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Occupational Noise Exposure Among Airport Workers in Malaysia: An Ergonomic Investigation

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Abstract: Occupational noise is defined as a disturbance of sound at a workplace received by a worker's auditory system when they are working. A sustained and prolonged exposure to the noise can cause permanent hearing loss or damage to the worker. According to Occupational Safety and Health Act (OSHA), there is a certain tolerable noise level that can be exposed to the workers at a given time. This study aims to investigate the level of noise produced at the landing area in Sultan Ahmad Shah (SAS) Airport, Kuantan, Malaysia. A comprehensive ergonomic assessment divided into two phases is utilized in order to evaluate the noise exposure of the workers. In Phase I, an initial Ergonomics Risk Assessment is applied to gather the information on the ergonomic risk factors of the noise exposure, while for Phase II, an advanced Ergonomics Risk Assessment is used by monitoring the noise using occupational noise level meter. Thirty workers from the landing area which consists of the ground handlers were included as the subjects for this study. The value of noise exposure is measured while the workers perform their job. Results suggested that (a) the workers are aware of the noise exposure as per results shown in initial Ergonomics Risk Assessment in Phase I, and (b) the workers were exposed to high level of noise as suggested by OSHA (> 100 dBA at 2 hours exposure). With the suggested findings, the management of SAS Airport needs to create sufficient awareness to emphasize the usage of hearing protection devices in the workplace.

1. Introduction

Employee's performance and morale can be impacted in both positive and negative ways by the workplace environment. Workplace environment plays a major role in terms of the performance and productivity of an employee. The policy of a workplace that have been established is important to be followed as it can avoid the risk factors that exists at the workplace such as hearing defect, accident, malfunction machine and so on. In this paper, the risk factor that we would like to highlight and discuss is on the hearing defect that might occur during working which is hearing loss and other hearing problems. This significant issue is scarcely discussed especially in the workplace that do not involve high volume of noise or sound. However, occupational noise is one of the major problems that might affect the workers at their workplace with high volume of noise, such as at the airport runaway. Occupational noise and hearing defects are most common effects recognized since the Industrial Revolution. There are many cases reported due to the occupational hearing loss in the workplace. Workers who tend to neglect the hearing problems at their workplace give consequences to their economics and daily life activities. The prolonged exposure of loud noise or high frequency noise will eventually affect their hearing. Thus, we need to find solutions to this problem, specifically through engineering and ergonomics knowledge.

The problem statement of this project is based on five years' recent articles, journals, books, encyclopedia, etc. starting from the year 2014 until 2018. In the findings for more than six decades, the hazards of occupational noise exposure have been recognized and documented. However, it took many years to raise sufficient interest in addressing the problem on a large scale. In 1970, the Occupational Safety and Health Act (OSHA) included a noise standard for all American industries, making it mandatory for them to prevent occupational hearing loss (OSHA, 1970).

Table 1 shows the guideline values of the permissible hours for the workers to be exposed to the noise. NIOSH established the Recommended Exposure Limits (REL) for noise based on the best available science and practice. These guidelines need to be applied to all workers in their workplace including airport which involves aircraft noise. Based on the Guidelines for Control of Occupational Noise 2005 by Department of Occupational Safety and Health (DOSH), Malaysia, these guidelines are intended as a basic practical guidance to the employer in developing noise control measures. With the growth of the aviation industry, Malaysia has to move towards a more systematic and standard aviation management. Malaysia follows the standard of aviation from the International Civil Aviation Organization (ICAO) which is an UN specialized agent that works with the Convention's 192 Member States and industry groups to reach consensus on international civil aviation Standards and Recommended Practices (SARPs) and policies in support of a safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector [1]. This research, however, utilizes the standard on the ICAO ANNEX 14 which specializes on the Aerodromes - Aerodrome Design and Operations. This manual acts as a guidance for the operation of aerodrome, runway of airports and certain appropriate facilities.

Table 1 Permissible hours for exposure level to the noise in 24 hours

Time to reach 100% noise dose	Exposure level per NIOSH REL	Exposure level per OSHA PEL
8 hours	85 dBA	90 dBA
4 hours	88 dBA	95 dBA
2 hours	91 dBA	100 dBA
1 hour	94 dBA	105 dBA
30 minutes	97 dBA	110 dBA
15 minutes	100 dBA	115 dBA

Although there are many different sources in and around the airport that produces noise, the aircraft itself is the most commonly known source of the noise. This noise is categorized as high decibel noise and affects the hearing performance if being exposed for a long period of time without any protection. Mostly, people will assume that all the noise produced by the aircraft comes from the engine, however, another anatomy of an aircraft that generates noise is the airframe. Many people are not aware of this noise, but it may be of concern as engine efficiency and noise reduction have decreased as much as is technologically possible. Nevertheless, technology has reached a point where there are few things that can be performed to decrease the noise of the engine. Most of the noise generated from the aircraft engines typically occur from the high velocity exhaust gases and the air flow in the fan system.

In conclusion, the occupational noise that occur at the workplace can significantly affect the workers if they are exposed to a high level of noise in a long period of time. It will cause hearing problems and other diseases if the workers neglect the safety procedures and regulations during working hours.

2. Methodology

This study was conducted in two phases at Sultan Ahmad Shah Airport (Kuantan). The airport is known with its high level of noise exposure by the aircrafts since it operates for two organisations which are Malaysia Airports Holding Berhad and Royal Malaysian Air Force. This research received full support and recognition from the Head Engineer of Malaysia Airport Berhad (Kuantan Branch). Figure 1 shows the details of the research procedure.

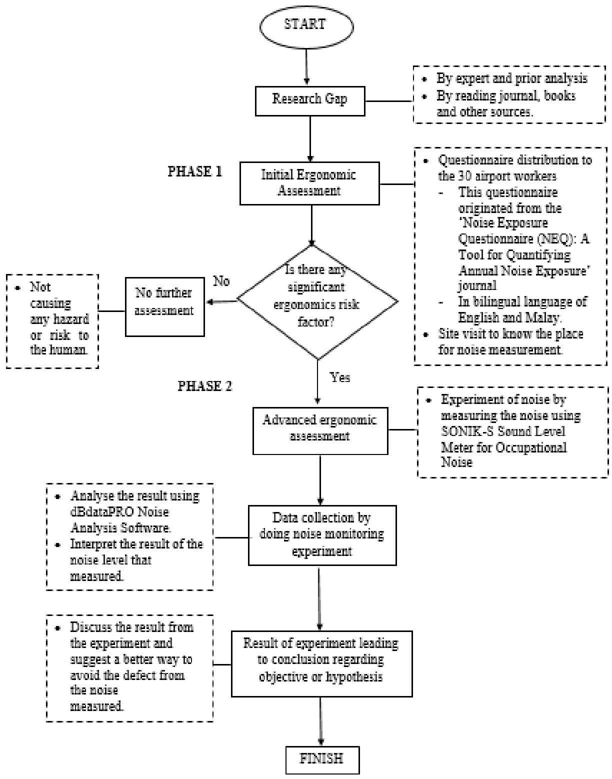


Figure 1 Flow chart of the research procedure

2.1 Phase I

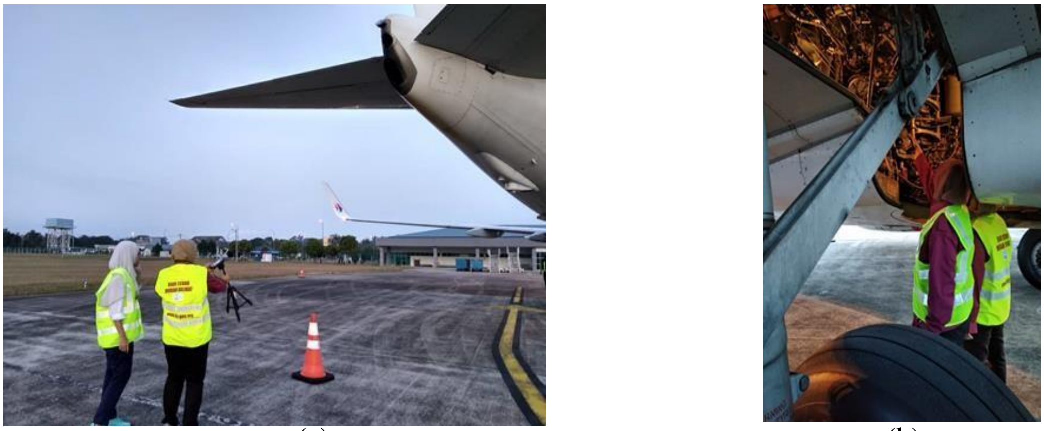
The objective of Phase I is to obtain information on the occupational noise exposure among the workers. In order to achieve the objective, an established 'Noise Exposure Questionnaire' (NEQ) [2] was distributed to ten ground-handlers (n = 10) at the taxing area. The questionnaire has been modified to suit the subjects' background, for instance, the language of the questionnaire was created in both English and Bahasa Melayu. This is important as respondents will response more accurately and rapidly to conditions that placed greater demands on working memory [3].

Each subject completed the self-administered Noise Exposure Questionnaire (NEQ; Appendix A), which required approximately 10 minutes to complete. Subjects were asked to recall participation in specific noisy activities during the past year. The NEQ consists of three sections: 1) basic demographic information (gender and age), 2) six potential screening questions for determining individuals with high-risk noise exposure (Q#1–6), and 3) eleven detailed questions related to participation in loud, noisy activities used to quantify the annual noise exposure (Q#7–17).

2.2 Phase 2

Phase 2 starts as soon as Phase 1 is completed and the information obtained from Phase 1 are further utilized to study the appropriateness in regards with this project's objective. Following from there, Phase 2 is continued with the advanced ergonomic assessment which consists of data collection of noise level and analyses of the result from the experiment. The data collection of noise is obtained by doing the noise monitoring experiment which was conducted by measuring the noise around the aircraft by following the aircraft parking stand.

In the experiment of noise, the measuring was conducted using a device for noise measurement known as SONIK-S Sound Level Meter for Occupational. This device captures the noise produced from the airplane and surrounding. The noise reading is then recorded with the average of 3 consecutive days and it involved the aircraft model of Boeing 737-800. The results were then analysed using an analysis software which sorts out and manages the data file to read the result accurately. The result can be interpreted and the corresponding value of the noise level can be decided.



(a) (b)

Figure 2 The area of noise measurement.

Before the investigation, safety briefing was given at the site and it is crucial to follow the safety requirements strictly as the procedure has stated. Next, the range for measurement of noise are situated near the aircraft, which is approximately 5 meters from the aircraft, as shown in Figure 2 (a) (b), which is in the range of safety lines. Total two readings of noise measurement were taken and the average of the reading is calculated. The reading is taken when the flight is in transit since that is the time when the staff works near the flight. Figure 3 shows the mapping of runway at Sultan Ahmad Shah Airport and the place where the investigation is conducted is in red circle which is the transit area for the airplane. It is called apron and is the area of an airport where aircraft are parked, unloaded or loaded, refuelled, or boarded.

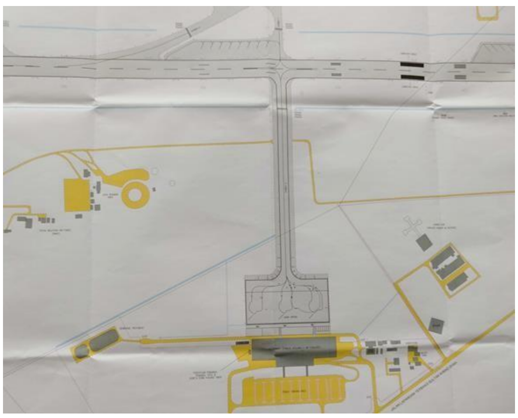


Figure 3 Runway of Sultan Ahmad Shah Airport.

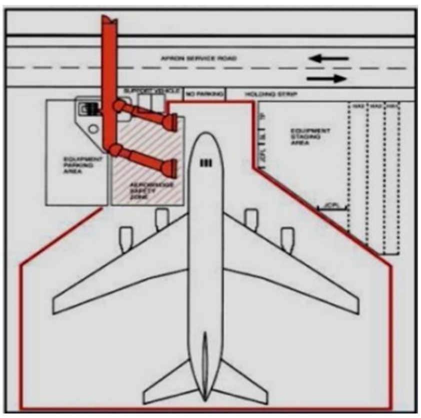


Figure 4 Aircraft parking stand.

The sound level meter is placed near the ears with the human average height of 155 cm to obtain a more accurate reading of noise that enters our ears. On the other hand, Figure 4 shows the aircraft parking stand where the noise reading is taken by following the red line. Furthermore, the ground handler workers work around the aircraft during the transit when the engine of the aircraft in running.

After Phase 2 is completed, the results produced from the experiment are analysed which then leads to the conclusion of this research. The result from the experiment are then discussed and suggests a better way to avoid the defect from the noise measured. Finally, the aim of this project is achieved by determining the degree of noise level that affects hearing especially at the airport and how to resolve this problem that may cause worries to the workers in this field.

2.3 The Experimented Aircraft

Figure 5 shows the aircraft of Boeing 737-800 which is the source of the noise exposed while the ground handler works. Boeing 737-800 is a twin-engine short-to-medium-range narrow body airliner with a capacity of maximum 189 passengers produced by the American manufacturer Boeing Commercial Airplanes. This model of aircraft has 2 turbofan engines with an engine power of 121.4 kN. Three aircrafts of the same model are measured to collect the data for three consecutive days and the average of the noise measurement is calculated. This aircraft produces the noise of more than 85 dBA and through this investigation, the result of the noise level proves the level of noise exposed

Figure 5 Boeing 737-800

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3. Results and Discussion

3.1 Phase 1

For this study, total of 11 respondents answered a questionnaire regarding the noise issues at their workplace. The total respondents were from ground handler unit of ramp services, technician, ground equipment operator, aviation security and general workers. From the questionnaire, we determined that three from the total respondents possess hearing problem due to their working condition. The worst scenario that one of the respondent faces is that one of the workers has already received compensation from the Social Security Organization (SOCSO) for his hearing loss due to working environment. He suffered from ruptured eardrum and hearing loss which caused difficulties for him to work. Due to his hearing loss, he was transferred to work in the office where he have worked there for 32 years now. On the other hand, two other respondents experience reduced hearing problem while they work as the ground handler and both of them have work there for more than 10 years. This shows the result of long-time exposure towards high level of noise due to the workplace condition.

3.2 Phase 2

Advanced Ergonomics Assessment stage revealed that the procedure for this investigation is accomplished. This significant study was conducted for three consecutive days by measuring the noise around the aircraft and identify the highest point of noise exposure around the aircraft. In Occupational Safety and Health (Noise Exposure) Regulation 2019 by law of the Occupational Safety and Health Act 1994 (Act 514) [4], the noise exposure limit should not exceed 85dB(A) in daily working time.
Following from there, during departure and arrival of aircraft, the reading of noise shows that different

impact of noise was emitted from the aircraft. The duration of less than 40 minutes reading was recorded to analyse the impact with the distance of 15 meters away from the aircraft. Day 1 reading of LAeq was 74.8 dBA, day 2 with the reading of 62.4 dBA and day 3 showed LAeq reading of 74.5 dBA, which gives an average of 70.6 dBA. It shows a lower reading of noise than the noise near the aircraft.

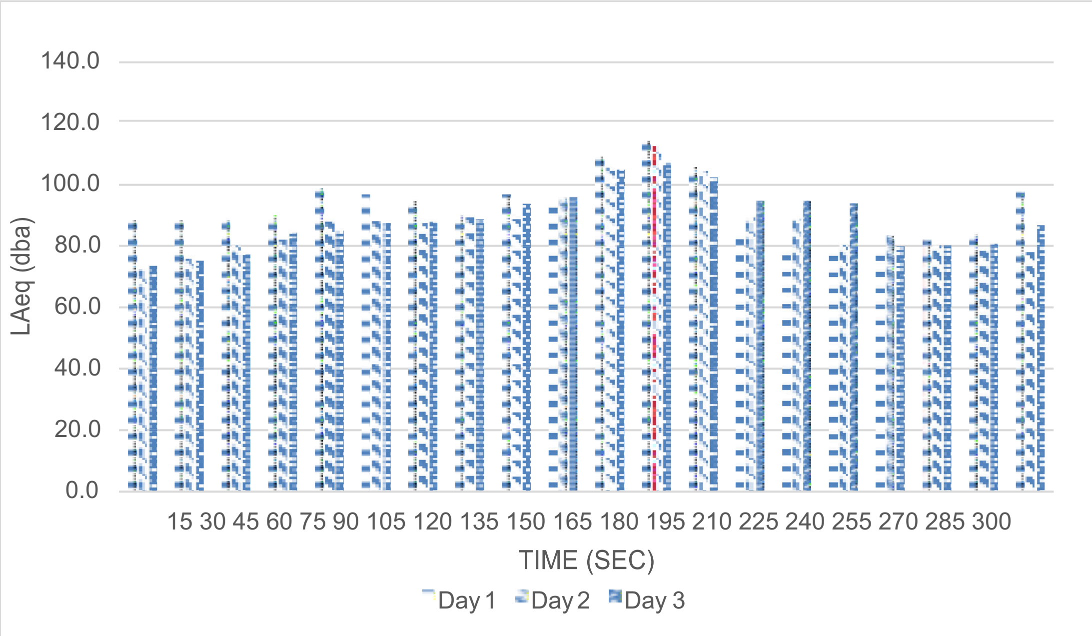

Figure 6 Noise measurement using Sonic-S sound level meter

Figure 6 shows the comparison of bar graph of noise measurement level for three consecutive days at the aircraft parking stand which is less than 5 meters distance from the aircraft. From the graph, it shows that Day 1 mostly have high values of reading while in Day 2 and Day 3, the values of reading are average. The graph was labelled with LAeq value on the *y*-axis and time in second on the *x*-axis. The increasing bar graph in Figure 6 shows the beginning of high level noise detected which was at the undercarriage of the aircraft.
From the bar graph, it shows that the highest source of noise emitted was taken at 165 seconds till 210 seconds. At this time, the highest noise produced an average of 111.4 dBA which exceeds the noise level allowed. Hence, precaution steps or safety awareness need to be taken to avoid the hearing problem among the workers.

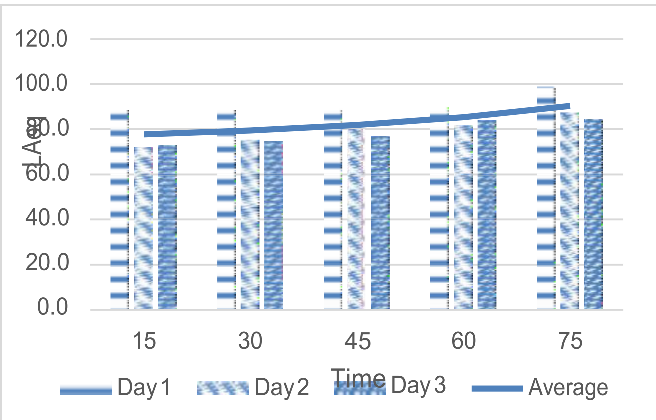

Figure 7 Bar graph of measurement in front of the aircraft

During the early measurement (0 - 75 seconds), the reading of sound level meter were in the range of below than 100 dBA with the highest value recorded on Day 1 at time 75 seconds, which occurred while walking from the front to the centre of the aircraft. The average of noise exposed is between 77.7 - 90.3 dBA and although it did not reach 100 dBA, it still present a small risk of developing hearing disability.

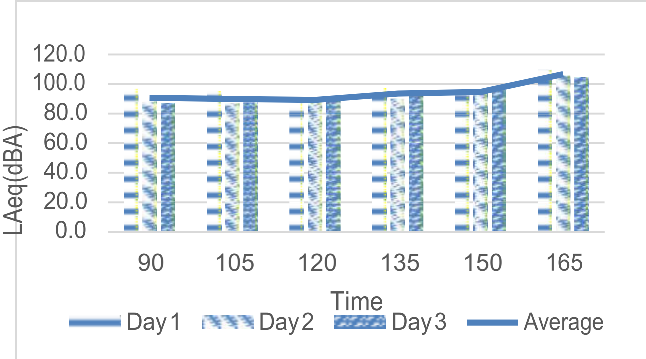

Figure 8 Bar graph at the centre of body aircraft

Next, the bar graph in Figure 8 shows the findings at the centre body of the aircraft which includes the wing and before the tail of the aircraft. Day 1 yield an average of 96.9 dBA during the measurement at the centre of the body which is higher than the reading on Day 2 with 92.7 dBA of reading and Day 3 of 93 dBA. The average value for total 3 days of measurement is 94.2 dBa and this amount may cause hazardous towards the workers. Workers are advised not to be exposed with this high level of noise for more than 8 hours of working.

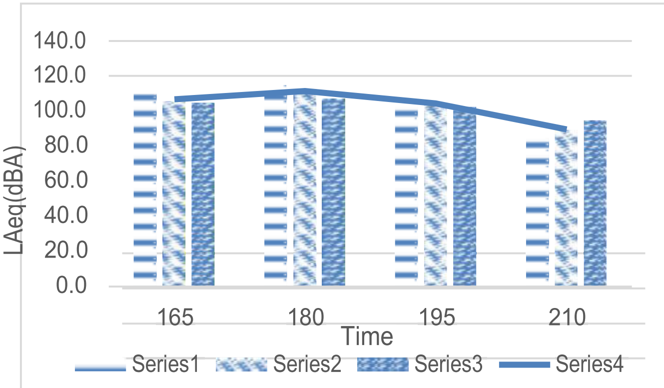

Figure 9 Undercarriage of aircraft.

During the investigation, as shown in Figure 9, we determined that the aircraft recorded the highest value of noise exposure at the undercarriage part of the aircraft with the average value of 111.4 dBA. Undercarriage is a part of aircraft that have landing gear located underneath of the aeroplane. The noise emitted from the aircraft system at undercarriage results with the highest level of noise exposure. Average range at the undercarriage area are between 90 dBA until 120 dBA which is in the hazardous state. During every transit of the airplane, the workers must check the condition of the aircraft including at the undercarriage. Hence, the risk of high level of noise exposure may cause defect to the workers.

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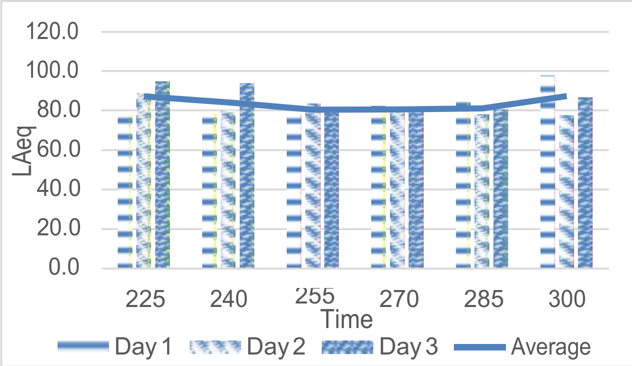

Figure 10 Result at Tail Area

The results show that the average range of noise exposure at tail area is 80 dBA to 90 dBA and this measurement is lower than at the undercarriage. By wearing the complete Personal Protective Equipment (PPE) while working may reduce the risk of hearing problem, thus, can improve the work quality of the ground handler as they are less worried about the damage that might occur. As concerned, excessive noise is a global occupational health hazard with considerable social and physiological impacts. Thus, an act towards this concern needs to be conducted to avoid further mishap towards the society.

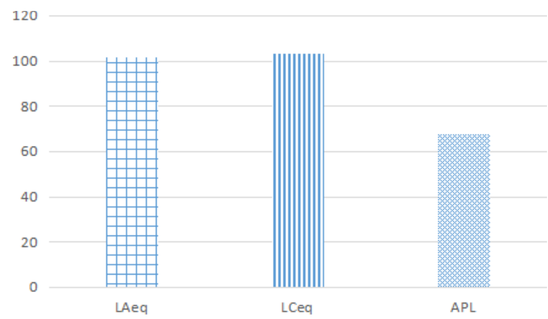

Figure 11 Example of application of Hearing Protection Comparison.

Through this application, a simulation for hearing protection for the noise exposure is performed and with the data from Day 1, a 3M Banded Earplug 1310 was applied to test the efficiency towards the noise. From Figure 11, the LAeq bar graph indicates the data from the log item while the APL bar graph showed the effect of the hearing protector. The noise level at 101.9 dBA can be reduced to the Assumed Protection level (APL) of 67.9 dBA. In other words, it can resist about 30 dBA of noise from the actual reading which is very effective to the user.

Based on the findings, we figured the aircraft's noise based on three categories which are mechanical noise, aerodynamics noise and noise from the aircraft system. This proved that noise pollution produced from the aircraft affected the workers near the aircraft and with today's available technology, manufacturers are trying to overcome this excessive noise problem as it will give good impact to society.

The result of this study shows that the workers were exposed to high level of noise at their workplace. The employer should take such measures to reduce the risk of noise expose to the workers such as providing high quality personal hearing protector to the workers and increasing the awareness and the importance of wearing this protector during working hours. It is also practicable to use the engineering method to reduce this excessive noise, but the employer should use this engineering control together with the administrative control. These controls are to be selected according to a hierarchy that emphasizes engineering solutions (including elimination or substitution) followed by safe work practices, administrative controls, and finally personal protective equipment. Through this precaution step, the impact of noise towards the workers can be reduced. Moreover, the occupational noise is a big concern in our society and many preventions from this problem can be taken by the employers.

4. Conclusions

The proposed objective of this study is in alignment with the noise exposure at the airport which is one of the occupational noise that affects the ground handlers. The predicted and measured noise values near the aircraft shows the same condition of noise exposure which is hazardous and provides high level of noise exposure towards the workers. The highest value of noise measured was at 114.6 dBA on Day 1 and the noise was over the allowable noise exposure of less than 90 dBA for 8 working hours daily. For suggestions, by implementing the control measures of prevention exposed to high level noise, we can ensure and retain an effective work performance of the workers as it can reduce the risk of hearing problem or hearing loss among the ground handlers.

Acknowledgments

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