Redesigning Generator of Landing Craft Tank 1500 DWT by Considering Technical and Economic Factors

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Abstract. The electrical system is very important thing on a ship, where the tool that functions as power to meet the electricity needs on the ship is a generator. In some cases, generator planning does not pay attention to technical and economic factors that have an impact on operations cost. The technical factor will be adjusted to the standard and regulations of the classification board, while the economic factor will be planning an efficient electrical installation and power installation system. The results obtained from this paper show the operational needs of the ship based on the condition when harbour, sailing, loading and unloading, and emergency during the day with total intermittent load of 110,6 KW and total continuous load of 130,6 KW while the operational needs of the ship at night with total intermittent load is 98,2 KW and total continuous load is 181,5 KW. Then it was found that the largest operational power requirement of the ship in an emergency at night was 38,5 KW and the largest power was in the condition of the ship at night of 102,5 KW. Then we get 3 generators with 2 sets of 60 KW power capacity and 1 set of 45 KW.

Keywords: Redesigning, Operations Cost, Landing Craft Tank

1 Introduction

The electrical system on the ship is an important thing in designing a ship. Generator is one of the equipment on the ship that is useful to meet all the power needs on the ship. In determining the capacity of the generator that will be used to meet the power needs of the ship, a load calculation will be carried out to determine the power capacity and changes in use for each operating condition. The goal is to find the minimum and maximum power required [1]. In some cases, Landing Craft Tank (LCT) 1500 DWT ship at Dok dan Perkapalan Kodja Bahari Jakarta Shipyard Unit III has a very large generator power so that it becomes inefficient for planning generator power requirements. Therefore, this paper aims to redesigning generator of LCT 1500 DWT by considering technical and economic factors. The technical factor in question is in accordance with the regulations that have been issued by a class, which in this case is the Indonesian Classification Bureau (BKI). Meanwhile, the economic factor in question is the efficiency of calculations regarding the determination of power installations and lighting installations. The author will calculate the load factor and the diversity factor on the ship. The load factor will be calculated conditions when harbour, sailing, loading and unloading and emergency. To calculate the

generator capacity, first requires secondary power balance data from the installed pumps, then calculates all electric motors from the winch, lamps and other electrical equipment installed according to technical factors and economic factors. According to the Indonesian Classification Bureau (BKI) listed in Volume 4 Chapter 1 of 2004, all electrical equipment on board and the capacity of each equipment must be listed in the table.

2 Generator Capacity

The generator output power required during sea voyages must be greater than 15% of the power requirements specified in the power balance [3].

3 Ship Electrical and Equipment

The electrical components contained in the ship are divided into several parts, as follows:

3.1 Electric motor and Winch

According to (Hartono, 1988) winch or a tool commonly called a crane is a tool that needs to be able to rotate slowly to lift or extend the tros and anchors.

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3.1.1 Windlass and anchor motor power

Included in the Indonesian Classification Bureau (BKI) volume 2 of 2018, regarding the calculation of the anchor plan, the following formula can be used to calculate the anchor plan:

$$Z = \frac{D^2}{3} + 2 \cdot h \cdot B + \frac{A}{10} \quad (1)$$

where D = Displacement of the ship [m³], h = fb + hi [m], B = Width of the ship [m], A = Area in side view of the hull, superstructure, and deckhouse [m²]

3.1.2 Winch and Lifeboat Electric Motor Power

According to the book "Ship Equipment and Supplies" written by Sukarsono N.A. On page 75, the motor power of the lifeboat can use the following formula:

$$N = \frac{W \times H}{60 \times 75 \times \eta} ; (kw) \quad (2)$$

where W = weight of lifeboat + weight of equipment + weight of crew [kg] According to the book "ship systems and equipment" by Sukarno NA, the lifeboat and equipment weighs 2,960 kg, H = lifeboat height [m], = motor efficiency, i.e. 0, 98 (for new motorcycle)

3.1.3 Winch and Ramp Door Motor Power

According to the book "Merchant Ship Design Hand Book Volume 5" page 58, calculating the winch drum can use the formula:

$$l = \frac{k \cdot d \cdot L}{\pi \cdot N \cdot (D + n \cdot d)} ; (kw) \quad (3)$$

where k = provisions for wire rope 1,2, d = Steel rope 3/4 inch [m], L = Length of rolled steel rope, n = standard roll rope maximum 7, D = Diameter of drum Then perform Hydraulic calculations based on "Maker Bosch Rexroth Hydraulics, Theory and Applications" using the formula:

$$M = F \times r ; (Nm) \quad (4)$$

where F = Load on winch drum 9810 N, r = radius of winch drum [m]

Then calculate the flow rate of the electric motor using the formula:

$$Q = \frac{v \cdot n}{(n \cdot v\%) \cdot 10^{-1}} ; (lt/min) \quad (5)$$

Then the calculation of the power input from the electric motor will be obtained using the formula:

$$P = \frac{Q \cdot p}{6 \cdot t\%} ; (kw) \quad (6)$$

where Q = Flow rate pump [lt/min], p = 207 bar (existing), t = v x hm = 0.85 x 0.98 = 0.765

The last step is to calculate the power output of the electric motor using the formula:

$$P = \frac{Q \cdot p \cdot t\%}{6 \times 10^{-4}} ; (kw) \quad (7)$$

where Q = Flow rate motor [lt/min], p = 207 bar (existing), t = v x hm = 0.85 x 0.98 = 0.765

From the calculation above, the power from the electric motor will be obtained according to the winch.

3.1.4 Air Conditioner (AC)

According to the book "Ship Equipment and Supplies" written by Sukarsono N.A. On page 75, the AC motor power can use the following formula:

$$N = \frac{3.8 \times V}{100} ; (kw) \quad (8)$$

where V = Room volume [m³]

3.1.5 Lighting Equipment

Determination of lighting equipment on the ship in accordance with the book "Merchant Ship Design Hand Book Volume 5" is divided into 3 parts of lighting. First, inside Lighting (a), includes interior lighting covers rooms such as rooms on the main deck, poop deck, and wheel house deck. Second, external lighting (b), includes aisles on the outside of the ship, as well as places for lowering lifeboats. Third, navigation lighting (c), includes lights used by ships when sailing, loading and unloading or leaning, and so on. So from the three parts of the lighting, the total lighting on the ship can be calculated with the following formula:

$$\Sigma = Total a + Total b + Total c \quad (9)$$

3.1.6 Other Electrical Equipment

The electrical equipment in question is equipment that can support the completeness of the ship, such as equipment in the kitchen (a), washing equipment (b) and navigation and communication equipment (c), the following formula is:

$$\Sigma = Total a + Total b + Total c \quad (10)$$

3.2 Generator Power Capacity Calculation

In this case it will be explained about the calculations in analyzing the power capacity of the generator, as follows:

3.2.1 Load Factor

The load factor is very important when planning the generator capacity to distribute all the electrical power requirements on the ship. The load factor is defined as the ratio of the working time of the equipment under certain conditions to the total working time under these conditions [3].

3.2.2 Continuous Load (CL)

Equipment that operates continuously under normal operating conditions. Here is the equation formula

$$CL = Input \times Total Work \times LF ; (kw) \quad (11)$$

where CL = Continuous Load [kw], LF = Load Factor, Input = Data Power Balance using Open Source software

3.2.3 Intermittent Load (IL)

Equipment that operates intermittently (periodically) in normal sailing conditions with an indefinite period of time. Here is the equation formula:

$$IL = Input \times Total Work \times LF ; (kw) \quad (12)$$

where IL = Intermittent Load [kw], LF = Load Factor, Input = Data Power Balance using Open Source software

3.2.4 Diversity Factor

In short, the diversity factor is the operating load in determining the total load on the generator. Where the value of the diversity factor according to the Indonesian Classification Bureau (BKI) should not be below 0.5. So the author uses a reference from the energy and electricity journal STT-PLN Vol.9 No.6 regarding "Electrical System on the Frosch-class Navy Warship KRI Teluk Celukan Bawang 532" which uses 0.6 for the diversity factor value. The following is the equation formula for calculating the diversity factor, as follows:

$$e = \frac{\text{Total IL}}{\text{Total Power}} \quad (kw) \quad (13)$$

where e = Diversity Factor [kw], IL = Intermittent Load [kw]

3.2.5 Power Requirement

The following is the formula for calculating the electric power capacity (power requirement), as follows:

$$\text{Power Requirement} = \text{Total IL} \times e; \quad (kw) \quad (14)$$

where IL = intermittent load [kw], e = Diversity Factor [kw]

3.2.6 Total Load Power Calculation

The following is the formula for calculating the total load power, as follows:

$$PB = CL + e \times IL; \quad (kw) \quad (15)$$

where CL = Continous Load [kw], e = Diversity Factor, IL = Intermittent Load [kw]

4 Analysis

4.1 Main Properties

Main properties is obtained from secondary data collection from Dok dan Perkapalan Kodja Bahari Shipyard Unit III. This data will be used as a reference for generator calculations, it can be seen in table 1, as follows:

Table 1. Main properties of mv. alfa trans dua

Parameter	Properties
Name	MV Alfa Trans Dua
Length Overall (LOA)	64 m
Length Between Perpendicular (LPP)	56.7 m
Breadth (B)	14 m
Height (H)	4.5 m
Draught (T)	3 m
Coefficient Block (CB)	0.76 m
Speed (Vs)	9 knots
Displacement	1950 ton
Crew	19 Person

4.2 Windlass and Anchor Power

The first thing to do is to calculate the anchor plan, based on BKI volume 2 can use the following formula:

$$Z = \frac{D^2}{3} + 2 \cdot h \cdot B + \frac{A}{10}$$

Where:

$$\begin{aligned} h &= fb + hi \\ &= 1.5 + 6.5 \\ &= 8 \end{aligned}$$

$$\begin{aligned} A &= \text{The area of the walls of the superstructure} \\ &= A1 + A2 + A3 + A4 \\ &= 96 \text{ m}^2 + 92 \text{ m}^2 + 15 \text{ m}^2 + 41 \text{ m}^2 \\ &= 172 \text{ m}^2 \end{aligned}$$

So,

$$\begin{aligned} Z &= \frac{19502}{3} + 2.8.14 + \frac{172}{10} \\ Z &= 156 + 224 + 17.2 \\ &= 397.2 \end{aligned}$$

So from the BKI table in section 7 regarding "ship equipment" regarding anchors, anchor chains and rigging based on the Z value obtained, it can be seen in table 2, as follows:

Table 2. Data on anchor, anchor chain and rope – rigging

Item	Anchor Requirement
Number of Anchor	2
Weight 1 Anchor	1140 kg
Diameter 1 (d1)	34 mm
Diameter 2 (d2)	30 mm
Diameter 3 (d3)	26 mm
Tail chain length for bow anchor (l)	385 m
pull rope length	180 m
Mooring rope length	140 m
Number of mooring ropes	4

Calculation of 1, Anchor Electric Motor Power

Diameter : 34mm
 Brand : Data
 Type : DZC 12001/12002
 Tensile Force : 12000 kg
 Motor Speed : 12m/min
 Motor Power : 22 kW

Then, calculation of 2 and 3, Anchor Electric Motor Power

Diameter : 30 mm and 26 mm
 Brand : Data
 Type : DZC 7001/7002
 Tensile Force : 7500 kg
 Motor Speed : 13m/min
 Motor Power : 15 kW

4.3 Winch and Lifeboat Electric Motor Power

Based on "Ship System and Equipment" by Sukarsono, you can use the formula:

$$N = \frac{W \times H}{60 \times 75 \times \eta} ; (kw)$$

Where:

$$\begin{aligned} W &= \text{weight of lifeboat} + \text{weight of equipment} \\ &\quad + \text{weight of crew} ; (kg) \\ &= 2960 + (19 \times 75) \\ &= 4385 \end{aligned}$$

So,

$$\begin{aligned} N &= \frac{4385 \times 0.7}{60 \times 75 \times 0.98} ; (kw) \\ &= 0.7 \text{ HP} \\ &= 0.52 \text{ kW} \end{aligned}$$

Then obtained davit specifications for lifeboats as follows:

Brand : Jiangsu Jiaoyan
 Type : JYR14
 Slewing Load : 14 KN
 Suits : 14 people

4.4 Winch and Electric Motor Power Ramp Door

To calculate the winch and electric motor power, a list of materials used in the ramp door is required, the material list is obtained from secondary data collection, below is a list of materials that can be seen in table 3, as follows:

Table 3. Rampdoor materials

NO	Type of Materials	Size	Total
1	Stay rampdoor plate	12mm x 1550 x 4500	4 Sh
		12mm x 4000 x 300	2 Sh
		12mm x 4500 x 300	2 Sh
2	Engsel	L 90x90x9mm	6 Bar
		25mm x 350 x 450	18 Sh
		30mm x 300 x 450	9 Sh
3	House Roll Plate	12mm x 150 x 150	18 Bh
		12mm x 650 x 300	2 Sh
		12mm x 300 x 300	2 Sh
4	House Roll Plate	12mm x 110 x 300	4 Sh
		Roll bearing as Dia. 280	2 Set
		12mm x 1641 x 180	2 Sh
5	House Roll Plate	12mm 100 x 550	4 Sh
		Roll bearing as Dia. 280	2 Set
		12mm x 854 x 180	2 Sh
6	Bracket Karet	12mm x 918 x 150	2 Sh
		Roll bearing as Dia. 280	4 Set
		12mm x 75 x 175	9 Sh
7	Wire rope	Plat strip 10mm x 34 x 10000	4 Set
		Rubber 80 x 40 x 10000	2 Set
		Dia. 16 mm	100 M
8	Chain	Dia. 25 mm	20 M
		Seal Dia. 25 mm	4 Bh
		Spanscrup Dia. 25 mm	2 Bh
9	sch 80 pipe	Dia. 4"	2 Bar
		Claim Dia. 16 mm	4 Set
10	tonguelike		
		Plate 12mm x 1500 x 6000	1 Sh
		RB Dia. 1" (@ = 12 m)	13 Bar

First, by calculating the drum winch, based on the "Merchant Ship Design book 5 outfitting" as follows:

$$l = \frac{k \times d \times L}{\pi \times N \times (D + n \times d)} ; (kw)$$

$$l = \frac{1.2 \times 16.100000}{3 \times 14 \times 7 \times (280 + 7 \times 16)} ; (kw)$$

$$l = 222 \text{ mm} \approx 230 \text{ mm}$$

Then perform the Hydraulic calculations, as follows:

$$M = F \times r ; (Nm)$$

$$M = 9810 \times 0.14$$

$$M = 1373.4 \text{ Nm}$$

Then calculate the flow rate of the electric motor, based on "Hydraulics. Theory and Applications, Bosch Rexroth p. 30", using the formula:

$$Q = \frac{v \times n}{(n \times v\%) \cdot 10^{-1}} ; (lt/min)$$

$$Q = \frac{2.8 \times 913.4}{98 \times 10^{-1}} ; (lt/min)$$

$$Q = 26.1 \text{ lt/min}$$

Then the calculation of the power input from the electric motor will be obtained using the formula:

$$P = \frac{Q \cdot p}{6 \cdot t\%} ; (kw)$$

$$P = \frac{144.12}{6 \cdot 76.5\%} ; (kw)$$

$$P = 65 \text{ (kw)}$$

The last step is to calculate the power output of the electric motor using the formula:

$$P = \frac{Q \cdot p \cdot t\%}{6 \times 10^{-4}} ; (kw)$$

$$P = \frac{26 \cdot 207 \cdot 76.5\%}{6 \times 10^{-4}} ; (kw)$$

$$P = 6.88 \text{ (kw)}$$

Then we get a winch ramp door with the following capacities:

Brand : Henan Mine Crane
 Type : JK2
 Rated speed : 24 m/min
 Rope Capacity : 150 m
 Power : 7 KW
 Weight : 550 kg

4.5 Air Conditioner (AC)

In calculating the electric motor power for the Air Conditioner (AC) it takes room volume data from the general arrangement of the LCT 1500 DWT ship which is obtained from secondary data collection. In this case, the measurement of the volume of the room contained on the main deck will be carried out, as follows:

Table 4. Volume and ac power requirement on main deck

Main Deck				
Room	Total	Volume	Power Needs (KW)	
CO2 Rom	1	51,8 m ³	1,5	
Provision Store	1	70,6 m ³	2,0	
Crew 1 Room	1	99,0 m ³	2,8	
Crew 2 Room	1	99,0 m ³	2,8	
Crew 3 Room	1	99,0 m ³	2,8	
Office	1	85,8 m ³	2,5	
Mess Room	1	303,7 m ³	8,7	
Galley	1	109,9 m ³	3,1	
Total		918,7 m ³	26,2	

In this case, the measurement of the volume of the room contained in the poop deck, as follows:

Table 5. Volume and ac power requirement on poop deck

Poop Deck				
Room	Total	Volume		Power Needs (KW)
Captain Room	1	105,3	m3	3,0
Crew 1 Room	1	78,0	m3	2,2
Crew 1 Room	1	76,3	m3	2,2
Owner Room	1	69,3	m3	2,0
Engineering Room	1	105,3	m3	3,0
Total		434,2	m3	12,4

In this case, a measurement of the volume of the room contained in the wheel house deck as follows:

Table 6. Volume and ac power requirement on wheel house deck

Wheel House Deck				
Room	Total	Volume		Power Needs (KW)
Chart Space	1	30,6	m3	0,9
Radio & Navigation Space	1	344,1	m3	9,8
Total		374,7	m3	10,7

Then the total power requirement is obtained according to the calculation for the entire deck of 49.3 KW.

4.6 Pumps

The data on the power requirements of the pumps are obtained from secondary data collection, as follows:

Table 7. Pump power requirement

NO	ITEM	No of		POWER	
		set	output	input	
1	Bilge Pump / Fire Pump	1	7,5	9	
2	General Service & Ballast Pump	2	7,5	18	
3	Sea Water Hydrophore Pump	1	2,2	2,6	
4	Fresh Water Hydrophore Pump	1	2,2	2,6	
5	Fuel Oil Transfer Pump	1	1,5	1,8	
6	Working Air Compressor	1	1,5	1,8	
7	Lub Oil Transfer Pump	1	1,5	1,8	
8	Fuel Oil Purifier	1	2,2	2,6	
9	Sludge Transfer Pump	1	1,5	1,8	
10	Sewage Treatment Plant	1	2,5	3	
11	Oil Water Separator	1	0,4	0,5	

4.7 Calculation of Lights on The Ship

The planning of lighting on the ship is based on the book "Merchant Ship Handbook Vol 5", as follows:

Table 8. Ship navigation lightning

No.	Item	Power (KW)	Jumlah	Total Power (KW)
1	Main Light	500	1	500
2	Side Light			
	a. Starboard Side	50	1	50
	b. port side	50	1	50
3	Morse lamp	100	1	100
4	Anchor Lamp			
	a. Bow Anchor Light	40	2	80
	b. Stern Anchor Light	40	1	40
5	Stern Light	75	1	75
6	Loading and Unloading Lights	500	1	500
7	Sailing Lights	40	1	40
8	Lifeboat Lamp	75	1	75
9	Spotlights	1000	1	1000
Total				2510

Table 9. Poop deck lighting power requirements

Poop Deck						
No.	Room	Total	Dimension (m)		W/m2	Power Needs (KW)
			P	L		
1	Captain Room	1	3,85	2,74	30	315,89
2	Crew 1 Room	1	3,50	2,55	30	267,75
3	Crew 1 Room	1	3,50	2,50	30	262,50
4	Owner Room	1	3,50	2,55	30	267,75
5	Toilet 1	1	1,65	1,96	30	97,12
6	Toilet 2	1	1,50	1,50	30	67,50
7	Toilet 3	1	1,33	1,50	30	59,76
8	Toilet 4	1	1,65	1,96	30	97,12
9	Engineering Room	1	3,85	2,74	30	315,89
Total						1751,28

Then the planning for lighting power requirements on the wheel house deck is carried out based on table 11, as follows:

Table 10. Main deck lighting power requirements

Main Deck						
No.	Room	Total	Dimension (m)		W/m2	Power Needs (KW)
			P	L		
1	CO2 Room	1	1,5	3,54	30	159,08
2	Provision Store	1	2,04	3,39	30	206,65
3	Toilet	1	2,60	3,54	30	275,73
4	Crew 1 Room	1	3,30	3,00	30	297,00
5	Crew 2 Room	1	3,30	3,00	30	297,00
6	Crew 3 Room	1	3,30	3,00	30	297,00
7	Office	1	3,30	2,60	30	257,40
8	Mess Room	1	6,60	4,80	30	950,40
9	Galley	1	3,30	3,33	30	329,57
Total						3069,83

Then do the lighting planning for the poop, the power requirements are obtained as follows:

Table 11. Wheel house deck lighting power requirements

Wheel House Deck						
No.	Room	Total	Dimension (m)		W/m2	Power Needs (KW)
			P	L		
1	Chart Space	1	1,584	1,93	30	91,86
2	Radio & Navigation Space	2	5,50	7,60	60	2508,00
Total						2599,86

There is an additional power requirement for internal lighting which can be seen in table 12, as follows:

Table 12. Other lighting power requirements

Others						
No.	Room	Total	Dimension (m)		W/m2	Power Needs (KW)
			P	L		
1	Engine Room	1	8,79	14	30	3691,80
2	Steering Gear Room	1	4,25	7	30	892,50
3	Aisle Lights Every Deck	60	-	-	40	2400
Total						6984,30

Table 13. Power requirements for lighting outside the ship

Lightning Outside Ship		
No.	Item	Power Needs (KW)
1	Outdoor Main Deck Alley	1000
2	Poop Deck Outer Alley	1000
3	Wheel House Deck Alley	120
4	Lifeboat Launching	1000
Total		3120

So,

$$\begin{aligned}
 \Sigma &= \text{Total lights inside the ship} + \text{Total lights outside the ship} \\
 &\quad + \text{Total navigation lights} \\
 &= 14405.27 + 3120 + 2510 \\
 &= 20035.27 \text{ Watt} \\
 &= 20.04 \text{ kW}
 \end{aligned}$$

It can be concluded that the need for lighting on the ship is 20.04 Kw

4.8 Other Electrical Equipment Calculation

The following are the power requirements of other installed electrical equipment, based on the book "Merchant Ship Handbook Vol 6", namely: In this case, the power used in kitchen equipment will be determined, as follows:

Table 14. Kitchen equipment power requirements

Kitchen Equipment		
No.	Item	Power (KW)
1	Exhaust For Galley	1,5
2	Waste Food Grinder	0,75
3	Rice Cooker	1,5
4	Freezer	0,5
5	Water Boiler	1,5
6	Electric cooking range	25
7	Electric universal cooking machine	0,75
8	Electric Coffee Burn	0,1
9	Electric Fryer	5
10	Refrigerator	2,5
11	Baking Oven	10
12	Hot Plate	4
13	Soup Boiler	9
14	Rice Washer	0,4
15	Others	15
Total		77,5

In this case, the power used in washing equipment will be determined which can be seen in table 15, as follows:

Table 15. Washing equipment power requirements

Washing Equipment		
No.	Item	Power (KW)
1	Dishwasher	0,5
2	Laundry (2 x 8 kW)	1,6
Total		2,1

In this case, the determination of the power used in navigation and communication equipment can be seen in table 16, as follows:

Table 16. Power requirements for navigation and communication equipment

Navigation and Communication Equipment		
No.	Item	Power (KW)
1	Marine Radar	0,5
2	Echo Sounder	0,3
3	Radio	0,3
4	Telephone	0,08
5	GPS	1
6	Telegraph	0,08
7	Others	3,5
Total		6

In this case, the power used in other equipment will be determined which can be seen in table 17, as follows:

Table 17. Power requirements for other equipment

Other Equipment			
No.	Item	Total	Power (KW)
1	Power pack for steering gear	2	3,7
2	Power pack for bow thruster	1	1,5
3	Exhaust fan for engine room	2	7,5
4	Exhaust fan for emergency generator	1	0,5
5	Battery Charger	1	1
6	Exhaust fan for toilet	5	1,5
Total			15,7

4.9 Analysis of Generator Power Capacity Calculation during the Day

At this stage, calculations will be made during daytime conditions, as follows:

Table 18. Harbour condition in day

No	Item	Set	Power		Day			
			kw	Total	%	Set	Cont	Int
A.	Pumps							
1	Bilge Pump / Fire Pump	1	7,5	7,5	50	1		3,8
2	General Service & Ballast Pump	2	7,5	15				
3	Sea Water Hydrophore Pump	1	2,2	2,2				
4	Fresh Water Hydrophore Pump	1	2,2	2,2	10	1		0,2
5	Fuel Oil Transfer Pump	1	1,5	1,5	10	1		0,2
6	Working Air Compressor	1	1,5	1,5	45	1		0,7
7	Lub Oil Transfer Pump	1	1,5	1,5	10	1		0,2
8	Fuel Oil Purifier	1	2,2	2,2	15	1		0,3
9	Sludge Transfer Pump	1	1,5	1,5	15	1		0,2
10	Sewage Treatment Plant	1	2,5	2,5	15	1		0,4
11	Oil Water Separator	1	0,4	0,4	15	1		0,1
B.	Operations							
1	Anchor windlass 1	1	22	22	25	1		5,5
2	Anchor windlass 2	1	15	15	25	1		3,8
3	Anchor windlass 3	1	15	15	25	1		3,8
4	Windlass Sekoci	1	0,52	0,52				
5	Windlass Rampdoor	2	7	14	100	2		14,0
6	Air Conditioner	1	49,3	49,3	25	1		12,3
7	Lights Inside the Ship	1	14,41	14,4	50	1		7,2
8	Lights Outside the Ship	1	3,1	3,1	20	1		0,6
9	Navigation Lighting	1	2,5	2,5				
10	Kitchen equipment	1	77,5	77,5	25	1		19,4
11	Washing Equipment	1	2,1	2,1	25	1		0,5
12	Navigation and Communication Equipment	1	6	6	100	1	6	
13	Other Equipment	1	15,7	15,7				
Intermittent Load		Total			72,9825			
		Diversity Factor			0,6			
		Requirement			43,7895			
Continous Load					6			
Total Power (KW)					49,8			
Generator Output					60		KW x 1	
Load Percentage (%)					83			

Table 19. Sailing condition in day

No	Item	Set	Power		Day			
			kw	Total	%	Set	Cont	Int
A.	Pumps							
1	Bilge Pump / Fire Pump	1	7,5	7,5	25	1		1,9
2	General Service & Ballast Pump	2	7,5	15				
3	Sea Water Hydrophore Pump	1	2,2	2,2	100	1	2,2	
4	Fresh Water Hydrophore Pump	1	2,2	2,2	15	1		0,3
5	Fuel Oil Transfer Pump	1	1,5	1,5	100	1	1,5	
6	Working Air Compressor	1	1,5	1,5	100	1	1,5	
7	Lub Oil Transfer Pump	1	1,5	1,5				
8	Fuel Oil Purifier	1	2,2	2,2	30	1		0,7
9	Sludge Transfer Pump	1	1,5	1,5	30	1		0,5
10	Sewage Treatment Plant	1	2,5	2,5	30	1		0,8
11	Oil Water Separator	1	0,4	0,4	30	1		0,1
B.	Operations							
1	Anchor windlass 1	1	22	22				
2	Anchor windlass 2	1	15	15				
3	Anchor windlass 3	1	15	15				
4	Windlass Sekoci	1	0,52	0,52				
5	Windlass Rampdoor	2	7	14				
6	Air Conditioner	1	49,3	49,3	100	1	49,3	
7	Lights Inside the Ship	1	14,41	14,4	50	1		7,2
8	Lights Outside the Ship	1	3,1	3,1	20	1		0,6
9	Navigation Lighting	1	2,5	2,5				
10	Kitchen equipment	1	77,5	77,5	35	1		27,1
11	Washing Equipment	1	2,1	2,1	50	1		1,1
12	Navigation and Communication Equipment	1	6	6	100	1	6	
13	Other Equipment	1	15,7	15,7	100	1	15,7	
Intermittent Load			Total		40,1825			
			Diversity Factor		0,6			
			Requirement		24,1095			
Continous Load					76,2			
Total Power (KW)					100,3			
Generator Output					60	KW x 2		
Load Percentage (%)					84			

Table 20. Loading and unloading condition in day

No	Item	Set	Power		Day			
					Loading&Unloading			
			kw	Total	%	Set	Cont	Int
A.	Pumps							
1	Bilge Pump / Fire Pump	1	7,5	7,5	25	1		1,9
2	General Service & Ballast Pump	2	7,5	15	75	1		5,6
3	Sea Water Hydrophore Pump	1	2,2	2,2	25	1		0,6
4	Fresh Water Hydrophore Pump	1	2,2	2,2	10	1		0,2
5	Fuel Oil Transfer Pump	1	1,5	1,5	30	1		0,5
6	Working Air Compressor	1	1,5	1,5	10	1		0,2
7	Lub Oil Transfer Pump	1	1,5	1,5	10	1		0,2
8	Fuel Oil Purifier	1	2,2	2,2	25	1		0,6
9	Sludge Transfer Pump	1	1,5	1,5	25	1		0,4
10	Sewage Treatment Plant	1	2,5	2,5	25	1		0,6
11	Oil Water Separator	1	0,4	0,4	25	1		0,1
B.	Operations							
1	Anchor windlass 1	1	22	22	25	1		5,5
2	Anchor windlass 2	1	15	15	25	1		3,8
3	Anchor windlass 3	1	15	15	25	1		3,8
4	Windlass Sekoci	1	0,52	0,52				
5	Windlass Rampdoor	2	7	14	100	2	14	
6	Air Conditioner	1	49,3	49,3	25	1		12,3
7	Lights Inside the Ship	1	14,41	14,4	50	1		7,2
8	Lights Outside the Ship	1	3,1	3,1	20	1		0,6
9	Navigation Lighting	1	2,5	2,5				
10	Kitchen equipment	1	77,5	77,5	25	1		19,4
11	Washing Equipment	1	2,1	2,1	25	1		0,5
12	Navigation and Communication Equipment	1	6	6	100	1	6	
13	Other Equipment	1	15,7	15,7				
Intermittent Load			Total		63,7175			
			Diversity Factor		0,6			
			Requirement		38,2305			
Continous Load					20			
Total Power (KW)					58,2			
Generator Output					60	KW x 2		
Load Percentage (%)					49			

Table 21. Emergency condition in day

No	Item	Set	Power		Day			
			kw	Total	%	Set	Cont	Int
A.	Pumps							
1	Bilge Pump / Fire Pump	1	7,5	7,5	100	1	7,5	
2	General Service & Ballast Pump	2	7,5	15	100	1		7,5
3	Sea Water Hydrophore Pump	1	2,2	2,2				
4	Fresh Water Hydrophore Pump	1	2,2	2,2				
5	Fuel Oil Transfer Pump	1	1,5	1,5				
6	Working Air Compressor	1	1,5	1,5				
7	Lub Oil Transfer Pump	1	1,5	1,5				
8	Fuel Oil Purifier	1	2,2	2,2				
9	Sludge Transfer Pump	1	1,5	1,5				
10	Sewage Treatment Plant	1	2,5	2,5				
11	Oil Water Separator	1	0,4	0,4				
B.	Operations							
1	Anchor windlass 1	1	22	22				
2	Anchor windlass 2	1	15	15				
3	Anchor windlass 3	1	15	15				
4	Windlass Sekoci	1	0,52	0,52	100	1	0,5	
5	Windlass Rampdoor	2	7	14				
6	Air Conditioner	1	49,3	49,3				
7	Lights Inside the Ship	1	14,41	14,4	100	1	14,4	
8	Lights Outside the Ship	1	3,1	3,1				
9	Navigation Lighting	1	2,5	2,5				
10	Kitchen equipment	1	77,5	77,5				
11	Washing Equipment	1	2,1	2,1				
12	Navigation and Communication Equipment	1	6	6	100	1	6,0	
13	Other Equipment	1	15,7	15,7				
Intermitten Load		Total		7,5				
		Diversity Factor		0,6				
		Requirement		4,5				
Continous Load				28,4				
Total Power (KW)				32,9				
Generator Output				45		KW x 1		
Load Percentage (%)				73				

power requirement of the ship during the day with a total intermittent load of 110.6 KW and a total continuous load of 130.6 KW, as well as the power requirement in an emergency

vessel condition of 32.9 KW and the largest power is in the condition of the sailing vessel of 100,3 kW.

4.10 Analysis of Generator Power Capacity Calculation during Day Night

At this stage, calculations will be made during day night conditions, as follows:

Table 22. Harbour condition in day night

No	Item	Set	Power		Night Harbour			
			kw	Total	%	Set	Cont	Int
A.	Pumps							
1	Bilge Pump / Fire Pump	1	7,5	7,5				
2	General Service & Ballast Pump	2	7,5	15				
3	Sea Water Hydrophore Pump	1	2,2	2,2				
4	Fresh Water Hydrophore Pump	1	2,2	2,2	10	1		0,2
5	Fuel Oil Transfer Pump	1	1,5	1,5	10	1		0,2
6	Working Air Compressor	1	1,5	1,5	45	1		0,7
7	Lub Oil Transfer Pump	1	1,5	1,5	10	1		0,2
8	Fuel Oil Purifier	1	2,2	2,2	15	1		0,3
9	Sludge Transfer Pump	1	1,5	1,5	15	1		0,2
10	Sewage Treatment Plant	1	2,5	2,5	15	1		0,4
11	Oil Water Separator	1	0,4	0,4	15	1		0,1
B.	Operations							
1	Anchor windlass 1	1	22	22	25	1		5,5
2	Anchor windlass 2	1	15	15	25	1		3,8
3	Anchor windlass 3	1	15	15	25	1		3,8
4	Windlass Sekoci	1	0,52	0,52				
6	Windlass Rampdoor	2	7	14	100	2		14,0
7	Air Conditioner	1	49,3	49,3	30	1		14,8
8	Lights Inside the Ship	1	14,41	14,4	100	1	14,4	
9	Lights Outside the Ship	1	3,1	3,1	100	1	3,1	
10	Navigation Lighting	1	2,5	2,5	100	1	2,5	
11	Kitchen equipment	1	77,5	77,5	25	1		19,4
12	Washing Equipment	1	2,1	2,1		1		
13	Navigation and Communication	1	6	6	100	1	6	
14	Other Equipment	1	15,7	15,7		1		0,0
Intermittent Load		Total		63				
		Diversity Factor		0,6				
		Requirement		38,01				
Continous Load				26,0				
Total Power (KW)				64,0				
Generator Output				60		KW x 2		
Load Percentage (%)				53				

Table 23. Sailing condition in day night

No	Item	Set	Power		Night			
			kw	Total	Sailing			
					%	Set	Cont	Int
A.	Pumps							
1	Bilge Pump / Fire Pump	1	7,5	7,5	25	1		1,9
2	General Service & Ballast Pump	2	7,5	15				
3	Sea Water Hydrophore Pump	1	2,2	2,2	100	1		2,2
4	Fresh Water Hydrophore Pump	1	2,2	2,2	15	1		0,3
5	Fuel Oil Transfer Pump	1	1,5	1,5	100	1		1,5
6	Working Air Compressor	1	1,5	1,5	100	1		1,5
7	Lub Oil Transfer Pump	1	1,5	1,5				
8	Fuel Oil Purifier	1	2,2	2,2	30	1		0,7
9	Sludge Transfer Pump	1	1,5	1,5	30	1		0,5
10	Sewage Treatment Plant	1	2,5	2,5	30	1		0,8
11	Oil Water Separator	1	0,4	0,4	30	1		0,1
B.	Operations							
1	Anchor windlass 1	1	22	22				
2	Anchor windlass 2	1	15	15				
3	Anchor windlass 3	1	15	15				
4	Windlass Sekoci	1	0,52	0,52				
6	Windlass Rampdoor	2	7	14				
7	Air Conditioner	1	49,3	49,3	70	1		34,5
8	Lights Inside the Ship	1	14,41	14,4	100	1		14,4
9	Lights Outside the Ship	1	3,1	3,1	100	1		3,1
10	Navigation Lighting	1	2,5	2,5	100	1		2,5
11	Kitchen equipment	1	77,5	77,5	40	1		31,0

12	Washing Equipment	1	2,1	2,1				
13	Navigation and Communication	1	6	6	100	1	6,0	
14	Other Equipment	1	15,7	15,7	100	1	15,7	
Intermittent Load		Total			35,185			
		Diversity Factor			0,6			
		Requirement			21,111			
Continous Load					81,4			
Total Power (KW)					102,5			
Generator Output					60	KW x 2		
Load Percentage (%)					85			

Table 24. Loading and unloading condition in day night

No	Item	Set	Power		Night			
					Loading&Unloading			
			kw	Total	%	Set	Cont	Int
A.	Pumps							
1	Bilge Pump / Fire Pump	1	7,5	7,5	25	1		1,9
2	General Service & Ballast Pump	2	7,5	15	75	1		5,6
3	Sea Water Hydrophore Pump	1	2,2	2,2	25	1		0,6
4	Fresh Water Hydrophore Pump	1	2,2	2,2	10	1		0,2
5	Fuel Oil Transfer Pump	1	1,5	1,5	30	1		0,5
6	Working Air Compressor	1	1,5	1,5				
7	Lub Oil Transfer Pump	1	1,5	1,5	10	1		0,2
8	Fuel Oil Purifier	1	2,2	2,2	25	1		0,6
9	Sludge Transfer Pump	1	1,5	1,5	25	1		0,4
10	Sewage Treatment Plant	1	2,5	2,5	25	1		0,6
11	Oil Water Separator	1	0,4	0,4	25	1		0,1
B.	Operations							
1	Anchor windlass 1	1	22	22	25	1		5,5
2	Anchor windlass 2	1	15	15	25	1		3,8
3	Anchor windlass 3	1	15	15	25	1		3,8
4	Windlass Sekoci	1	0,52	0,52				
6	Windlass Rampdoor	2	7	14	100	2	14	
7	Air Conditioner	1	49,3	49,3	30	1		14,8
8	Lights Inside the Ship	1	14,41	14,4	100	1	14,4	
9	Lights Outside the Ship	1	3,1	3,1	100	1	3,1	
10	Navigation Lighting	1	2,5	2,5	100	1	2,5	
11	Kitchen equipment	1	77,5	77,5	25	1		19,4
12	Washing Equipment	1	2,1	2,1				
13	Navigation and Communication	1	6	6	100	1	6	
14	Other Equipment	1	15,7	15,7				
Intermitten Load		Total			57,685			
		Diversity Factor			0,6			
		Requirement			34,611			
Continous Load					40,0			
Total Power (KW)					74,6			
Generator Output					60	KW x 2		
Load Percentage (%)					62			

Table 25. Emergency condition in day night

No	Item	Set	Power		Night			
			kw	Total	Emergency			
					%	Set	Cont	Int
A.	Pumps							
1	Bilge Pump / Fire Pump	1	7,5	7,5	100	1		7,5
2	General Service & Ballast Pump	2	7,5	15	100	1		7,5
3	Sea Water Hydrophore Pump	1	2,2	2,2				
4	Fresh Water Hydrophore Pump	1	2,2	2,2				
5	Fuel Oil Transfer Pump	1	1,5	1,5				
6	Working Air Compressor	1	1,5	1,5				
7	Lub Oil Transfer Pump	1	1,5	1,5				
8	Fuel Oil Purifier	1	2,2	2,2				
9	Sludge Transfer Pump	1	1,5	1,5				
10	Sewage Treatment Plant	1	2,5	2,5				
11	Oil Water Separator	1	0,4	0,4				
B.	Operations							
1	Anchor windlass 1	1	22	22				
2	Anchor windlass 2	1	15	15				
3	Anchor windlass 3	1	15	15				
4	Windlass Sekoci	1	0,52	0,52	100	1		0,5
6	Windlass Rampdoor	2	7	14				
7	Air Conditioner	1	49,3	49,3				
8	Lights Inside the Ship	1	14,41	14,4	100	1		14,4
9	Lights Outside the Ship	1	3,1	3,1	100	1		3,1
10	Navigation Lighting	1	2,5	2,5	100	1		2,5
11	Kitchen equipment	1	77,5	77,5				
12	Washing Equipment	1	2,1	2,1				

13	Navigation and Communication	1	6	6	100	1	6	
14	Other Equipment	1	15,7	15,7				
Intermittent Load		Total			7,5			
		Diversity Factor			0,6			
		Requirement			4,5			
Continuous Load					34,0			
Total Power (KW)					38,5			
Generator Output					45	KW x 1		
Load Percentage (%)					86			

it can be seen that the operational power requirement of the ship at night with a total intermittent load of 98,2 KW and a total continuous load of 181,5 KW and power requirements in an emergency vessel condition of 38,5 KW and the largest power is in the condition of the sailing vessel of 102,5 KW

4.11 Generator Selection

The generator selection is based on the calculation of the largest operational power capacity which is located on the condition of the ship sailing at night as much as 2 sets. Then we get a generator with the following capacity:

Brand : Caterpillar
 Type : EM 5153
 Number of Cylinders : 4
 Rpm/Frequency : 1800/60 Hz
 BHP : 60 KW
 Bore : 105 mm
 Stroke : 127 mm
 Weight : 1142 kg
 Length : 1699 mm
 Width : 956 mm
 Height : 1245 mm

Then the generator selection based on ship operations in an emergency is 1 set as follows:

Brand : John Deere
 Type : 4045DFM70
 Number of Cylinders : 4
 Rpm/frequency : 1800/60 Hz
 BHP : 45 KW
 Bore : 106.5 mm
 Stroke : 127 mm
 Weight : 462 kg
 Length : 885 mm
 Width : 712 mm
 Height : 902 mm

5 Conclusion

In accordance with the calculation results obtained with various ship operating conditions. The condition of the ship anchored during the day is 49.8 KW. The condition of the ship anchored at night is 64 KW, The condition of the ship sailing during the day is 100.3 KW, The condition of the ship sailing at night is 102.5 KW. The condition of loading and unloading ships during the day is 58.2 KW. The condition of loading and unloading ships at night is 74.6 KW. Emergency ship condition during the day is 32.9 KW. The condition of the emergency ship at night is 38.5 KW. Determination of generator power capacity based on the operational electricity needs of the largest ship when the ship is sailing as many as 2 sets with power 60 KW x 2. Then determine the generator power capacity based on the condition of the ship when in an emergency as much as 1 set with power 45 KW x 1.

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