM & CNC area

The hourly-average noise level has been calculated for all days studied. **Figure 5** shows the average noise level recorded for all departments. It is apparently CNC & CAM area recorded the highest compared to the other departments. The hourly reading within 90dBA to 120dBA are exceed the allowable limit recommended by NIOSH and OSHA. For the other departments, similar noise levels were recorded. The noise level of these departments are within the allowable limit between 62dBA and 90dBA.

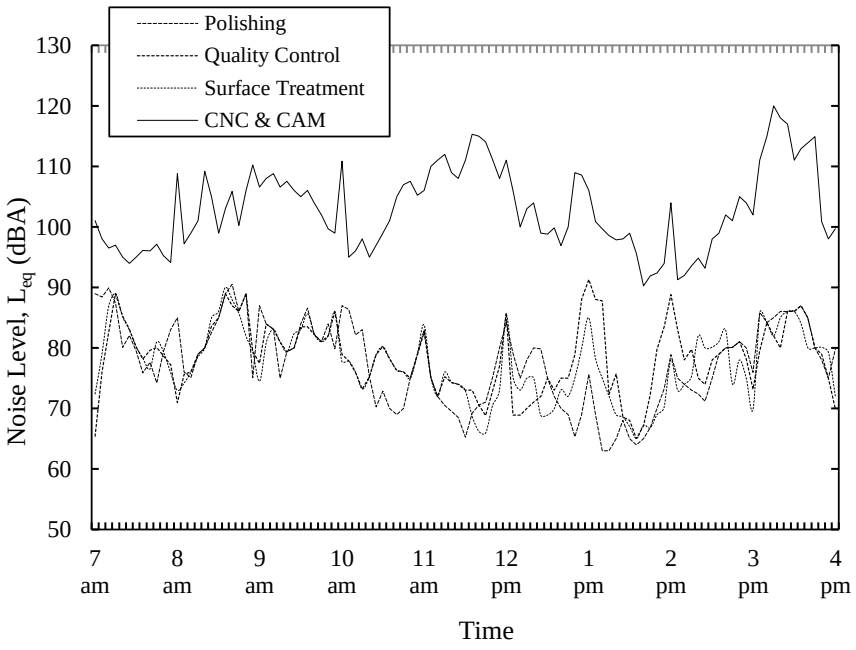

Figure 5 Hourly-average noise level for all departments on Saturday

3.1 Assessment of noise dose and shift exposure

In order to determine the of shift exposure following NIOSH and OSHA recommendation, the actual noise exposure (L_{EX}) and noise dose needs to be calculated. L_{EX} is a noise energy level-averaged over 8 hours and it is closely related to the Leq. Leq is the equivalent steady sound level of a noise energy-averaged over time. Those values can be measured using the following Equation 1 [13].

$$L_{EX} = \text{Leq} + \text{correction for the shift length} \quad (1)$$

where the correction is given by the **Figure 6**

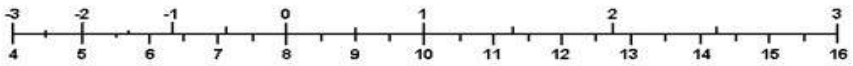

Figure 6 Shift time correction to measure L_{EX}

Table 1 tabulates the comparison of noise level with NIOSH (1998) and OSHA (1983) guidelines. The L_{ex} values calculated based on 8 hours/day and 5 days/week work pattern. In addition, the noise dose (%) was measured following interpolation and the nomograph in Appendix 1 of WorkSafeBC [13]. As can be seen from **Table 1**, the permissible working hours for CAM and CNC per shift should be less than 0.125 and 1.33 hours based on NIOSH and OSHA guidelines respectively. Here, the noise exposure significantly 64 times and 6300% of noise dose level which is higher than permissible level. In contrast, other departments are permitted to work for more than 8 hours per shift.

Table 1 The comparison of noise level with NIOSH (1998) and OSHA (1983) guidelines

Department	Leq (dBA)	L_{EX} (dBA)	Noise Dose (%)	Permitted Shift Length (hr)/day (NIOSH)	Permitted Shift Length (hr)/day (OSHA)
Polishing	77.97	77.97	20	>8 hours	>8 hours
CAM & CNC	103.27	103.27	6300	0.125 hours	1.33 hours
Quality Control	77.10	77.10	16	>8 hours	>8 hours
Surface Treatment	76.67	76.67	15	>8 hours	>8 hours

4.Conclusion

The noise survey was successfully carried out in this manufacturing factory. Since the exposure monitoring confirmed levels is over of the permissible exposure limit as stipulated in the NIOSH and OSHA regulations, remedial action need to be undertaken by the management. It has been identified that the CAM & CNC department recorded highest noise reading at average of 103.27dBA. The entire departments are allowed to operate more than 8 hours per shift except CNC & CAM department which limited to 1.33 hours per shift to reduce the hearing impairment issue. In order to minimize the noise exposure the employer should been issued an ear plug or ear muff to respective department as additional control measures in the factory.

Acknowledgments

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If the decision is revision required, the author should follow the correct journal template (or format guidelines) for the revised version.

Comments Below:

1. Please indicate the maximum working hours based on noise exposure in abstract

   Abstract is updated.

2. OSHA 1994 doesn't mention about noise exposure regulation as per stated inside Factory & Machinery Act 1967

   Please refer Noise Exposure (201X) under OSHA 1994 where action level is equal 82dB(A) and PEL is 85 dB(A) for 8 hours.

3. Nowadays, there were no more toll tellers after highway management started to implement electronic transaction using touch & go at every toll plaza. Thus, this noise problem had been controlled.

   This section is referring to manuscript by Nadya et al. They studied the effect of noise among toll tellers in 2010. Sure, the result is valid at that time.

4. Personal noise measurement shall be measured by using dosimeter. The methodology indicates the sound source measurement.

   We are not measuring a personal noise and the study focus on sound source measurement using SLM.

5. Do justify whether the graph that shown in Figure is Leq or Lpeak.

   We use Leq recording modes from SLM

6. Do justify whether the mode for SLM is fast or slow response

   SLM is recorded in slow response. In slow response mode, the noise measurements are easier to read and data is smoothed out recorded in average noise level.

7. The high noise generation were due to background noise and additional of noise for others machinery.

   No it isn't. No it isn't. Each department is separated and the noise not penetrate others section

8. Figure 5 is unclear

   Figure 5 is updated

9. Do show the formula or equation which convert Leq to dose value.

   Please refer to Appendix 1, WorkSafeBC. It is nomograph.