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MONITORING THE NOISE EXPOSURE IN MANUFACTURING FACTORY USING MALAYSIA (FACTORIES AND MACHINERY (NOISE EXPOSURE) REGULATION 2019)

Zainal Fitri Zainal Abidin [1], Fiona Jenai ak Anthony Nait [2]

[1,2] Associate Professor, Mechanical Engineering Department, Universiti Kuala Lumpur Malaysia France Institute Section 14, Jalan Teras Jernang, 43650, Bandar Baru Bangi, Selangor, Malaysia

Email: [1] zainalfitri@unikl.edu.my, [2] fionaanthony93@gmail.com

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ABSTRACT

This research is about the monitoring the noise level in manufacturing industry by using Factories And Machinery (Noise Exposure) Regulations 2019 the new regulation operated on 1st June 2019 replacing using Factories And Machinery (Noise Exposure) Regulations 1989. Noise with high level has been known as a potential danger to the workers. The noise higher than the permissible according to Noise exposure regulation can lead to auditory and non-auditory effects like hearing loss, decrease production of the performance, the disturbing, and cardiovascular health effects among the workers. The objectives of this research are to identify which workstation produce noise level that has a possible to lead auditory and non-auditory effects to the workers. This result used to compare the noise level in the manufacturing company by using Factories and Machinery (Noise Exposure) Regulations 2019 and 1989. In order to get result for 1989, technical calculation is used. Based on the data produce in the manufacturing factory, the noise mapping then will be construct to highlight which area produce more than the allowable noise level. If the noise exposure exceed the allowable recommend alternative to reduce noise exposure for the workers in the company. Sound meter Tenmars ST-107 and noise dose of Soundtek meter ST-130/ST-130s is used as technical device to perform measurement of noise level. All the result, will compared with Malaysia Factories and Machinery (Noise Exposure)

Regulation 2019. A noise mapping will be constructed by using AutoCAD drawing software to draw the floor layout and using Rap-One to do the mapping.

1. Introduction

The number of manufacturing and production sector in Malaysia has shown some growth rapidly every year. Manufacturing stay as a critical force in both improved and developing economies. The sector has contribute enormously to the GDP and it has massive potential for creating employment opportunity. Almost two thirds of employment in the informal sector were intensive in the Services industry (62.1%) followed by Construction (20.0%). Informal sector employment in the Manufacturing industry comprised of 17.2 per cent, increased 1.3 percentage points from 15.9 per cent in 2015.[1]

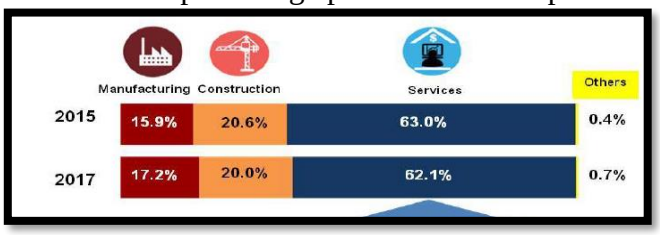

Figure 1 *Bar chart of employment in the informal sector by industry, Malaysia 2015 and 2017[1]*

Unfortunately, industrial machines generate noise that can impact hearing of the worker if they are exposed to the noise on a more than recommended duration on the daily basis. According to Xiuting, group exposure to noise above than 85 dBA, obtained result of hypertension, abnormal electrocardiogram (ECG), hearring difficulty was 13.64%, 13.74% and 25.74%. Noise exposure below than 85dBA was 11.38%,13.06% and 21.35%.[2] This supported by Buksh, In industry marble and mosaic that was exposure level of 88.0 dBA, 35% feel uncomfortable, 70% headache, and 55% speech interface. And 35% employees felt stress with high level stress.[3] The occupational safety and health administration expects employers to supply personal protection equipment for hearing protection when commotion levels surpass explicit dimensions. As claimed by Kelly, ear-muffs and ear-plugs is a sensible, immediate control measure which is a simple to protect workers. [4] Regardless of whether assurance is required relies upon the sound dimension and the length of the exposure.
Unfortunately, industrial machines generate noise that can impact hearing of the worker if they are exposed to the noise on a more than recommended duration on the daily basis. The occupational safety and health administration expects employers to supply personal protection equipment for hearing protection when commotion levels surpass explicit dimensions.

One of the health costs of the modern workforce is hearing loss. Meanwhile, musculoskeletal wounds often get attentions regarding of media coverage,

hearing loss is a deep more subtle way problem that is frequently fail to notice by both management and employees alike. The simple fact is that exposure to noisy sounds over a specific limit for extended timeframes will result in permanent hearing destruction from which there is no regaining back.

2. Factories And Machinery (Noise Exposure) 2019 And 1989

In Malaysia, for 30 years Factories and Machinery (Noise Exposure) Regulation 1989 had being used as guideline for all companies. On 1st March 2019, a new regulation is announced that the Occupational Safety and Health Noise Exposure) Regulation 2019 started operation on 1st June 2019. This regulation replaced the Factories and Machinery (Noise Exposure) Regulation 1989.

A. Factories and Machinery (Noise Exposure) Regulation 1989

The noise level of equivalent idea forms the exposure criteria basis used in the Noise at Work Regulations 1989 which known it 'daily personal noise exposure'. In this regulation the dosimeter set up must follow according to Table 1.

Table 1 *Dose Meter Set Up For Regulation 1989*

Data	1989
Criterion level	90dBA
Exchange rate	5 dB
Time constant	Slow
Impulsive noise	140 dBA
Maximum noise exposure	115 dBA

In Table 2 show the noise exposure level for duration of exposure. Where maximum PEL for eight hours is 90 dBA in Regulation 1989.

B. Factories and Machinery (NOISE exposure) 2019

A new regulation may be cited as the Factories and Machinery (noise exposure) regulation 2019. This regulation start into operation on 1 June 2019. The major difference in this new regulations is the daily noise exposure level which 85 dBA for daily personal noise dose. The data set up dose meter show in Table 2.

Table 2 *Dose meter set up for regulation 2019*

Data	2019
Criterion level	85dBA
Exchange rate	3 dB
Time constant	Slow

Impulsive noise	140 dBA
Maximum noise exposure	115 dBA

C. Sound Pressure level

The sound level meter made up of a microphone, an amplifier with a weighting network and read-out display form of a meter or digital. The microphone changes the fluctuating pressure of sound toward a voltage which is amplified and weighted (A, B or linear etc.). The electrical signal then drives a meter or digital read-out.

D. Dose Meter

The major different between dosemeters and sound meter level is the Nosie dose captured and measure completely full workings shifts of an employee. Almost all dose meter will generate the eight hours dose of noise so no calculation is needed. A noise dose meter made up of microphone on a cable, which attach to a person collar at the beginning of the shift and let it run until the end of the shift. The best dose meter can be placed to workers that prepared to make variety of works throughout the day.

E. AutoCAD

AutoCAD is one of the most common software [7]and widely used drawing tool among other software. In the floor layout plan. AutoCAD helps creating 2D drafting and drawing process and editing technical drawings, and also annotating designs. [8]

As for this project, the floor layout was design according to 12 workstation in production for Bioenergy Machinery located in Seremban. The area for this company is 69000mm x 20000mm.

F. Rap -One

Rap-one is one out of many software that help create noise mapping. This software is basically user friendly and can easily being used than other software. Any kind of room design, and size of room can used Rap-One as it is powerful tool with advance technology.

This software allow the intervention analysis and design in industrial and architectural. [9]

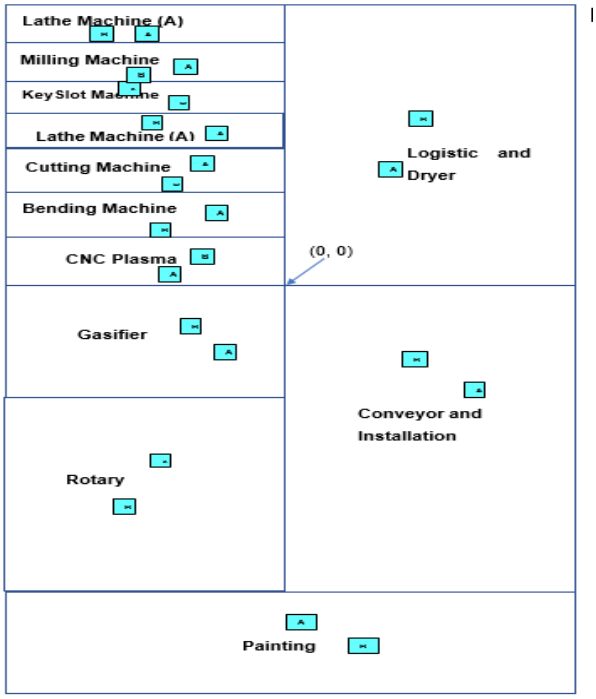

Figure 2 *The layout and position for point A and B*

As for this project, noise monitoring specifically position one meter away from the machine or equipment. As for the Figure 2 is the layout position measurement taking placed for each point.

G. Process of measuring using sound level meter

The experiment was conducted two days straight due to time taken for each workstation required 20 minutes for each point. Each workstation had two points, point A and B (according to coordinate in Figure 2). The result is taken between two points which is one meter away from the machine. In order to hold the sound meter level in fixed position tripod with height of one meter is used. The result for SPL is taken after 20minutes for each point. Repeat the procedure for each workstation.

Figure 3 *Set up for Sound Pressure level*

H. Procedure of measuring using dose meter

In order to get the data for Dose meter, there was two employees are selected to conduct this experiment from

production line with different workstation. This dose meter ST-130 is used and attached to the employees' collar neck for continuously eight hours from 8.30 a.m. to 5.30 p.m. Before the measurement started, the employees is required to fill in the information data and being explained briefly on carrying dose meter in a correct manner for straight eight hours.

3. RESULT

Analysis of data result obtained from sound pressure level and dose meter. The dose meter obtained result for two selected workstation where LEPd, Leq, Lavg, Dose%, and Twa resulted is obtained from the device itself. Meanwhile, for sound pressure level the result obtained from all workstation. The result is taken from two different points and each point spend about 20 minutes to get the average sound. Calculation for average SPL and SWL is needed. The result from SPL is used to construct noise mapping. Rap-one is software used to construct the noise mapping.

A. Graph for Sound Pressure Level and Sound power

Average SPL

In this table below is divided with twelve difference section department and the example calculation is shown to get the average SPL.

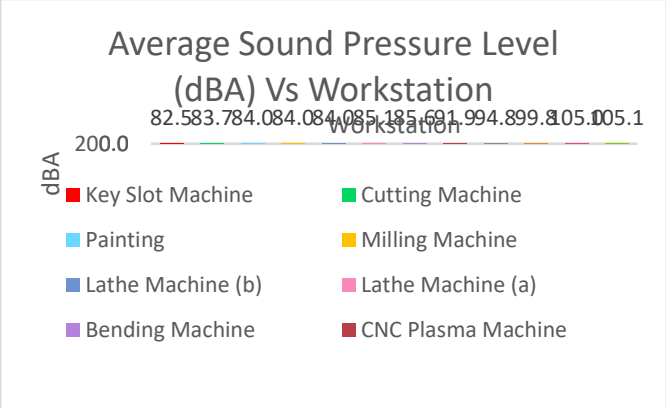

Figure 4 *Graph of the average pressures level vs section department*

As the shown in Figure 4, there are seven workstation exceed the allowable noise exposure regulation 2019 which more than 85 dbA. The highest noise recorded during this project is department rotary screening with noise exposure 105.1 dbA. Meanwhile, key slot machine is the lowest noise recorded in this factory which is only 82.5 dbA.

Sound power level and Radiated power

Formula for Sound power level is shown equation Sound source close to a flat surface; able to radiate acoustical energy to half of a sphere where Q=2 :

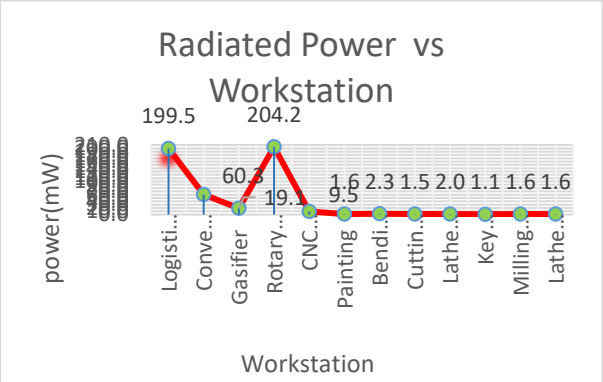

Figure 5 *Graph of radiated power vs workstation*

As shown Figure 5, the highest radiated power in graph is Rotary screening which is 204.2mW and follow by workstation Logistic and dryer which is 199.5 mW. As for Conveyor and Installation and Gasifier both 60mW and 19.1mW

Types of Noise

In Table 3 briefly explain the data analysis for type of noise produce for each workstation.

Table 3 *Type of noise produce for each workstation.*

CNC Plasma Machine	Intermittent noise	Mix of relatively quiet and noisy periods. Where CNC plasma machine is used if necessary only.	Noise recorded is exceed PEL
Painting	Intermittent noise	Mix of relatively quiet and noisy periods. Where painting spray is used for finishing only.	Noise recorded is below PEL
Bending Machine	Intermittent noise	Mix of relatively quiet and noisy periods. Where bending machine is used if necessary only.	Noise recorded is exceed PEL
Cutting Machine	Intermittent noise	Mix of relatively quiet and noisy periods. Where cutting machine is used if necessary only.	Noise recorded is below PEL
Lathe Machine (a)	Continuous noise	The noise constant and stable from lathe machine (a) throughout eight hours.	Noise recorded is exceed PEL
Key Slot Machine	Intermittent noise	Mix of relatively quiet and noisy periods. Where key slot machine is used if necessary only.	Noise recorded is below PEL
Milling Machine	Intermittent noise	Mix of relatively quiet and noisy periods. Where Milling machine is used if necessary only.	Noise recorded is below PEL
Lathe Machine (b)	Continuous noise	The noise constant and stable from lathe machine (b) throughout eight hours.	Noise recorded is below PEL

Noise Mapping

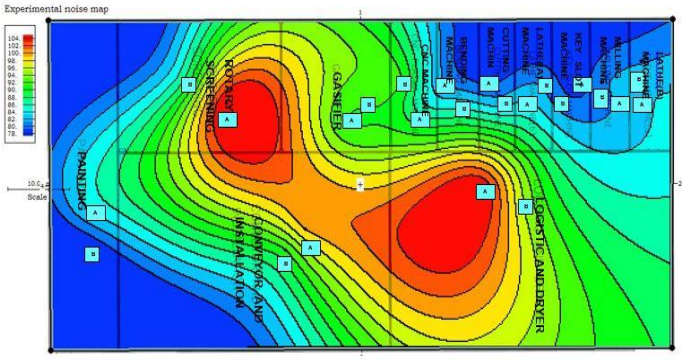

Figure 6 *Noise Mapping*

The Figure 6 show the result noise mapping for floor plan of the company. The highest leading noise generate is located on the rotary screening which 105.1 dBA and follow by logistic and dryer which 105.0 dBA. The software that used to conduct this project is Rap-one demo set software. Which limited to the types of material on the wall number one only.

B. Result for Dose Meter

Rotary Screening workstation

The first experiment is conducted on 9th October 2019 around 8.37 am until 5.39 pm.

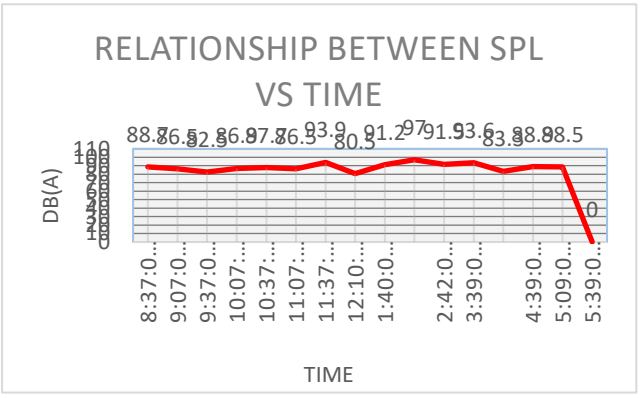

Figure 7 *Graph of relationship between SPL vs time*

In Figure 7, the result showed that the highest sound produce around 2.10 pm 97 dBA, this time around the participant using grinding machine to grind the excess slag produce from CNC plasma machine on the materials. In table below summarise the noise measurement for eight hours.

Table 4 *Summarise the noise exposure in rotary screening*

Time Weighted Average (TWA)	98.17
Actual Measured Dose (Dose %)	310.2%
Average Sound Level (Lavg)	90.3
Equivalent Sound Level (Leq)	94.9
Daily Personal Exposure Level (LEPd)	90.6

Logistic and dryer section department

The second experiment is conducted on 23th October 2019 9.40 am until 6.40 pm. But the experiment able to conduct until 6.27 pm only because the participant only work until 6.30 pm. In Figure 10 show the result for dose meter SPL.

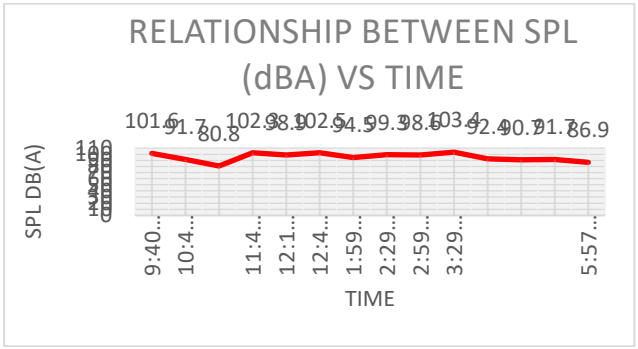

Figure 8 *Graph of relationship between SPL vs time*

In Figure 8, the data showed that the around 3.29 pm the SPL recorded the highest sound produce around 103.4 dBA, where the participant actively welding and mallet hammer blade fin s inside the dryer. Next, the lowest sound produce 80.8 dBA around 11.20 am. For 6.27 pm the result is unavailable due to the sound produced below than 70 dBA.

Table 5 *Summarise the noise exposure for logistic and dryer*

Time Weighted Average (TWA)	111.2 dBA
Actual Measured Dose (Dose %)	1876.5%
Average Sound Level (Lavg)	98.1 dBA
Equivalent Sound Level (Leq)	102.7 dBA
Daily Personal Exposure Level (LEPd)	103 dBA

C. The comparison Factories and Machinery (Noise Exposure) Regulations 1989 and 2019

Malaysia had been using Factories and machinery (noise exposure) regulation 1989 for 30 years and on 1st June 2019, the regulation had been revoked and replace by new regulation cited as Factories and machinery (Noise Exposure) Regulation 2019.

Factories and machinery (Noise Exposure) Regulation 1989

In regulation 1989, the Permissible noise exposure for eight hours 90 dBA with exchange rate of 5 dB as shown in table 1. In order to get result for each valuefor dose meter according to the regulation 1989, the theoretical calculation needed to apply Table 6 show the result for theoretical calculation for both workstation.

Table 6 *The result for theoretical calculation for both workstation*

Section Department	Rotary Screening	Logistic and Dryer
Time Weighted Average (TWA)	89.2 dBA	96.3 dBA
Actual Measured Dose (Dose %)	89.50%	240.30%
Average Sound Level (Lavg)	90.2 dBA	97.4 dBA
Equivalent Sound Level (Leq)	90.9 dBA	98.4 dBA
Daily Personal Exposure Level (LEPd)	90.5 dBA	97.9 dBA

The comparison between regulation 2019 and 1989 for Rotary Screening

In the result obtained in regulation 1989 had huge different with regulation 2019 especially for the dose meter.

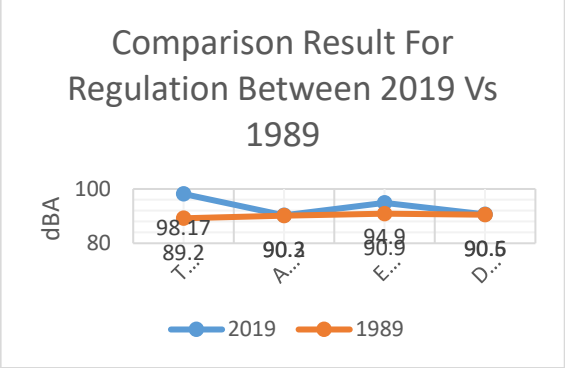

Figure 9 *Graph comparison result for regulation 2019 Vs 1989*

For Logistic and dryer workstation department show the significant different for actual measured dose which for regulation 2019 is 1876.48%. Meanwhile, regulation 1989 the dose is only 240.3%. This mainly due to the exchange rate. However, the result for permissible noise exposure for eight hours exceed both old and new regulation. The time weighted average between this both regulation also had huge different where the regulation of 1989 is 96.3dBA while the regulation exceed 100 dBA but below than 115dBA.

As for the logistic and dryer workstation department must wear a proper PPE because the employee had high potential that may lead auditory and non-auditory effects due to extreme level of noise exposure.

D. Recommendation and suggestion to reduce the noise exposure among the employees

Based the result from the SPL and dose meter obtained, out of 12 workstation in production department, 7 workstation had exceed the permissible exposure limit according to Factories and Machinery (Noise Exposure) Regulation 2019. In order to prevent more serious auditory and non-auditory effects, there are few recommendation for employer that can help to reduce the risks in the work place.

Personal hearing protection (PHP)

This PPE is very crucial for employer to provide to the employees as this help to reduce the noise exposure. However, the proper PHP should be practice as each different level of noise required different kind of PHP. If the noise exceed 85 dBA, the employees should use ear plug or ear muff. Table 7 show the result of noise reduction rating needed for each workstation.

Table 7 *Noise reduction rating for each workstation*

Workstation.	Average Sound Pressure Level (dBA)	Personal Hearing Protection (PHP)	Noise Reduction Rating
Lathe Machine (a)	85.1	foam ear plug	NNR 22 and above
Bending Machine	85.6	foam ear plug	NNR 22 and above
CNC Plasma Machine	91.9	foam ear plug	NNR 22 and above
Gasifier	94.8	foam ear plug	NNR 27 and above
Conveyor and Installation	99.8	foam ear plug	NNR33+ NNR 21
Logistic and Dryer	110.2	foam ear plug and ear muff	NNR 33 + NNR 21
Rotary Screening	98.7	foam ear plug	NNR33 (maximum)

Inspection and maintenance for PHP

It is really important to make sure the PHP are inspected regularly in order make sure that the employees use a proper PHP. If the ear plugs or cushions are no longer pliable, PHP need to be replace. The ear muffs cushion also need to clean by washing it with mild detergent in warm water. However, make sure the sound attenuating material inside the ear cushions does not get wet.

Hearing protection zones

Under regulation of factories and machinery (Noise exposure) Regulation 2019, the employer must adequate proper signage of warning to mark out the hearing protection zones. By using the noise mapping, identified the workstation exceed the PEL and warning sign shall be posted as "Hearing Protection Zones". This to ensure that no employees should entering the hearing protection zone without any proper PHP. Arrangement of alternative should be made to make sure the employees recognize and acknowledge circumstances in which PHP are required.

Information, instruction and training

The information, instruction and training must be provided to the employees who are vulnerable to the excessive noise so that they know and understand the noise exposure risk. It is really crucial to make sure the employees know and informed on effects to their health resulting from excessive noise exposure. That why the employees highly suggested to participate training on the following Occupational Safety and health (noise exposure) regulation 2019. This mainly to ensure the employees well understanding the noise pollution and its control and prevention.

Engineering control

Engineering control are process to reduce and limit the area of exposure to the excessive noise which involve insulation, damper, absorption, silencer and vibration insulation. Different machine or equipment require different approach that can help reducing the noise exposure. Table 8 show recommendation of engineering control for each equipment

Table 8 *Recommendation of engineering control for each equipment*

Equipment/ Machine	Engineering control
CNC Plasma Machine	-Adjust arc voltage and speed according to the thickness - make sure the distance between nozzle and work piece is 3-5mm
Compressor	-Isolated the compressor
	-Isolation pad between the machine and the structure (reduce vibration)
Hand Grinder	-by adding damping in to the system -Basic maintenance(replacing the carbon brushes if the brushes less than 5mm)
Drill	- use sharp drill bits - Start with a small hole if need to drill a big hole. Increase the drill bit size until reach the desire size. -use lubricant or cutting fluid as lubricating the help reduces friction noise -use drill bit isolator

Administrative Control

Usually this method is being use when it is impossible to reduce noise exposure through engineering noise control measured. Measures include create job rotation and job design to limit the time employees spend in the areas.

In order to create the job rotation, use the result from Table 9. In this table show the result for maximum time exposure in each workstation. With this information, the employer know how long each employee should spend in each workstation.

Table 9 *The guideline for job rotation according to the maximum time duration exposure in each workstation*

Workstation	SPL average	Maximum time duration exposure
Lathe Machine (a)	85.1	7 hours 48
Bending Machine	85.6	7 hours
CNC Plasma Machine	91.9	1 hour 36 minutes
Gasifier	94.8	48 minutes
Conveyor and Installation	99.8	18 minutes
Logistic and Dryer	110.2	Not allowed without PHP
Rotary Screening	98.7	18minutes

E. Summary

For sound pressure level, most of all workstation had more than 80 dBA. This mainly because this is not a big company and they just started 10 years ago. So most of the machine is out dated machine with minimum maintenance. This one of the reason why the noise produce from each machine is fairly loud. However, the study of daily area noise zones may change or different because stepwise changes in process of operation like different rate of production. The variable for this project which is the moveable/portable equipment also can affect the result, as the equipment can be used in different placed (outside the

coordinate for this project) in the workstation. Since this company only do the biomass machine upon order only, so current month the production might higher than previous month. This can change the noise exposure level. This noise also can effect by number of machine operate. This due to the maintenance. Most of the machine is out dated and need regular maintenance.

For SPL, the highest result obtained in Rotary Screening workstation which 105.1 dBA. Types of noise at that time various kind of noise from different machine and equipment which was welding, hammering using mallet hammer, and drilling. Impulsive noise also appeared since mallet hammer is being. The second highest SPL is followed by Dryer and logistic workstation which is 105 dBA. Types of noise in this workstation is similar with Rotary Screening. This noise obtained from grinding and welding activity.

For this project, in order to generate noise mapping the data for each point A and B is taken into account by using AutoCAD do to the layout and Rap-One software to do the mapping of noise. As for the limitation for this software is the properties for the floor cannot be assigned as it is only a demo set. As the result show that red colour zones is the highest noise produce in this company which located in Rotary screening and logistic and dryer department.

As for dose meter, since result for SPL for rotary screening and Logistic and dryer generated the highest noise in the production line, the dose meter device is used in this two workstation. As the result, the logistic dryer generated the highest noise exposure with dose more than 1800%, which make it 6 times higher than rotary screening opposite result from SPL result. This mainly because at the when data taken at the moment for SPL, the noise generated in Rotary screening, the equipment or machine is used at the same time more than the normal routine. Each dose meter is need to be used for 8 hours to get the result for full working hours. In the previous studied, according to Wang, Boshen, 85 dBA, obtained result of hypertension, abnormal electrocardiogram (ECG), hearing difficulty was 13.64%, 13.74% and 25.74%. Noise exposure below than 85dBA was 11.38%,13.06% and 21.35%.[2] With this new regulation able help deceasing the presentation of hypertension, abnormal electrocardiogram (ECG hearing difficulty since the new PEL 85dBA.

On 1st June 2019, Factories and Machinery (Noise Exposure) Regulations 1989 is revoked and replace with Factories and Machinery (Noise Exposure) Regulations 2019. The mainly reason why regulation 2019 needed to compare with regulation 1989 is mainly because with this result, the industry has a better understanding the different and how crucial to obligate the new regulation in industry. With this new regulation able to maximize the protection of the employees. Table 10 show the workstation that not comply with new or old regulation.

Table 10 *the workstation that not comply with new or old regulation.*

Not comply in 1989	Not comply in 2019
Logistic and Dryer, Conveyor and Installation, Gasifier, Rotary Screening, CNC Plasma Machine	Logistic and Dryer, Conveyor and Installation, Gasifier, Rotary Screening, CNC Plasma Machine, Bending Machine, Lathe Machine (a)

Lastly, the one of recommendation in order to reduce the noise exposure for the employees is by using a proper personal hearing (PHP) protection. Basically there are two types of PHP which is ear plug and ear muff. If the noise is below than 98 dBA, the employees only required to use single hearing protection. Meanwhile, if the noise exceed 99 dBA, it is highly suggested to use double hearing protection which mean using ear plug together with ear muff. As in the previous studied in Airport Workers in Malaysia, the research show that, employees in airport was exposure more than 90 dBA (the highest 114.6 dBA), out 3 out of 11 employees of had hearing problem. One of the employee had permanent hearing loss.[12] So prevention is really important to prevent any further damage to the employees. As for the engineering control, a regular maintenance for machine and devices is necessary since this is one of the factor that contributed to high noise exposure. Besides, using extra equipment like silencer and damping can help a reduce 15-25% noise in the place. As for the absorption noise using foam or others is not suitable as this company has no wall. With this method, the employees exposure to high noise can prevent all the most common problem due to the noise exposure.

4. Conclusions

As the conclusion, this monitoring noise exposure in the manufacturing factory has successfully met all three objectives. The result for both devices by using by Factories And Machinery (Noise Exposure) Regulations 2019 show that the noise exposure for this company has exceed the allowable and can lead to lead auditory and non-auditory effect. The main reason the new regulation set 85 dBA is to prevent and reduce the potential occupational noise induced hearing loss progression among the employees and maximize the protection for the employees

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