Journal of Applied Engineering and Technological Science
Vol 3(2) 2022 : 74-79

ANALYSIS OF THE NOISE LEVEL OF THE DIESEL ENGINE WITH 1100 RPM IN THE INDOOR CONDITION

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Received : 14 February 2022, Revised: 10 June 2022, Accepted : 11 June 2022
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ABSTRACT
One of the weaknesses of diesel engines that most users complain about is the vibration and the noise. Therefore, it is very important to know the noise level of an engine in a room to consider the allowed duration of the exposure time, which is the aim of this study. The instrument used in this study was the Sound Level Meter, by first determining the radius of the hemisphere used in determining the location for the data collection. The measurement was carried out four times, where the largest value was considered as main data, at four points. The result in this study indicated that the noise level of the diesel engine with a speed of 1100 rpm was 92.805 dBA with the background noise in the diesel engine room of 51.6 dB. Based on government regulations, the maximum exposure time to the noise at this level is 2 hours.
Keywords: *Diesel engine; noise level; Sound Level Meter; background noise*

1. Introduction

The diesel engine is a machine that is widely and generally used to generate electricity. This engine is an internal combustion engine in which the fuel is ignited by the increased temperature of the air in the cylinder caused by the mechanical compression (adiabatic compression; Cao et al., 2020), making it a compression-ignition engine (CI engine) (Bari, 2013; Mollenhauer & Tschoke, 2010; Noor et al., 2018). One of the weaknesses of the diesel engine that most complained about is the vibration and the noise (Redel-Macías et al., 2018). Noise is the sound that ears do not want it to be. Sounds that are continuous or impulsive can cause damage to the ears. The ear damage usually occurs to the eardrum or ossicles. Initially, there will be hearing loss for high frequencies, but slowly at the decreasing frequency to low frequencies (Fredianta, Huda, & Ginting, 2013). Therefore, it is very important to know the noise level of the engine in a room to consider the allowed duration of the exposure time(Sedighi et al., 2022).

Some of the standards issued by the ISO (International Organization for Standardization) include ISO 11200-11204 (Iso, 2014). These standards are standards designed to describe the method of measuring the sound emission, at the SPL (Sound Pressure Level) value, in a workroom and at a specific position of a machine or equipment. ISO 11200 provides an explanation in choosing the method to be used to obtain the SPL emission value on machines and equipment. In ISO 11202, the method of measuring the SPL emission in situ is especially explained. The method given in the ISO standard can be applied to all types of machines, both moving and at rest, both indoors and outdoors(Mao et al., 2020; Svec & Granqvist, 2018).

Uncertainty in measurement results is a common thing. Uncertainty in SPL emission measurement results increases based on several factors, some of which are related to environmental conditions of the measurement room and may also be caused by measurement techniques. Therefore, in general, extensive measurement data is needed to obtain the standard deviation of emissions resulted. It is not possible to use measurement result data generally. A data set can only be used as a reference for certain environmental conditions and certain machine types(Zhang et al., 2019; Patil et al., 2021; Gorji et al., 2018).

2. Instruments and Methods

The instrument used in measuring SPL emissions was the digital sound level meter DEKKO SL-130, as shown in Figure 1, which had met standard requirements for class 1 and class 2 instruments as described in IEC 60651, a standard for the sound level meter (Narang & Bell, 2008; 三浦甫, 佐藤宗純, 鈴木英男, 舘野誠, & 瀧浪弘章, 1998). The Sound level meter is a measuring instrument that is designed to be able to respond that similar to the human sense of hearing and can show a measure of the sound level. The main components of the equipment are the microphone, the processor, and the output pointer. Three main components can be separated or become a single piece of equipment. In the processor, a weighting process was carried out, namely filtering and amplifying the signal to simulate the distribution of the level of the hardness which was adjusted to the sensitivity of the human sense of the hearing to the frequency of the sound. The result of the measurement process which had been adjusted with the A, B, C, or D weighting was shown as the reading of the result on the screen. A calibrator was used to verify the calibration of the entire measurement system before or after the measurement process. The calibrator used was a calibrator with an accuracy of ± 0.3 dB.

Fig. 1. Digital sound level meter

Fig. 2. The condition of the diesel engine observed

The first step was to measure the dimensions of the diesel engine, as shown in Figure 2. After that, background noise measurements were taken. The radius of the hemisphere was then determined to be used in determining the location for the data collection. The guidance in determining the radius (r) of the hemisphere was the equation 1 as follow (Bies, Hansen, & Campbell, 1996; Nag et al., 2019):

$$r \geq 2 \times T \tag{1}$$

where T was the longest dimension

Four points for the data collections, as illustrated in Figure 3, were determined by equation 2 as follow (Bies et al., 1996):

$$\text{Height of the microphone} = 0.6 \times r$$
$$\text{Distance from Z-axis} = 0.8 \times r \tag{2}$$

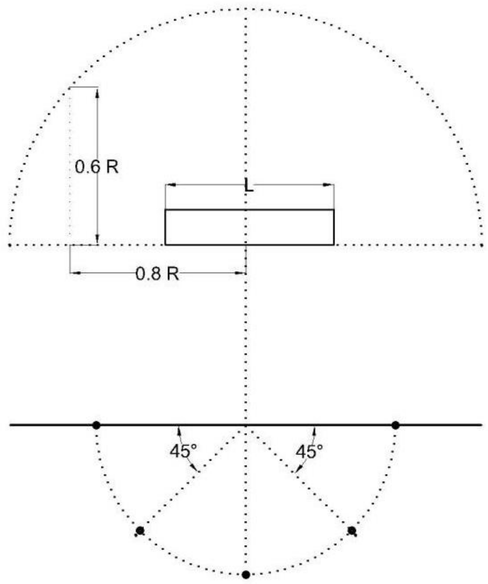

Fig. 3. Determining the location of data collection

Afterward, the diesel engine was turned on at 1100 rpm. The SPL data collection was carried out at four predetermined points. Data was collected three times at each point and then considered the highest. After each data was obtained, the noise level was calculated using the noise level equivalent by equation 3 as below (Fredianta et al., 2013):

$$L_{eq} = 10 \log 0{,}5 \left(10^{0{,}1P1} + 10^{0{,}1P2} + 10^{0{,}1P3} + 10^{0{,}1P4}\right) \quad (3)$$

The result of the calculation obtained was then compared with the regulation of The Ministry of Manpower, Republic of Indonesia, No. Kep-51/MEN/1999 regarding the noise threshold value and the allowable working duration in the work area as shown in Table 1 (Depnaker, 1999).

Table 1 - The guideline regarding the noise threshold value

SPL	Maximum duration
82 dBA	16 hours
85 dBA	8 hours
88 dBA	4 hours
91 dBA	2 hours
94 dBA	1 hour
97 dBA	30 min.
100 dBA	15 min.
103 dBA	7,5 min.
106 dBA	3,75 min.
109 dBA	1,88 min.
112 dBA	0,94 min.
115 dBA	28,12 sec.
118 dBA	14,06 sec.
121 dBA	7,03 sec.
124 dBA	3,52 sec.
127 dBA	1,76 sec.
130 dBA	0,88 sec.
133 dBA	0,44 sec.
136 dBA	0,22 sec.
139 dBA	0,11 sec.
140 dBA	Not allowed

4. Results and Discussions

Figure 4 is an illustration of the result of measuring dimensions of the sound source to determine the measurement distance and the microphone array on the hemisphere. Using equation 1, with T is 95 cm, radius obtained was 190 cm, or rounded to 200 cm. Then, using equation 2, the distance from the Z-axis and the height of the microphone array obatined were 160 and 120 cm, respectively.

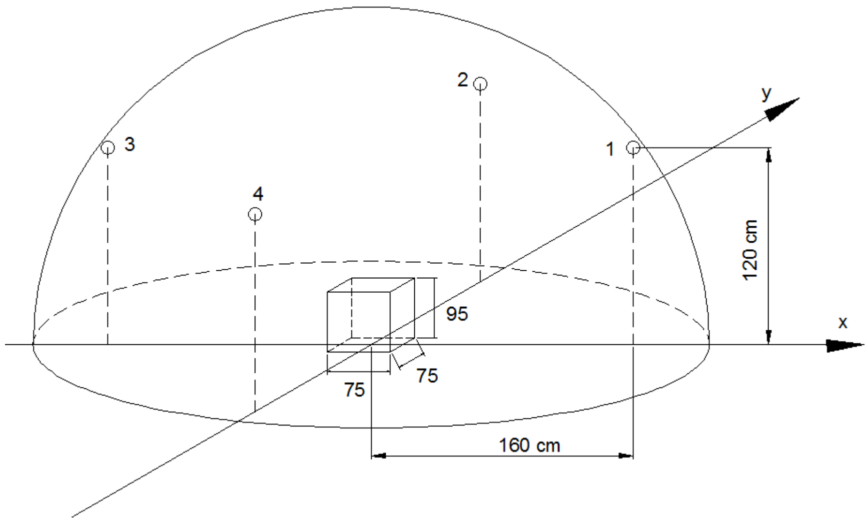

Fig. 4. The measurement distance and microphone array on the hemisphere

SPL measurements were done four times at positions 1, 2, 3, and 4 as shown in Figure 4. Two parameters were measured, namely when the engine was off and when the engine was turned on with 1100 rpm. Results of the data collection are presented in Table 2 and Table 3.

Table 2 - The results of the background noise measurement

Position	Background noise (dB)		
	I	II	III
1	51,6	49,2	49,5
2	51,4	47,6	48,9
3	47,7	49,6	48,2
4	49,2	46,3	48,7

Table 3 - The results of the diesel engine noise measurement

Position	Diesel engine noise (dB)		
	I	II	III
1	88	89	90
2	90,3	90,5	91,3
3	88,6	88,8	88,4
4	88,5	88	88,4

After data from noise measurement results were obtained, as shown in Table 3, the next step was to analyze these data and obtain measurement results of the diesel engine noise, as shown in Table 4. From Table 4, it could be explained that Pi was the noise from the sound source or the engine. This value was the largest result from three attempts which was then determined as the Pi-value at a position. Similar to Pi, Pi-BN was also the largest result of the measurement from three measurement attempts. Pi-BN was the background noise or the environmental noise level without being influenced by sound sources or diesel engine sounds. From the data obtained, the correction factor value was set to 0 because the range of differences between Pi and Pi-BN was more than 12. Furthermore, actual P was the difference between Pi and the correction factor, because the correction factor was 0, so the value of Pi was the same as the actual P-value. Furthermore, using equation 3, by entering all actual P-values at all positions into the equation, the noise level in the diesel engine room was 92.805 dBA. Based on regulation No. Kep-51/MEN/1999, as shown in Table 1, with a noise level of 92.805 dBA, the maximum exposure time to the noise was 2 hours.

Table 4 - Analysis of measurements of diesel engine noise with 1100 rpm

RPM 1100				
Position	Pi	Pi - BN	Correction Factor	P Actual
P1	90	51,6	0	90
P2	91,3	51,4	0	91,3
P3	88,8	49,6	0	88,8
P4	88,5	49,2	0	88,5

From results obtained, of course, efforts to reduce the diesel engine's noise level were required. There are three methods that may be done. First, by controlling the noise source by modifying the engine work or replacing the noise source component. Second, by exercising control along the sound path by adding a porous layer around the source. Both approaches require further research which we will carry out in the following research. The last method is to control at the receiver level, for example by using an earplug or earmuff. The use of the earplug may reduce the noise by ± 30 dB, while the earmuff may reduce noise by 40-50 dB (Utami, Winata, Sillehu, & Marasabessy, 2019; Tuccar, 2018; Iakovenko et al., 2020). Thus, the sound level experienced by the operator is already in a safe condition.

5. Conclusions

From this analysis of the result of diesel engine noise measurements with an operational speed of 1100 RPM, the following conclusions were obtained:

- Based on measurement results, the background noise in the diesel engine room was 51.6 dB.
- Based on the calculation, the noise level from a diesel engine was 92,805 dBA.
- With a noise level of 92,805 dBA, the allowed maximum exposure time to the noise was 2 hours.

References

Baek, H. M., & Lee, H. M. (2022). Experimental investigation of ringing intensity and combustion noise level from biodiesel fuel in CRDI diesel engine with various injection timings. *Journal of Advanced Marine Engineering and Technology (JAMET), 46*(2), 56-63.

Bari, S. (2013). *Diesel Engine: Combustion, Emissions and Condition Monitoring*: BoD–Books on Demand.

Bies, D. H., Hansen, C. H., & Campbell, R. H. (1996). Engineering noise control. In: Acoustical Society of America.

Cao, D. N., Hoang, A. T., Luu, H. Q., Bui, V. G., & Tran, T. T. H. (2020). Effects of injection pressure on the NOx and PM emission control of diesel engine: A review under the aspect of PCCI combustion condition. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 1-18.

Depnaker, R. I. (1999). Kepmenaker Nomor: KEP-51/MEN/1999 tentang Nilai Ambang Batas Faktor Fisik di Tempat Kerja. In: Jakarta: Departemen Tenaga Kerja RI.

Fredianta, D., Huda, L. N., & Ginting, E. (2013). Analisis Tingkat Kebisingan untuk Mereduksi Dosis Paparan Bising di PT. Xyz. *Jurnal Teknik Industri USU, 2*(1).

Gorji, M., Ghassemi, H., & Mohamadi, J. (2018). Calculation of sound pressure level of marine propeller in low frequency. *Journal of Low Frequency Noise, Vibration and Active Control, 37*(1), 60-73.

Iso, E. (2014). 11200 (1995) Acoustics–Noise emitted by machinery and equipment–Guidelines for the use of basic standards for the determination of emission sound pressure levels at a work station and other specified positions (ISO 11200: 1995). *European Committee for Standardization (CEN), Bruxelles*.

Mao, Y., Zhao, W., Lu, S., Yu, L., Wang, Y., Liang, Y., ... & Pan, Y. (2020). Copper-catalysed photoinduced decarboxylative alkynylation: a combined experimental and computational study. Chemical science, 11(19), 4939-4947.

Mollenhauer, K., & Tschoke, H. (2010). *Handbook of diesel engines* (Vol. 1): Springer Berlin.

Nag, S., Sharma, P., Gupta, A., & Dhar, A. (2019). Combustion, vibration and noise analysis of hydrogen-diesel dual fuelled engine. *Fuel,* 241, 488-494.

Narang, P., & Bell, T. (2008). New IEC standards and periodic testing of sound level meters. *Proceedings of the Internoise, Shanghai*.

Noor, C. M., Noor, M. M., & Mamat, R. (2018). Biodiesel as alternative fuel for marine diesel engine applications: A review. *renewable and sustainable energy reviews, 94*, 127-142.

Redel-Macías, M. D., Hervás-Martínez, C., Gutiérrez, P. A., Pinzi, S., Cubero-Atienza, A. J., & Dorado, M. P. (2018). Computational models to predict noise emissions of a diesel engine fueled with saturated and monounsaturated fatty acid methyl esters. *Energy, 144*, 110-119.

Sedighi, S., Kalantari, D., & Redl, J. (2022). Measuring and Characterizing the Noise Emission of a Small Combustion Engine after Acoustical Topology Optimization of the Muffler. Available at SSRN 4098747.

Švec, J. G., & Granqvist, S. (2018). Tutorial and guidelines on measurement of sound pressure level in voice and speech. *Journal of Speech, Language, and Hearing Research, 61*(3), 441-461.

Tüccar, G. (2018). Effect of hydroxy gas enrichment on vibration, noise and combustion characteristics of a diesel engine fueled with Foeniculum vulgare oil biodiesel and diesel fuel. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 40*(10), 1257-1265.

Utami, T. N., Winata, R., Sillehu, S., & Marasabessy, R. S. (2019). Earplug as a Barrier on Hearing Disorders Due to Noise Exposure. *Indian Journal of Public Health Research & Development, 10*(12), 2028-2032.

Zhang, D., Tenpierik, M., & Bluyssen, P. M. (2019). Interaction effect of background sound type and sound pressure level on children of primary schools in the Netherlands. *Applied Acoustics*, 154, 161-169.

三浦甫, 佐藤宗純, 鈴木英男, 舘野誠, & 瀧浪弘章. (1998). IEC/TC 29" 電気音響" 浜松会議. *日本音響学会誌, 54*(3), 239-240.