INDONESIAN JOURNAL OF MARITIME TECHNOLOGY (ISMATECH)
Vol. 1, Issue 2, December 2023
eISSN: 3025-518X
DOI: https://doi.org/10.35718/ismatech.v1i2.1038

Analysis of Generator Power Requirements for Lighting Distribution Using LED Lights on a 500 DWT Sabuk Nusantara

Gusra Wati[1*],Suardi[1] , Azhar Aras Mubarak[2], Nova Fabila[1], Lowry Gabriel S[1],Imam Rifqi Adila[1],Evan Myistro[1]

[1]Department of Naval Architecture, Kalimantan Institute of Technology, Balikpapan, 76127, Indonesia
[2]Department of Naval Engineering, Faculty Science and Technology, Universitas Sembilanbelas November, Kolaka, 93517, indonesia

KEYWORDS
Sabuk Nusantara
Ilumination Research
Zonal Cavity Method
LED lights

ABSTRACT – Sabuk nusantara ship serve as the lifeline of transportation for remote, frontier, underdeveloped, and border islands (3TP), especially in areas devoid of other land and air transportation. These vessels, capable of accommodating up to 500 individuals, connect 3TP-category islands to larger ports, playing a pivotal role in sustaining the economic activities of these regions.This study focuses on the use of LED lights within ship interiors, employing the zonal cavity method. This method divides each room into three segments: the height ceiling cavity (hcc), the height room cavity (hrc), and the height floor cavity (hfc). Illumination values are then determined based on established standards for each specific room.The principal finding reveals that the lighting electricity load for the 500 DWT Pioneer Ship, utilising LED lighting, amounts to 8.74 kW. This research not only addresses technical considerations but also underscores the significance of adequate illumination for passenger comfort and the seamless operation of the ship.By concentrzating on research outcomes, this study provides valuable insights for understanding and enhancing the lighting system on Pioneer Ships. Future steps may involve implementing recommendations to improve efficiency and comfort on such vessels, ensuring the sustainability of the economic and connectivity aspects in regions reliant on these ships.
.

*Corresponding Author | Gusrawati | ✉ (09211022@Student.itk.ac.id)

INTRODUCTION

The development of pioneer ships in Indonesia, a crucial step towards ensuring balanced regional growth, is closely associated with the implementation of a sea highway programme [1]. This maritime logistics initiative, initiated by President Joko Widodo, aims to establish connections between major ports in the archipelago, facilitating seamless goods distribution in remote areas. To support the success of this programme, the government is actively constructing ships designed to facilitate the transportation of people and goods from various regions of Indonesia to remote areas. Among these vessels is the 500-DWT pioneer ship, specifically designed to pioneer tasks such as reaching remote areas untouched by other ships [2]. Similar to land structures, ships require effective lighting sources, particularly during nighttime operations. The ship's lighting system must align with technological advancements, incorporating energy-saving solutions like LEDs (light-emitting diodes) [3]. Given the importance of energy conservation in planning ship lighting installations, it directly impacts the generator power installed on the ship.

Considering the upward trend in fuel prices, especially diesel oil, in Indonesia, optimising operational costs is paramount. A comprehensive study of LED lights becomes imperative as they offer 50% greater energy efficiency compared to other lamp types, such as fluorescent lamps, and boast a lifespan twice as long [4]. Ensuring a high-quality lighting system in every room on the ship is essential. ABS class regulations have been issued to standardise lighting criteria for each accommodation room on board, aiming to facilitate crew mobilisation, passenger access, and overall safety. The zonal cavity method is commonly employed to determine the appropriate lighting levels in each room, providing valuable insights into the necessary number of lights for optimal functionality [5]. This research underscores the significance of integrating LED technology into ship lighting systems to enhance sustainability and operational efficiency in support of Indonesia's regional connectivity goals.

METHOD

This ship is a Ro-Ro type ship whose power source is a 3-phase generator, a Perkins brand 6TG2AM Marine Auxiliary Engine with a power of 64 kW. This ship was built in Surabaya in 2014 at the PT shipyard, PELNI. This ship is capable of carrying a crew of 12 people and 185 passengers. The total gross tonnage (GT) of the ship is 500 tons. The main specifications of the ship can be seen in Table 1. Basically, the main objective of this research is to find the optimal level of lighting on board the ship as is done in other ship lighting distribution planning so that optimal generator power is obtained for ship lighting [6].

Table 1. Main specifications of Pioneer Ship 500 DWT.

Sabuk Nusantara 500 DWT Specification	Unit
Length over all (LOA)	51,80 m
Moulded breadth (BMLD)	10,4 m
Designed draught (TMLD)	2,85 m
Molded depth (HMLD)	4,2 m
Speed Service (Vs)	12,00 knot
Complements	12 persons
Cargo Hold Capacity	240 ton
Passenger Capacity	185 Persons
Generator	Perkins 6TG2AM Marine Auxiliary Engine 2 x 110 Kw

Figure 1. 500 DWT Pioneer Ship

A. Electrical Installation (500 DWT Pioneer Ship)

In the maritime domain, akin to structures on land, ships require a robust electrical supply to facilitate onboard activities [7]The 500 DWT Pioneer Ship, a beacon of maritime innovation, draws its power from two primary generators boasting a combined capacity of 110 kW. Complementing these are a harbour generator and an emergency generator, with power capacities of 12 kW and 24 kW, respectively. The intricate network of generators serves the crucial function of providing electrical power to illuminate key areas on the ship. These areas encompass the tank top (JL 1), main deck (JL2), poop deck (JL3), and navigation deck (JL4), crucial zones that collectively ensure the seamless functioning of maritime operations. The ship's electrical infrastructure, depicted in Figure 2, showcases the intricacies of the wiring diagram installation on the Perintis 500 ship [8], [9].

This well-designed electrical system is pivotal not only for illuminating various sections of the ship but also for supporting navigation activities and ensuring the safety of the crew and passengers. The diversity of generators, each serving a distinct purpose, underscores the ship's commitment to reliability and preparedness in diverse operational scenarios. As maritime endeavours continue to evolve, understanding and optimising the electrical infrastructure on pioneering vessels like the 500 DWT Pioneer Ship becomes fundamental to ensuring sustained functionality, safety, and efficiency in maritime operations.

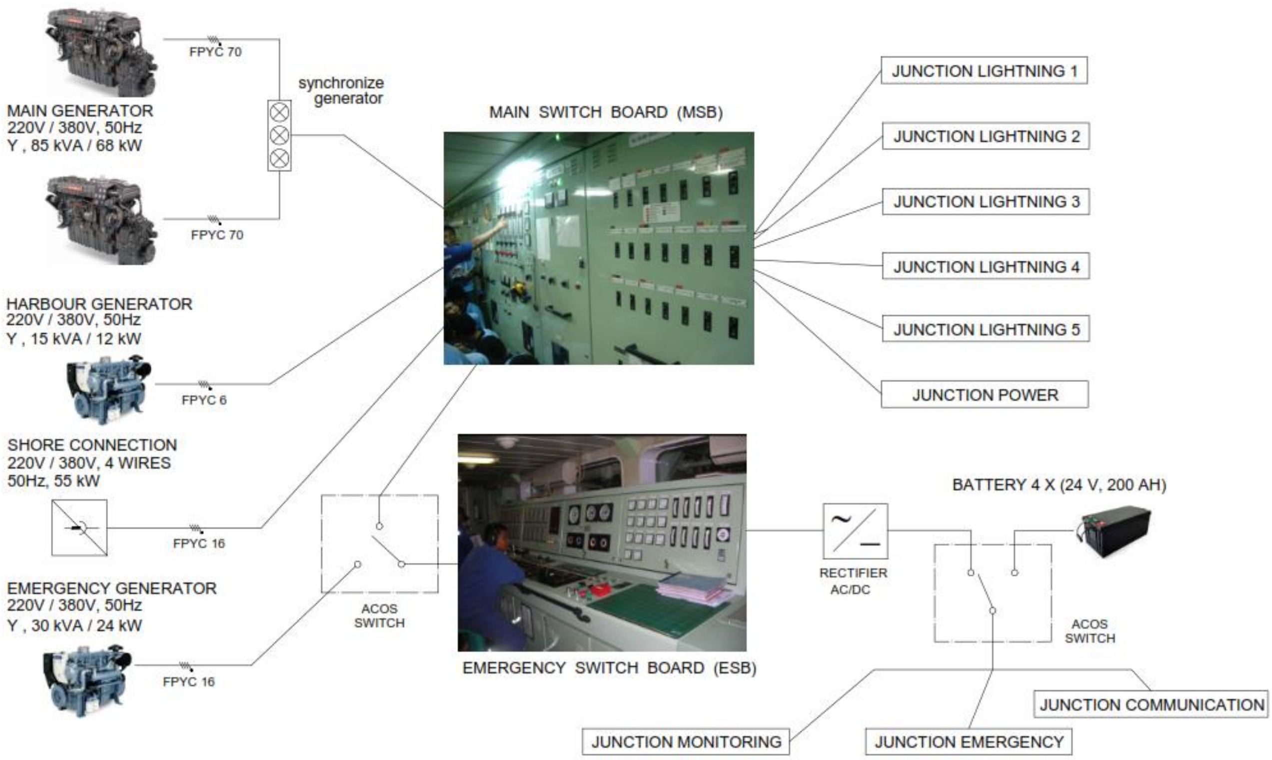


Figure 2. Wiring Diagram of the Sabuk Nusantara 500 DWT [3]

B. Standards for illumination of rooms on board ships

Illumination is defined as the intensity of the light flux received by the surface area of an area [9][10]. Illumination is related to the level of lighting, such as sunlight, which shines brightly in the summer, so that is when the level of illumination is highest. On a ship, the illumination standards for each room must be met so that every activity can be carried out well. The lighting criteria for crew accommodation rooms can be seen in Table 2.

Table 2. Lighting Criteria for Crew Accommodation Spaces

Space	Illuminance Level in Lux	Space	Illuminance Level in Lux
Cabins and Sanitary Spaces			
General Lighting Reading	150		
Reading and Writing		Sanitary Spaces	
Desk	500	Lavatory/Toilet	200
Bunk Light	200	Bath/shower Area	150
Changing Room	200	Light During Sleep Period	<30
Dining Space			
Mess Room and Cafetaria	300	Snack or Coffee Area	150
Recreation Space			
Lounges	200	Gymnasiums	300
Library			
General Lighting	150	Bulletin Board	150
Reading Area	500		
Multimedia/Computer Room	300	Game Rooms	200
TV room/Movie Theater	150	Reception Areas	300

Source: ABS GUIDE for crew habitability on ships [12]

C. Zonal Cavity (Lumen) Method

The zonal cavity method, commonly known as the Lumen method, plays a crucial role in determining lighting levels in indoor spaces. Widely applied due to its accuracy, this method proves particularly effective for assessing lighting in ship interiors. Its significance lies in its consideration of inter-reflections, ensuring a precise evaluation of illumination levels [13].

This method operates on the fundamental understanding of a room's cavity. Figure 3 illustrates the breakdown of cavity dimensions, including the ceiling, floor, and room cavities. This dimensional analysis is pivotal for a comprehensive grasp of light distribution within confined spaces, ensuring optimal visibility and functionality.In maritime environments, like ships, where effective lighting is essential for various operational tasks, the zonal cavity method offers valuable insights. By accounting for the complexities of reflective surfaces in confined spaces, it provides nuanced information on how light interacts, aiding in the determination of appropriate lighting levels.In summary, the zonal cavity method proves invaluable in accurately assessing lighting needs in indoor settings, contributing to enhanced visibility, efficiency, and safety. Its adaptable nature, particularly evident in ship interiors, emphasises its relevance and importance in the realm of illumination engineering [11]

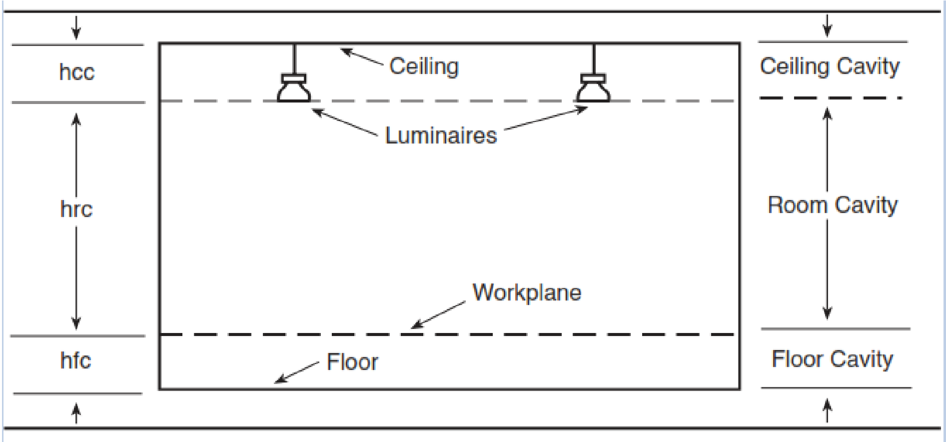


Figure 3. Cavity dimensions of the room

The calculation stages in finding the lighting level are: first, determining the cavity ratio; then, determining the reflectance factor; then, determining the coefficient of utilisation; and finally, calculating the average illuminance level.

To get the value of the Room Cavity Ratio (RCR) ratio, you can use the following formula:

Room Cavity Ratio (RCR) = 5 hrc (L + W) / (L x W) (1)

Where :

hrc = distance from lighting to the work area

L = length of room (m)

W = room width (m)

The amount of light flux required in a room is calculated using the following formula:

Φ Room = (E Room x A) / (CU x LLF) (2)

Where :Φ Room = light flux produced in a room (lumen)

E Room = Nominal illumination required in a room (lux)A = Area of a room (m2)

CU = Coefficient of Utilization/Luminire Utilisation Coefficient

LLF = Total light loss factorMeanwhile, to calculate the number of lights needed in a room, you can use the following formula:

N Rooms = Φ Rooms / Φ Lamps (3)

Where :

N rooms = number of lights needed in a roomΦ Room = light flux produced in a room (lumen)

Φ lamp = light flux in the lamp to be selected (lumen).

RESULTS AND DISCUSSION

Measurement of the lighting intensity in each room on board is carried out by referring to room conditions such as room width, room height, room length, and room area and determining the illumination value in accordance with the standards that have been set for each room [9]. As previously explained, the generator on the ship supplies power for all electrical needs on board the ship, which includes lighting power, power for pumping installations, power for telecommunications, and monitoring. This analysis focuses on lighting requirements with the aim of finding out how much power the LEDs on the 500 DWT Pioneer ship have based on the lighting regulations issued by the ABS.The total power requirement for lighting on the 500 DWT Pioneer Ship using LED lights on each deck is 24.31 kW, as shown in Table 3.

Tabel 3. Lighting load on LED lamps.

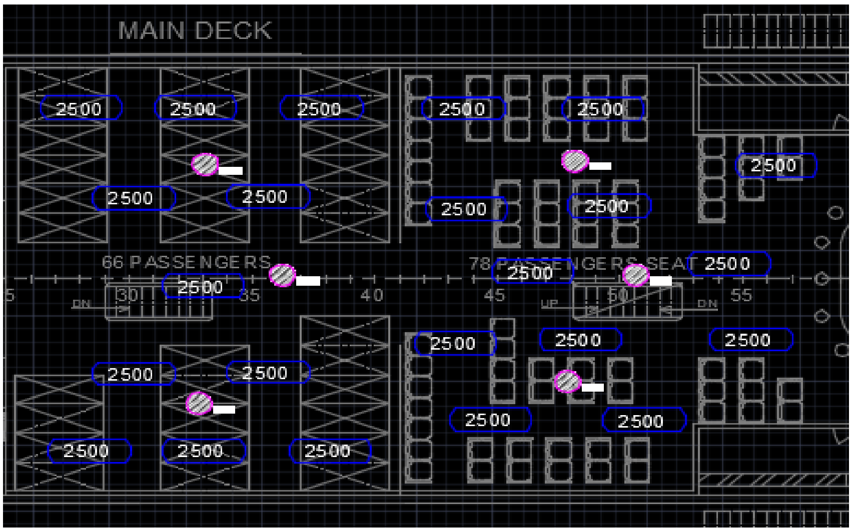
No.	Deck	Power (kW)
1	Tank Tops	1.33 Kw
2	Main Deck	6.66 Kw
3	Poop Deck	0.46 Kw
4	Navigation Deck	0.3536 Kw
	Amount	8.74 Kw

From table 3, it can be seen that the results of testing the power requirements for LED lights are very efficient, such as in the engine room/double bottom after carrying out the cavity (Lumen) method analysis using LED lights, which is 1.33 kW, the main deck is 6.66 kW, the Poop Deck is 0.46 kW, and the Navigation Deck is 0.3536 kW. For the total generator power requirements on the 500 DWT Pioneer Ship, see table 5 for LED lamps.

Table 4. Lighting load on LED lamps.

	Information	Sailing Conditions	Enter and exit the port	Anchored	Emergency
1	Total Power				
2	Continuous load (kW)	-	1.1	1.1	-
3	Intermittent Load (kW)	8.7	7.6	7.6	0.2
4	Diversity Factor (0,7)	6.1	5.3	5.3	0.1
5	Total Load (kW)	6.1	6.5	6.5	0.1
6	Power Amount Generator (kW)	1 x 7	1 x 8	1 x 8	1 x 25
7	Power Capacity Available (kW)	7.2	7.5	7.5	25
8	Load Factor Generator	85 %	86 %	86 %	0.6 %

From Table 4, it can be seen that the saving effect of LED lamps is proven to be very efficient in terms of ship operational costs in terms of generator engine fuel consumption.



.

Figure 5. 2D passenger deck plan using LED lamps.

CONCLUSION

The analysis of light power on the 500 DWT Pioneer Ship, utilizing LED lighting, revealed a lighting electricity load of 8.74 Kw. This observation underscores the efficiency of LED-type lights in maritime applications. The comprehensive power needs for the ship's electrical system employing LED lights are delineated as follows: 6.1 Kw during sailing, 6.5 Kw for port entry and exit, 6.5 Kw while anchoring, and a minimal 0.1 Kw in emergency scenarios.

The findings emphasize the suitability of LED lights for various operational states of the ship, showcasing their ability to meet power demands effectively. In sailing conditions, where optimized power usage is crucial, the LED lights demonstrate a power requirement of 6.1 Kw. Similarly, during port entry and exit, as well as anchoring, the LED lights maintain an efficient power consumption of 6.5 Kw. The minimal power demand of 0.1 Kw in emergency situations further accentuates the reliability and effectiveness of LED lighting in ensuring safety during unforeseen events.In summary, the analysis underscores the advantage s of employing LED-type lights on the 500 DWT Pioneer Ship, showcasing their efficiency across different operational scenarios and contributing to a more sustainable and cost-effective electrical system.

REFERENCES

[1] “KM Sabuk Nusantara 43 Layani Masyarakat Pesisir Selatan Lembata | Koran NTT.” https://korantt.com/2021/01/16/km-sabuk-nusantara-43-layani-masyarakat-pesisir-selatan-lembata/ (accessed Nov. 04, 2023).

[2] “Situs Resmi PT Pelayaran Nasional Indonesia (Persero).” https://www.pelni.co.id/kapal-perintis (accessed Nov. 29, 2023).

[3] A. I. Suardi, Kyaw, Aung Ye, Wulandari and F. Zahrotama, “Impacts of Application Light-Emitting Diode (LED) Lamps in Reducing Generator Power on Ro-Ro Passenger Ship 300 GT KMP Bambit,” *Int. J. Mech. Eng. Sci.*, vol. 7, no. 1, pp. 45–53, 2023.

[4] X. Wang, Z. Liu, Z. Zhao, J. Wang, S. Loughney, and H. Wang, “Passengers’ likely behaviour based on demographic difference during an emergency evacuation in a Ro-Ro passenger ship,” *Saf. Sci.*, vol. 129, no. 1, p. 104803, 2020, doi: 10.1016/j.ssci.2020.104803.

[5] H. A. Ali, J. X. Lu, K. Sun, and C. S. Poon, “Valorization of spent fluorescent lamp waste glass powder as an activator for eco-efficient binder materials,” *Constr. Build. Mater.*, vol. 352, no. August, p. 129020, 2022, doi: 10.1016/j.conbuildmat.2022.129020.

[6] S. W. Suardi, K. A. Ye, and M. R. T, “Plan for the Power Requirements of The Lights in the Fishing Boat Room Using LED Lights,” *Indonesian Journal of Maritime Technology.*, vol. 1, no. 1, pp. 1–6, 2023, doi: 10.35718/ismatech.v1i1.891

[7] S. B. Boulevard, “Lighting” [Online]. Available: www.imtra.com

[8] M. U. Suardi, Pawara, A. Mursid, and N. Arifuddin, “PERENCANAAN DISTRIBUSI PENERANGAN UNTUK RUANGAN DI ATAS KAPAL TB LIBERTY 217 GT,” *Inovtek Polbeng*, vol. 13, no. 1, pp. 29–34, 2023, doi: 10.35314/ip.v13i1.3164.

[9] dan M. U. P. Suardi, Alamsyah, Wira Setiawan, “PERENCANAAN DISTRIBUSI PENERANGAN KAPAL IKAN MULTIPURPOSE 70 GT MENGGUNAKAN METODE ZONAL CAVITY,” *J. Inov. Sains Dan Teknol. Kelauta*, vol. 4, no. 3, pp. 23–29, 2023.

[10] A. Andersen and Velux, *Daylight, Energy and Indoor Climate Basic Book*, 3rd ed. 2014.

[11] R. E. Levin, “Zonal-Cavity in Small Rooms and Long Corridors,” *J. Illum. Eng. Soc.*, vol. 16, no. 1, pp. 89–99, 1987, doi: 10.1080/00994480.1987.10748669.

[12] ABS, *Guide For Crew Habitability On Ships*, no. September. 2016, pp. 1–96. [Online]. Available: http://www.eagle.org/eagleExternalPortalWEB/ShowProperty/BEA Repository/Rules&Guides/Current/102_CrewHabitabilityonShips/Pub102_CrewHabitability

[13] H. and R. G. Hofmann, *Handbook of Lighting Design*, 1992nd ed. Germany, 1997.