ORIGINAL ARTICLE

NOISE MONITORING CASE STUDY: LIQUEFIED PETROLEUM GAS TERMINAL

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ABSTRACT

The main objective of the study is to determine the noise level emitted by the machinery and equipment used at a Liquefied Petroleum Gas in Melaka, Malaysia. The study also aims to determine the exposure level of noise to the employees. The machinery and equipment noise level was measured using a calibrated sound level meter. Noise level of each source was measured by pointing the sound level meter microphone at normal working distance to the source. Personal noise exposure was conducted at the shoulder of the personnel and as close as possible to the personnel's ear. From a total of 154 noise sources points identified at three work areas surveyed, 122 points were above Action Level of 85 dBA of which 57 points had exceeded the Permissible Exposure Limit of 90 dBA. For the personal exposure monitoring, ten out of fourteen had exceeded the Action Level of 85 dBA for those working for 8 hours and 82 dBA for those working for twelve hours and one of them had exceeded the Permissible Exposure Limit of 87 dBA for those working for twelve hours. The monitored personnel have exceeded the Maximum Level and the Peak Level limit of 115 dBA and 140 dB respectively. From the study, it is concluded that further noise monitoring is needed especially when there are changes to the work process and equipment used. Also the requirement to notify the selected workers on the personal noise exposure result, actions to reduce noise level at the workplace through engineering control methods and administrative controls.

***Keywords**: Standing work; Workstation design; Ergonomic; Standing risk assessment*

INTRODUCTION

Excessive noise increases blood pressure and heart rate. Zamanian et al.[1] showed in their study that blood pressure increased slightly at each level of noise. In addition, it is observed that the mean heart rate decreased at all levels of noise. Noise also known to disturb human sleep and directly affects human health in the long term. In addition, Chang et al.[2] proved that noise can cause hypertension. It was revealed that prolonged exposure to noise levels ≥85 dBA increased males' systolic and diastolic blood pressure levels. This correlation may translate into a higher incidence of hypertension. According to the researchers, the current regulated threshold with respect to noise exposure may prevent adverse health effects from noise-induced hearing loss to the development of hypertension. Jarup et al.[3] showed that there was some habituation to noise for problems related to sleep but not annoyance. The prevalence of both annoyance and sleeps was higher when bedroom windows were facing streets.

A study conducted on rats imposed noise impact has affected the rat brain. Based on the study by Ersoy et al.[4] indicated that rat brain tissues were affected by oxidative stress as a result of continued exposure to noise. Based on Schmidt et al.[5], a group of young and healthy volunteers were found to be significantly impaired on their hearing after only one night of aircraft noise exposure with 60 noise events. Epidemiologic studies have demonstrated associations between long term exposure to air-craft noise and an increased incidence of arterial hypertension and therefore cardiovascular disease.

Bhattacharjee et al.[6] stated that noise is one of the most found physical contaminants in the manufacturing industry. In Malaysia, there are a number of Liquefied Petroleum Gas (LPG) terminal plants under the administration of PETRONAS. The work process at these LPG Terminal includes a lot of movements of the heavy LPG cylinders. LPG is bottled into 12kg, 14kg or 50kg cylinders. The filled LPG cylinders are transferred via chain conveyors but quality inspections are done manually by the foreman or supervisor. The filled cylinders will be loaded to a pallet at the pallet plant and then transferred via forklift to the tank truck. These movements produced very noisy work environments almost similar to a metalworking shop floor.

Therefore, this study aims to identify noise sources at various sections for both filling plants, then measure the noise level and determine the type of noise for each noise source identified. Also, to map the facilities areas into different noise zones.

METHODS

The selected LPG terminal plant is located in Mukim Sungai Udang on a 20 acres land in the vicinity of Penapisan (Melaka) Sdn Bhd (PPMSB). The terminal has been operated and maintained by PETRONAS Dagangan Berhad since April 2000 with total employee of approximately 86 personnel The LPG terminal plant consists of two bottling plants that accommodate filling carousels as shown in Figure 1. The Fuel Terminal operates 8 hours a day and 6 days a week. For this study, the selected workgroup that belongs to two work schedules. They are operation technicians that work from 7am to 7pm for day shift and 7pm to 7am for night shift.

Noise measurement was carried out using sound level meter. The sound level meter was calibrated at 114 dB of 250Hz frequency using a RION Pistonphone NC-72 prior to conduct noise survey. As for the employee noise exposure monitoring, noise dosimeters with noise data logging mechanism were used. All dosimeters used were also calibrated at 114.0 dB of 1000Hz fixed frequency using QUEST QC10 sound calibrator. Monitoring details for both areas and personnel are as illustrated in Table 1. Noise sources within the production areas were identified through observation (hearing). The pre-calibrated sound level meter was used to measure the continuous equivalent A-weighted sound level (LAeq) and types of noise for each noise source at its operation mode. During measurement, sound level meter which was set at A- weighting and slow-response mode was hand held at a height of one meter from the ground and situated at a distance of one meter away from the noise source. Readings of the sound pressure level were taken over a period of at least 60 seconds. For each noise source, noise readings were taken at different positions surrounding the noise source in order to obtain the range of noise levels generated by it.

During this study, background noise level of each work area was also recorded whenever possible. The background noise level was recorded when all the machines or activities that generated noise were ceased in operation temporarily. Then noise was measured again when the respective machines or activities are at the operation mode. Considering the difference in noise levels at these two operation stages and the background noise correction factor, noise level of the particular source was corrected and calculated. As the machinery keep running it is impossible to correct the noise source for background noise. Therefore, the noise source level estimated is considered as the level when the source is in operation.

Figure 1 *Terminal Layout Plan*

***Table 1**. Monitoring Details*

Type of monitoring		Work Activities
Area Monitoring	Personnel Exposure Monitoring	
Filling Plant A Filling Plant B Pump House	11st April 2014 (Night Shift) Filling Plant B Operation Technician (3 pax) 12nd April 2014 (Day Shift) Filling Plant A Operation Technician (3 pax) 12nd April 2014 (Night Shift) Filling Plant A Operation Technician (4 pax) 13th April 2014 (Day Shift) Filling Plant B Operation Technician (4 pax)	1. Receiving of LPG via pipeline. 2. Storage of LPG in pressurized storage tanks. 3. LPG bottling into 12 kg, 14 kg or 50 kg cylinders using automated filling carousels. 4. Weight, leak inspection and quality control. 5. Cap sealing of finished cylinder. 6. Loading of finished cylinder onto LPG cylinder road tanker for distribution to customer. 7. Troubleshooting and plan preventive maintenance activity.

The production areas were mapped into three noise zones. The measurement was conducted using sound level meter set at slow-response and A-weighting mode. Noise level of each noise source was first recorded. Then the sound level meter was moved a little bit further from the noise source. The distances from the source where noise level reached 90 dBA were identified and marked. The area from the contour line of 90 dBA and above was colored red on the floor plan as shown in Figure 2. Similar procedure was also applied for determining noise contour of 85 dBA to 89 dBA and below 85 dBA and the zones were colored as yellow and green respectively. Selection of personnel for personal noise exposure monitoring was based on noise levels recorded at each work area. Personnel working at work area with noise levels close to or above 85 dBA (Action Level) were selected for noise exposure measurement. Fourteen personnel were selected randomly for noise exposure measurement from the identified work areas. Personal noise exposure monitoring was carried out using calibrated dosimeters. The purpose and usage of the dosimeter was explained to the personnel. They were informed that the dosimeter did not record speech but only noise level, and that it would not interfere with his normal duties. The noise dosimeter was fixed at the shoulder of the personnel and as close as possible to the personnel's ear (hearing zone). The total monitoring period was at least 80% of working hours inclusive of break, which were been taken within the LPG terminal's vicinity.

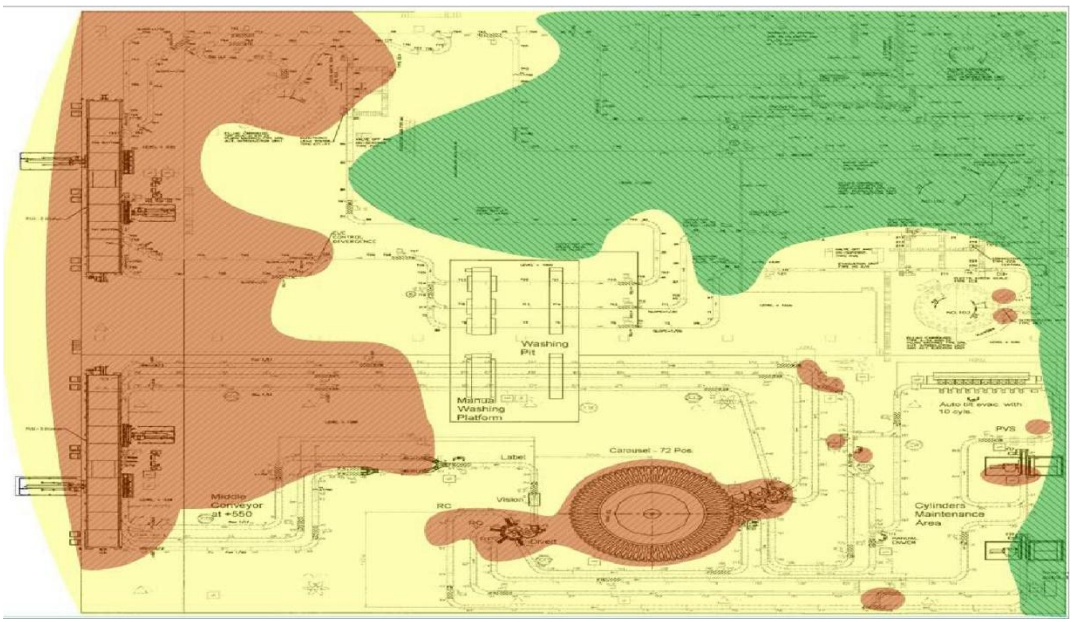

***Figure 2** Mapped area*

RESULTS

Noise zones were identified from noise levels measured and if any impulsive noise is present, it is also indicated in the noise mapping. The noise zones identified were drawn on the floor plans and shown in Figure 2. The highest noise was measured from Plant B, from gas release activity (103.4 dBA), followed by cylinder impact noise (93.9 dBA), conveyor chain noise (91.9 dBA) and background noise (89.9 dBA). Plant A is similar to Bottling Plant B except that it does not have gas release activity. Pump House produced 90.1 dBA when the pump is running and 84.6 dBA when it stops.

High noise level exceeding the Action Level and Permissible Exposure Limit were recorded at most of the Plant A and Plant B area. The impact noises are due to cylinder tanks and pallet banging each other, conveyor chain movement, gas release from re-valve activity and loading/unloading of cylinder tank activities.

At the pump house, there are seven LPG pumps. The highest noise level recorded was at Pump P-6202D which was used for bottling activities. The highest noise level recorded was in between 89.1 dBA to 90.1 dBA.

Personal Noise Exposure Monitoring

The result of the personal noise exposure as per Figure 3 shows that the sampled personnel had exceeded the Permissible Exposure Limit of 82 dBA for six personnel working for 12 hours. The highest exposure reached up to 88.4 dBA. The other eight sampled subjects were monitored to have exceeded the Action Level of 85 dBA for personnel working for 8 hours. The highest noise monitored is 88.5 dBA and at least four of the sampled personnel shown in Figure 4 experienced noise level exceeding the Action Level for TWA_8. The data shown in Figure 5 are for 115 dBA where twelve of the personnel selected for the monitoring are exposed to the noise. The workplace showed they experienced noise exposure even higher than 140 dBA. The result is shown in Figure 6.

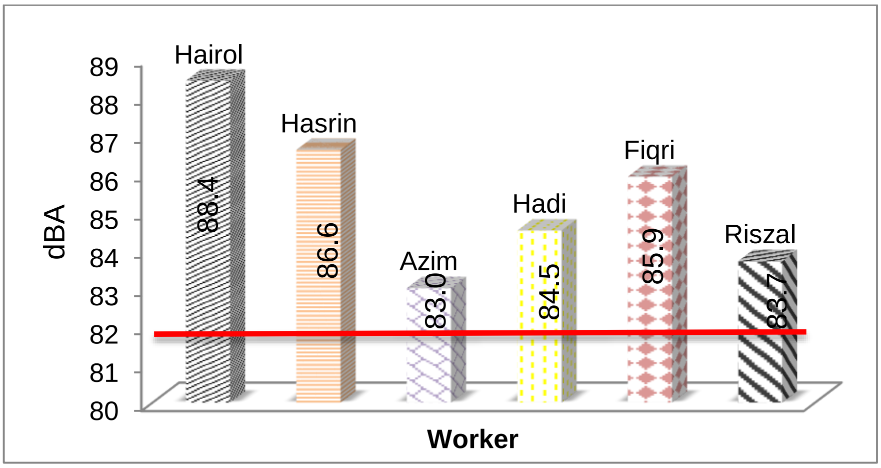

Figure 3 *Personal noise exposure exceeding Action Level (82 dBA) for TWA_{12}*

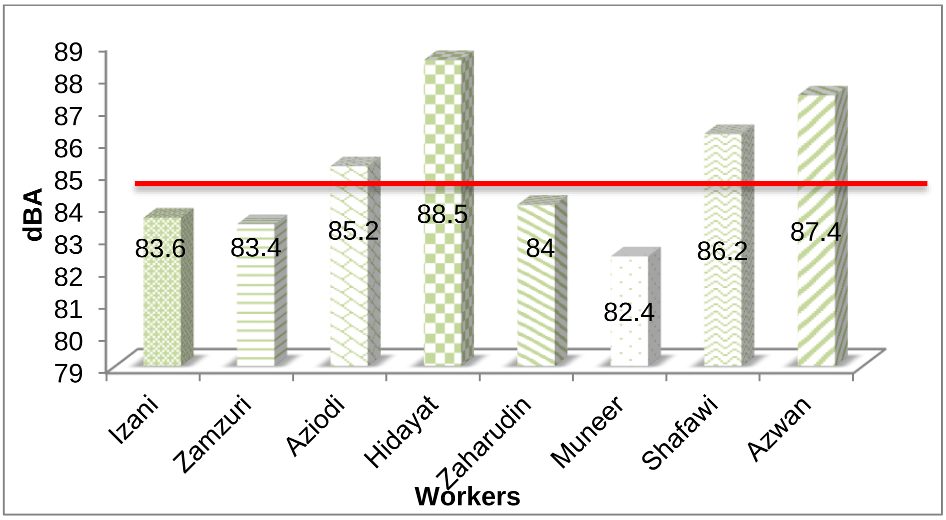

Figure 4 *Personal noise exposure exceeding Action Level (85 dBA) for TWA_8*

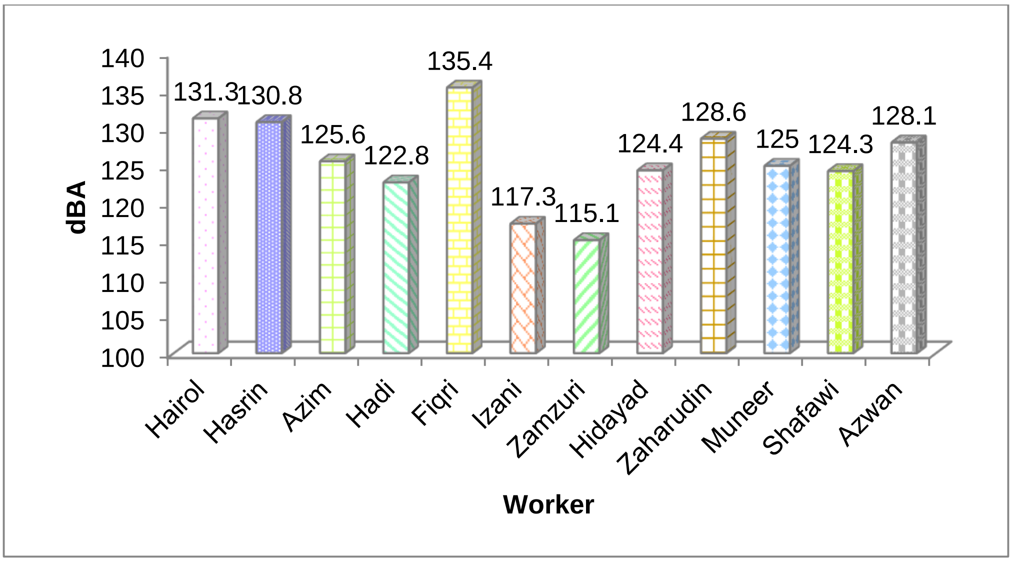

Figure 5 *Workers exceed maximum level of 115 dBA*

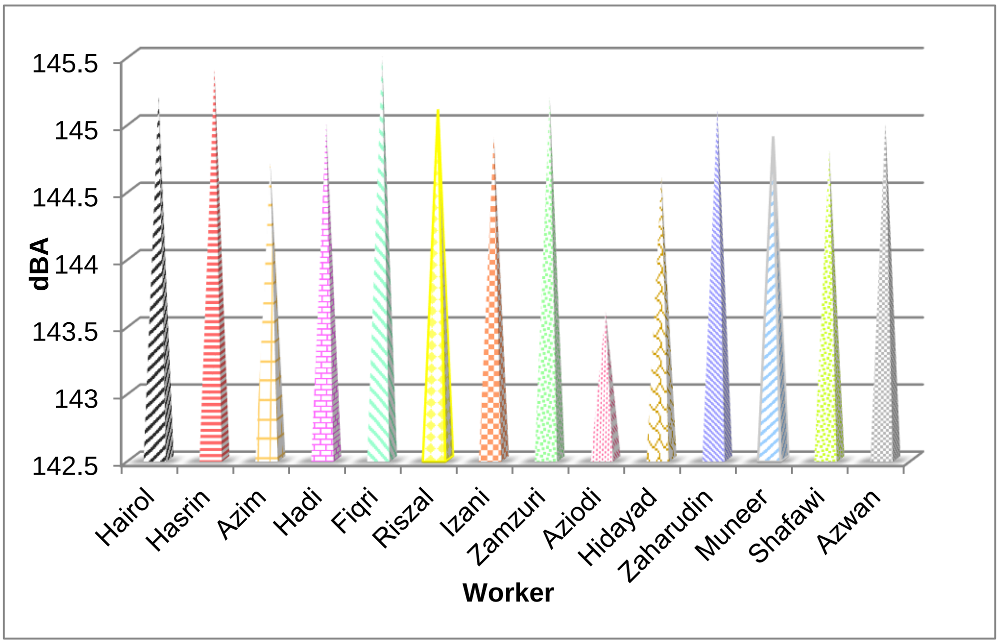

Figure 6 *Workers exceed maximum level of 140 dBA*

When the monitoring was carried out, it was observed that the management had issued the hearing protection device to the personnel. The hearing protection device issued is Moldex Rockets 4605 earplug with Noise Reduction Rate (NRR) of 27 dB. Effective NRR is when the NRR value in dB which is corrected for A-weighted measurement by subtracting 7 dB from the NRR given by the manufacturer as recommended by National Institute of Occupational Health (NIOSH) of USA. LAeq after attenuation is calculated by subtracting the Effective NRR from the 8-hours LAeq measured. It is clear that the earplug issued by the management is sufficient to protect the personnel exposed to noise when they carrying out their routine task at both LPG bottling areas if it is worn correctly.

The results obtained from this Additional Noise Exposure Monitoring showed that the three areas namely LPG bottling plant A, LPG bottling plant B and pump house area have been identified as possible areas with high noise level above the Action Level of 85 dB(A). As such, for the personnel working at or entering this area shall wear the proper and approved hearing protection device especially when they intend to stay longer at this area.

Based from the personal noise exposure results, most of the personnel monitored had exceeded the Action Level of 85 dBA (8 hours working time) and 82 dBA (12 hours working time). In addition, whenever there is a change in a production process, equipment, control measures or personnel in the production area monitored, the management shall conduct additional noise exposure monitoring within six months from the date of such change or changes.

Engineering Control and Administrative Control

From this study it is recommended for the management to consider installing engineering control such as silencer and acoustic enclosure for equipment that generated high noise levels such as pumps at the pump house area. To reduce the loud noise due to impact from the gas cylinder, the management can consider installing the acoustic enclosure or screen to its conveyor line and allow access to any section of the line. In addition, the damping material can be applied to the deck at the palletizing area in order to reduce impact noise from the pallet.

Regular maintenance and lubrication of machinery is important as well-maintained machinery tends to be less noisy than machinery that is not maintained. It is also important to ensure that moving parts of machines are properly adjusted to within tolerance specified by the manufacturer. Other than that, rotation schedule for personnel exposed to high noise can also be implemented. As part of administrative control, the team leaders, supervisors and managers can also perform strict supervision in ensuring that the noise-exposed employee to wear the hearing protection device when they are entering the high noise level area.

The management shall continue providing the approved hearing protection device to the personnel which are at risk of exposed to noise level exceeding the Action Level of 85 dBA and Permissible Exposure Limit of 90 dB. The selection of the suitable hearing protection device either earmuff or earplug need to be determined based on the noise level at that area. The following noise attenuation formula need to be considered when selecting the hearing protection device[7]:-

$$EE\ (dBA) = TWA\ (dBA) - [(NRR - 7) < 85\ dBA \quad Eq.\ (1)$$

Abbreviation:
EE = Estimated Exposure

The Noise Reduction Rating (NRR) of the hearing protection device must be sufficient to provide the protection required under the specific work environment. Hearing protector must be comfortable to wear; otherwise, the users might not want to use it continuously for long period, and thus reducing the protection intended. Table 2 gives an indication of the protector factor that is likely to be suitable for different levels of noise.

Table 2 *Suitable NRR Protector Factor*

A-weighted noise level (dB)	Select a protector with an NRR of
85-90	20 or less
90-95	20-30
95-100	25-35
100-105	> 30 or using double hearing protection

CONCLUSION

Based from this result, LPG bottling plant B and plant A had been identified as the areas with high noise levels exceeding both Action Level and Permissible Exposure Limit. In addition, pump house area also showed high noise level. Most of the personnel selected for this monitoring had exceeded the Action Level and one of them had exceeded the Permissible Exposure Limit. As such, it is very important for the management to remind them to wear the issued hearing protection device correctly should engineering control cannot be implemented in order to reduce the noise level. Results show that the bottling activities had generated noise level that had caused high noise level at most of the area at both bottling plants based from the area and personnel assessment result. As such, the conclusion of the noise level at this LPG Terminal need to be improved and the management need to take noise control measure.

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