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Design of the electrical system on a general cargo ship with a length of 105,669 meters

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Cargo ship, LED lights, Zonal cavity method, Lighting design, Generator power, Maritime safety.

ABSTRACT – This research investigates the incorporation of LED lights and the zonal cavity method in the initial design stage of a cargo-type ship, focusing on efficient lighting for diverse ship zones. The study aims to determine optimal lighting requirements, adhering to industry standards, for zones such as double bottom, maindeck, poopdeck, boatdeck, bridgedeck, navdeck, and emergency conditions. Ships play a vital role in transporting passengers and goods across seas and rivers, necessitating effective lighting systems for safe operations, particularly at night. This paper explores the integration of LED lights and the zonal cavity method in the general arrangement design of a cargo ship.The zonal cavity method is applied to ascertain lighting intensity in different ship zones based on room dimensions, including width, height, length, and area. Illumination values are determined according to established standards for each zone. The cumulative lighting electricity load for various ship zones using LED lights is calculated to identify specific power requirements. The lighting power requirements for the double bottom, maindeck, poopdeck, boatdeck, bridgedeck, navdeck, and emergency conditions are found to be 0.141 KW, 0.75 KW, 1.068 KW, 0.762 KW, 0.671 KW, 0.42 KW, and 0.296 KW, respectively. The total lighting power for all zones is calculated at 3.7776 KW, suggesting the installation of a 4 KW generator for optimal power supply. The application of the zonal cavity method in the planning and design of a cargo ship's lighting system, combined with energy-efficient LED lights, proves to be an effective approach. The results indicate that a 4 KW generator is sufficient to meet the lighting power demands for various ship zones, ensuring compliance with safety standards and technological advancements in maritime lighting.

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INTRODUCTION

This comprehensive scientific journal investigates the pivotal role of lighting in ship construction, with a specific emphasis on the integration of LED lights and energy-efficient design to ensure economical and sustainable illumination. The study delves into the intricate process of designing room layouts in modern steel ships, with a keen focus on adhering to the lighting regulations stipulated by the American Bureau of Shipping (ABS) class [1]. Furthermore, it explores the multifaceted impact of lighting choices on generator power requirements and operational costs, particularly in light of the persistent challenge posed by escalating fuel prices in the maritime industry [2]. The planning and construction of ships, especially those crafted from steel, demand meticulous attention to detail to achieve optimal room layouts. These layouts are crucial for ensuring the safety, comfort, and efficiency of the ship's crew and passengers. Equally critical is the implementation of a reliable lighting system that aligns with the latest technological advancements. This study recognizes and emphasizes the utilization of Light Emitting Diode (LED) lights in ship lighting to ensure not only energy efficiency but also cost-effectiveness in the long run. Several studies have shown that the use of LED lights is more economical than fluorescent lights on ships [3]–[6]. By adopting LED technology, ships can significantly reduce their energy consumption, contributing to both economic and environmental sustainability. The research object used is the design of a general cargo ship, which is a ship that is used to transport general cargo with a large weight and has a length of more than 100 meters [7], [8].

The research goes beyond the conventional aspects of ship design, highlighting the need for compliance with ABS class regulations regarding lighting standards [9]. The adherence to these regulations is pivotal for creating a safe and conducive working environment on board, where lighting plays a crucial role in supporting various activities. The study employs the zonal cavity method to determine precise lighting levels in each room of the ship. This method allows for the optimization of lighting conditions while minimizing energy consumption, aligning with the overarching goal of achieving sustainable and cost-effective ship illumination [3]–[6]. The investigation also extends to the correlation between engine power and fuel consumption, emphasizing the urgent need for energy-saving measures in lighting planning. As fuel prices continue to rise, ships face increasing operational costs, making energy-efficient lighting solutions more critical than ever. To address this, the research recommends replacing traditional fluorescent lamps with energy-efficient LED lamps in ship lighting systems. This transition not only aligns with the industry's push towards sustainability but also contributes to significant cost savings in the long term.

In summary, this research underscores the paramount importance of integrating LED lighting and energy-efficient design in ship construction. By adhering to ABS class regulations and utilizing advanced methods such as the zonal cavity approach, shipbuilders can optimize lighting systems [10]. This not only ensures compliance with safety standards but also contributes significantly to cost savings, particularly in the face of the ongoing challenges posed by rising fuel prices. As the maritime industry continues to evolve, embracing innovative lighting solutions becomes not just a choice but a necessity for achieving both economical and sustainable ship illumination.

METHOD

This ship is a Cargo type ship which is still in the general plan design stage (General Arrangement) and lighting will also be planned in the ship design, where to plan the lighting in the design of this ship to determine the generator power for this ship is to use the zone capacity method.

Table 1. Main specifications of General Cargo Ship KMP Rojo Samudro

Kapal Perintis 500 DWT Specification	Unit
Length over all (LOA)	105.669 meter
Moulded breadth (BMLD)	16.3 meter
Designed draught (TMLD)	6.6 meter
Molded depth (HMLD)	8.15 meter

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. Illumination is related to the level of lighting, such as sunlight which shines brightly in 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 [8]

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C. Electrical Installation

Similar to buildings on land, ships require a stable electricity supply to facilitate onboard activities. The proposed installation design includes a generator power source intended to supply electrical power to various lighting installations throughout the ship. These installations encompass the engine room (JL 1), (JL 2), vehicle deck (JL 3), intermediate deck (JL 4), passenger deck (JL 5), and navigation deck (JL 6). The generator's primary function is to ensure a reliable and consistent power supply to illuminate these critical areas on the ship, supporting both operational and safety requirements. This strategic planning aligns with the essential need for well-lit spaces across different sections of the ship for efficient functioning and passenger safety.

D. Zonal Cavity (Lumen) Method

The zonal cavity method or commonly known as the Lumen method is a method that is currently widely applied to determine the lighting level of an area indoors. This method is considered accurate for indoor applications including rooms in ships because this method considers the effect of inter-reflections on lighting levels. The basis of this method is because there is a cavity in the room, in Figure 3 you can see the division of cavity dimensions in a room, including ceiling cavity, floor cavity and room cavity

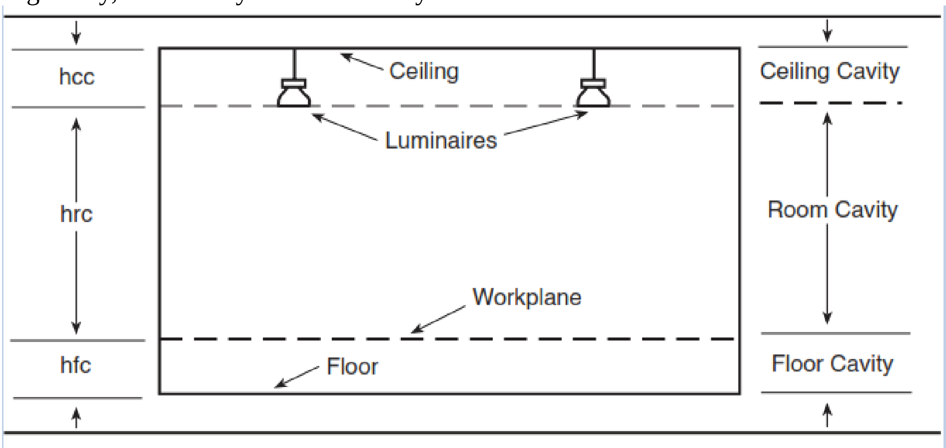


Figure 3. Cavity dimensions of the room

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

The measurement of 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. 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 needs, with the aim of finding out the power ratio between fluorescent lamps and LED lamps on ships. The total generator power requirements for cargo can be seen in the following table for fluorescent lamps and table 6 for LED lamps.

Table 3. Lighting load on LED lamps.

Normal Condition

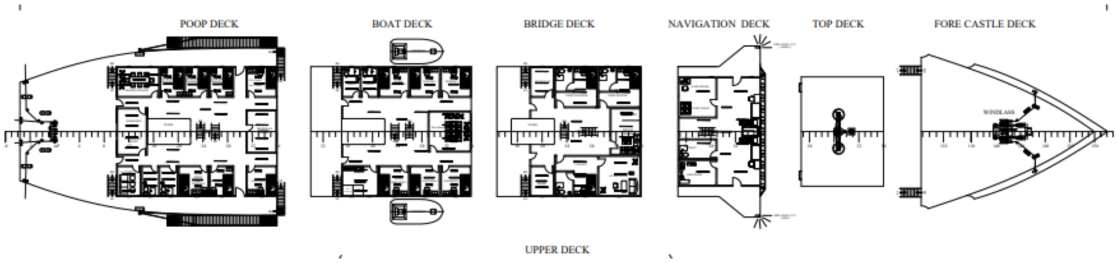
No.	Room	Flux Lamp (Lumen)	number of light points Procurement	Light Flux Total Lumen	Procurement (Unit)	Power (Watt)	Total Power (Watt)
1	Engine Room	4400	3	13200	3	42.0	126.0
2	Accomodation Ledder	1500	1	1500	1	15.0	15.0

Emergency Condition

No	Room	Flux Lamp (Lumen)	number of light points Procurement	Light Flux Total Lumen	Procurement (Unit)	Power (Watt)	Total Power (Watt)
1	Engine Room (Rudder)	1050	5	5250	5	8	40
2	Gang Way	1050	1	1050	1	8	8
3	Void Room	1050	1	1050	1	8	8

Table 3 explains the lighting conditions using LED lights in the engine room. The total amount of power produced begins with the number of light points that have been calculated according to the standard lumen cavity method. The accumulation of the total lighting power requirements using LEDs on board the ship from the bottom deck to the top deck can be seen in Table 4.

No	Load	Sail Condition	Entering and Exiting the Port	Anchored	Emergency
1	Total of Power				
2	Continuous Load (kW)	9.8	0.4	3.7	-
3	Intermiten Load(kW)	17.0	5.6	7.4	0.3
4	Diversity Factor (0,7)	11.9	3.9	5.2	0.2
5	Total Load (kW)	21.7	4.3	8.9	0.2
6	Total Generator Power (kW)	2 x 12	2 x 5	2 x 12	1 x 1
7	Available Power Capacity (kW)	24	10	24	1
8	Generator Load Factor	90 %	43 %	37 %	17.6 %



CONCLUSION

The findings from the assessment of light power utilization on General Cargo ships, employing the cavity zone method and LED lights, revealed the cumulative electrical load for various sections. In the double bottom lighting, the load was determined to be 0.141 K; on the main deck, it was 0.75 KW; on the poopdeck, it reached 1.07 KW; on the boatdeck, it amounted to 0.762 KW; on the bridge deck, it measured 0.671 KW; on the navdeck, it accounted for 0.42 KW; in emergency conditions, it stood at 0.296 KW. Considering all lighting zones, the total power calculated was 3.7776 KW. Consequently, based on this total power, the design plan for the cargo ship suggests the installation of a generator with a capacity of 4 KW. These results indicate the comprehensive assessment of lighting requirements, ensuring that the proposed generator capacity aligns with the ship's lighting demands.

REFERENCES

[1] "Do you know how ships are protected from lightning? - SAFETY4SEA." https://safety4sea.com/cm-do-you-know-how-ships-are-protected-from-lightning/ (accessed Dec. 12, 2023).

[2] T. E. Notteboom and B. Vernimmen, "The effect of high fuel costs on liner service configuration in container shipping," *J. Transp. Geogr.*, vol. 17, no. 5, pp. 325–337, 2009, doi: 10.1016/j.jtrangeo.2008.05.003.

[3] 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," *Indones. J. Marit. Technol.*, vol. 1, no. 1, pp. 1–6, 2023.

[4] 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.

[5] 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.

[6] 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.

[7] D. J. Eyres and G. J. Bruce, "Shell plating and framing," in *Ship Construction*, Elsevier, 2012, pp. 189–205. doi: 10.1016/b978-0-08-097239-8.00017-9.

[8] H. A. Karanassos, "Ship's Outfit," in *Commercial Ship Surveying*, Elsevier, 2016, pp. 157–178. doi: 10.1016/b978-0-08-100303-9.00009-2.

[9] 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.

[10] 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