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# Performance study between polyurethane and styrofoam as diesel engine sound insulating materials on the traditional passenger ship

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**Abstract.** Indonesia as a maritime country and islands, boats are the only option for people to travel outside the region in order to meet daily needs and usually ships operating from morning to evening with the average shipping time 2-3 hours each way in which ships are generally small so that the engine and the passenger seemed to be in the same room and produce damage to the ear drums. The objectives of this study are knowing noise level and choose proper material for absorbing or dampening noise level. This research using under the provisions of the above then performed experiments to create a Diesel engine casing made from plywood to the outside while the inside is used Polyurethane (PU) and Styrofoam successful minimize noise due to the Diesel engine operation.

## 1. Introduction

Indonesia as a maritime country and islands, where the distance between remote island areas which are difficult to access, making the boats as the only option for people to travel outside the region in order to meet daily needs. These usually ship operating from morning to evening with old shipping an average of 2-3 hours each way in which ships are generally small so that the engine and the passenger seemed to be in the same room. Consequently inevitably generated noise sound machine cannot be avoided and noise arising this will certainly affect the health of people if the noise exceeds the threshold value that has been set if it happens constantly in a long time Threshold Limit Value (TLV) noise (caused by the sound of the engine, etc.) has been established by local standards, namely the Minister of Manpower and Transmigration No. PER.13 / MEN / X / 2011, On the Threshold Limit Value Factor Physical and Chemical Factors at Work and Indonesian National standard (SNI 16-7063-2004) About Threshold limit Values Work Climate (Heat), Noise, Hand-Arm Vibration and Light Ultra Violet Radiation at Work and the International Maritime Organization resolution of 85 decibels (dB). While international standards, namely the International Maritime Organization resolution MSC.337 (91) Adoption of the Code On Noise Levels on Board Ships for ships that have the weight of 1,600 s / d 10,000 10,000 GT and GT exceeds the limit is 110 dBA, but because the size of the machine is used on small boats similar to the Diesel engine at the Workshop on the standard used is the standard engine in the workshop that is equal to 85 dBA. Based on the above and the experience gained then allegedly noise that occurs in the passenger boat transport exceeds the provision, so that there should be a research to find out more about the level of noise that the problem of noise pollution caused by the noise of the sound of the Diesel engine can be minimized to fit health and safety requirements.



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### 1.1. Study objectives

The objectives of this study are:

- Knowing the level of noise generated in a conventional diesel engine passenger ship.
- Knowing better materials between Polyurethane and Styrofoam to muffle the sound of ship diesel engines.

### 1.2. Problems limitation

Problem limitations of this study are:

- Sampling voices or SPL (Sound Pressure Level) are performed in general regardless of the existing frequency range.
- Researcher did not perform theoretical calculations about the ability of sound dampening material used and the design of the casing.

## 2. Methodology

The definition of the sound wave is propagated interference on elastic medium, gaseous, liquid, or solid form in which a person receives sound vibrations in the eardrum in a frequency region of human hearing. The vibrations generated from a variety of air pressure generated by the noise source and propagated into the surrounding medium, known as acoustic field and when the sound of crashing a boundary of the medium through which it passes, then the energy in the sound waves can be transmitted, absorbed or reflected by boundaries. In general, all three happened at a different degree, depending on the type of boundary in its path [1].

Sound Absorption or sound absorption is the change in energy of sound energy into heat energy. In general, the wood absorbs sound directed at him. The speed of sound in the wood slower than the speed of sound in iron and glass, this is because the wood has pores [2]. According to Tsoumis G, part of the acoustic energy that goes into the wood absorbed by the mass [3]. Massa converts acoustic energy into thermal energy, or rather a sound absorbs. The ability of wood to absorb sound is usually measured by the coefficient of sound absorption. Acoustic materials can be divided into three basic categories, namely absorbing material, barrier material, damping material [4]. In general, the absorbent material is naturally resistive, fibrous and porous.

Comparison of the sound energy absorbed by a material with sound energy that comes to the surface of the material is defined as the absorption coefficient ( $\alpha$ ), where:

$$\alpha = \frac{\text{Absorbed sound energy}}{\text{Sound energy that comes to the surface of the material}}$$

### 2.1. Insulation materials

**2.1.1. Styrofoam.** Styrofoam (polystyrene foam) is a petroleum-based plastic foam. Generally, Styrofoam used as damping material objects that are susceptible to pressure or impact, because it has a relatively light mass and can make the protected goods safe from collision undesirable. In addition, Styrofoam are often used as well as the storage medium of food/drinks to keep them cool because this material is also capable of acting as an insulator because Styrofoam is composed of 95% air, which makes it possible to trap warm air and prevent heat loss when used as insulation in the building or cup coffee where air trapped inside the Styrofoam able to inhibit heat transfer properly.

Styrofoam selected as a raw material alternative damper on this research because due to having a porous nature, which serves as an absorbent property of sound energy into other energy. So there is a sound energy is converted into heat energy, and this has resulted in the reflected sound is reduced. Styrofoam is also easily processed so easily manipulated in accordance with the desired research methods.

**Table 1.** Absorption coefficient materials in the frequency of 600 Hz with a sample thickness of 1 cm.

Materials	Initial Intensity (dB)	End Intensity (dB)	Absorbent Coefficient ( $\alpha$ )
Plywood	83.4	66.5	0.23
	83.3	66.3	0.23
	83.2	66.7	0.22
	83.2	66.6	0.22
	83.2	66.8	0.22
<i>Average</i>			<b>0.22</b>
Styrofoam	83.4	76.4	0.09
	83.3	76.8	0.08
	83.2	76.9	0.08
	83.2	76.8	0.08
	83.2	76.3	0.09
<i>Average</i>			<b>0.08</b>

**2.1.2. Polyurethane.** Polyurethane is a polymeric material containing urethane groups with chemical formula  $\text{-NH-CO-O-}$  is produced from a mixture of two types of chemicals namely A (polyol) and B (isocyanate) are mixed together, causing a reaction and forming Foam. Polyurethane is a function of temperature insulation material and also has advantages as a sound absorbing material, lightweight and rigid as a construction material. Polyurethane is also present in various forms, such as flexible foam, hard foam, anti-chemical coatings, adhesives, and insulation, as well as elastomers. Hard polyurethane foam used as an insulating material in buildings, water heaters, refrigerated transport tool, and coolers for industry and households. This foam is also used for flotation and energy regulation.

The main advantages of polyurethane are in a liquid form. To apply, the liquid medium is sprayed onto the desired application. For example, the walls, the room Karaoke, tank (for coating), and concrete. Once sprayed, the liquid was allowed to dry for a matter of seconds. react to form a foam. The bubble then stuck firmly in the surface of the building. Bubble/foam that is then worked as retaining heat propagation, retaining leaking, and silencers. The bubble was fit to be a substitute for another existing insulator. Regarding the mass load-owned, polyurethane also has a specific gravity that does not burden a building. Therefore, very lightweight polyurethane. Its specific gravity is only about  $36 \text{ kg/m}^3$ . Results of testing by the manufacturer shows that the propagation coefficient of heat generated by the polyurethane is only about 0.017. It was a sign that once plastered polyurethane, heat transmission capacity into a building is very little. Polyurethane election as the absorption material due to having a porous nature, which serves as an absorbent property of sound energy into other energy. So there is a sound energy is converted into heat energy, and this has resulted in the reflected sound is reduced. Its characteristics include low frequency, the absorption coefficient ( $\alpha$ ) is small and the higher the frequency, the greater the  $\alpha$  also as shown in the following table:

**Table 2.** Absorption coefficient for some basic materials.

Materials	Frequency (Hz)					
Fibrous glass (typically 4 lb/cu ft ) hard backing)	125	250	500	1000	2000	4000
1 inch thick	0.07	0.23	0.48	0.83	0.88	0.8
2 inches	0.2	0.55	0.89	0.97	0.83	0.79
4 inches thick	0.39	0.91	0.99	0.97	0.94	0.89
Polyurethane foam (open cell)						
1/4-inch thick	0.05	0.07	0.1	0.2	0.45	0.81
1/2-inch thick	0.05	0.12	0.25	0.57	0.89	0.98
1 inch thick	0.14	0.3	0.63	0.91	0.98	0.91
2 inches thick	0.35	0.51	0.82	0.98	0.97	0.95
Hairfelt						
1/2-inch thick	0.05	0.07	0.29	0.63	0.83	0.87
1 inch thick	0.06	0.31	0.8	0.88	0.87	0.87



## 2.2. Materials preparation and sound frequency measurement

Casing-making process with polyurethane material is planned with plywood laminated materials by fiber with a size of 120 x 60 x 85 cm (length x width x height), and after that we mixed polyol solution and isocyanate solution with a ratio of 1: 1 to form a foam as insulation materials on the inside of the casing. Whereas for Styrofoam insulation materials, we attach a Styrofoam on the inside of the casing without any additional process.

At the time of sampling noise sources, there are some things that must be considered to comply with the applicable standards, first measurements were performed with a distance of between 1-2 meters from the machine. Then the height measurement is 1.2 to 1.6 m from the surface and lasts the duration of the measurement time is  $\pm 10$  seconds for 5 minutes. Moreover, set the measurement conditions in order to facilitate the analysis as follows, condition 1: when the engine is operating without a silencer casing and condition 2: when the engine is operating with a silencer casing.



Figure 1. Part front casing sound absorbers.



Figure 2. Sound intensity measuring instrument.

## 3. Results and discussion

Table 3. Measurements at a distance of 1 meter with the polyurethane casing (dB).

Condition	Minutes to 1	Minutes to 2	Minutes to 3	Minutes to 4	Minutes to 5	Average
1	95.7	95.4	95.1	94.6	94.5	95.1
2	79.8	81.7	81.4	83.2	82.9	81.8

Table 4. Measurements at a distance of 2 meters with the polyurethane casing (dB).

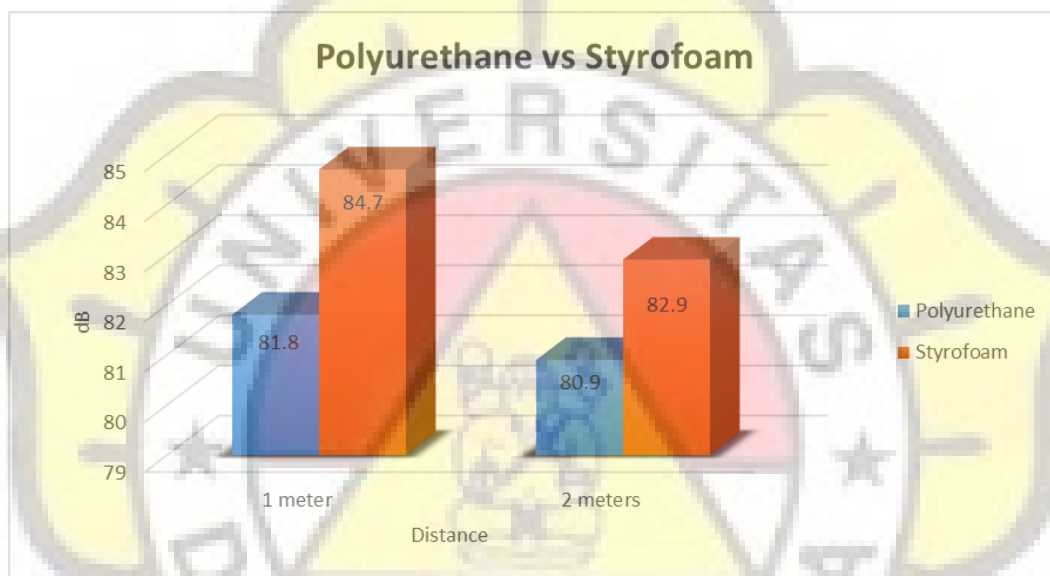
Condition	Minutes to 1	Minutes to 2	Minutes to 3	Minutes to 4	Minutes to 5	Average
1	93.7	93.4	93.8	92.8	92.5	93.2
2	80.9	80.8	81	81	80.8	80.9

**Table 5.** Measurements at a distance of 1 meters with the Styrofoam casing (dB).

Condition	Minutes to 1	Minutes to 2	Minutes to 3	Minutes to 4	Minutes to 5	Average
1	84,6	84,8	84,9	84,7	84,5	84,7
2	83,9	83,5	82,9	82,6	83,5	83,5

**Table 6.** Measurements at a distance of 2 meters with the Styrofoam casing (dB).

Condition	Minutes to 1	Minutes to 2	Minutes to 3	Minutes to 4	Minutes to 5	Average
1	84,4	84,2	84,1	84,3	84,3	84,5
2	83,1	83,4	82,8	82,1	82,9	83,1

**Figure 3.** Comparison chart between polyurethane casing and Styrofoam casing.

The results of measurements carried out show that the polyurethane is better in reducing noise arising out of Styrofoam for a distance of 1 meter where there is a difference of 2.9 dB for a distance of 2 meters, while the difference is 2 dB.

#### 4. Conclusion

Although the test results Styrofoam casing beats polyurethane casing, in terms of health and ease in manufacturing the Styrofoam casing more appropriate to have as noise absorber, other than that the casing also conforms to the regulations concerning noise threshold value is below 85 dB.

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