The Effect of Refrigerant Pressure on The Accommodation Cooling System on The MV. Meratus Medan 1 Ship

Riko Dwi Cahyo[1*], Azis Nugroho[2], Shofa Dai Robbi[3], Antonius Edy kristiyono[4], Wulan Marlia Sandi[5]

[1,2,3,4,5] Politeknik Pelayaran Surabaya Program Studi Sarjana Terapan Teknologi Rekayasa Permesinan Kapal, Indonesia.
*Corresponding Author:
Email: cahyorikodwi@gmail.com

Abstract.

The ship's accommodation cooling system is crucial for crew comfort, but often experiences decreased performance due to suboptimal refrigerant pressure. This study aims to analyze the effect of refrigerant pressure on the performance of the accommodation cooling system on the MV. Meratus Medan 1. Using a descriptive quantitative approach with primary data from observations and interviews with second engineers, as well as secondary data from log books. The population is operational data from one year of sea practice, purposive samples from daily measurements. Instruments include a manometer and SPSS for regression analysis (F, t, R^2 tests). The results show R^2 0.960, F test sig. 0.000, and the equation $Y = 122.644 – 1.435X1 – 4.712X2$, confirming the significant effect of low (X1) and high (X2) pressure on room temperature (Y). The conclusion recommends routine PMS maintenance to prevent leaks and optimize COP, with limited generalization to normal sailing conditions.

Keywords: *Air Conditioning; Container Ship; Maintenance; Refrigerant Pressure and Cooling System.*

I. INTRODUCTION

A ship is defined as a watercraft of a specific shape and type that is propelled by wind, mechanical, or other energy, towed, or towed, including dynamically supported vehicles, submarines, floating equipment, and fixed floating structures (Government of Indonesia, 2021). Container loading and unloading activities at ports, particularly container receipt and delivery, are the main indicators of terminal service speed, measured from entry to exit through the gate system (Triyono et al., 2024).Maritime transportation requires optimization of ship engine performance, including accommodation cooling systems, to maintain crew comfort during extreme weather conditions. Restroom comfort depends on stable temperatures and good ventilation, which support crew health and quality sleep, thus enhancing operational effectiveness (Habli et al., 2021).Although the human body adapts to environmental changes, an ideal room temperature of 22-28°C remains essential for optimal comfort and performance.

Routine maintenance of components such as compressors, condensers, oil separators, dryers, expansion valves, evaporators, refrigerant pipes, and electrical panels is essential to prevent fatal failures that could jeopardize crew safety and cause significant financial losses for the company (Siregar et al., 2023).Common problems include refrigerant leaks due to damaged filter dryers, resulting in hot and stuffy rooms, disrupting crew well-being and ship operations. These failures increase overtime and maintenance costs, highlighting the importance of a Planned Maintenance System (PMS) to maintain ship habitability standards (Zidane Shevchenko et al., 2023).This study aims to analyze the relationship between refrigerant pressure and ship accommodation cooling systems, focusing on pre- and post-compressor measurements using a quantitative approach through direct data on system pressure, seawater cooling, and room temperature. The research's urgency lies in preventing damage that threatens crew safety and operational efficiency amidst Indonesia's dependence on maritime transportation, while its novelty lies in the successive empirical measurements that distinguish it from previous studies (Suyanto & Riyanto, 2024).

II. METHODS

Types and Methods of Research

This study uses a descriptive quantitative approach to analyze the relationship between refrigerant pressure and the performance of a ship's accommodation cooling system, focusing on empirical measurements of pre- and post-compressor pressure during a one-year sea practice. The quantitative approach allows for the systematic collection of numerical data through direct observation, which is processed to describe phenomena accurately and measurably. This type of research is based on the philosophy of positivism to produce objective empirical findings (Sugiyono, 2022; Syafrida Hafni Sahir, 2022). The descriptive method was chosen to present the facts of the actual condition of the cooling system, including cross-checking engine room and bridge logbooks to identify causes of performance declines such as filter dryer damage, which supports the causal analysis of refrigerant pressure (Creswell & Creswell, 2023; Emzir, 2021).

Data Collection Instruments and Techniques

The research instruments included a refrigerant pressure gauge (manometer), a room temperature thermometer, and ship documents such as logbooks and instruction manuals to compare actual values with standards. Primary data collection techniques were obtained through direct observation during cooling system operation, daily recording of low and high pressures, and semi-structured interviews with a second engineer as an auxiliary machinist, ensuring honest and competent data (Syafrida Hafni Sahir, 2022; Sudaryono, 2022). Secondary data were collected from the chief engineer's report, PMS maintenance archives, and literature studies related to ship AC maintenance, complementing the analysis with historical evidence of damage such as refrigerant leaks (Zidane Shevchenko et al., 2023; Triyono et al., 2024).

Population and Sample

The study population was all operational data of the accommodation cooling system on board the ship during one year of sea practice, including variables of refrigerant pressure, room temperature (ideal 22-28°C), and seawater cooling in the condenser (Habli et al., 2021). Samples were taken purposively from daily measurements for several consecutive days under normal sailing conditions, representing the independent variables (low pressure X1, high pressure X2) and dependent (system performance Y), with a total observation sufficient for statistical analysis using SPSS (Sugiyono, 2022; Emzir, 2021).

Research Procedures

The procedure begins with identifying the refrigerant pressure problem, formulating limitations, objectives, and literature review; followed by developing a conceptual framework, collecting observational, interview, and documentation data, and conducting quantitative analysis. Data analysis combines descriptive statistics to describe the average pressure and temperature, as well as inferential statistics through variable tests, R^2 (coefficient of determination), t (partial), and F (simultaneous) in SPSS, with a sig < 0.05 criterion for the significance of the effect of X on Y (Syafrida Hafni Sahir, 2022; Cresswell & Creswell, 2023). The process concludes with the preparation of a report, ensuring that the findings contribute to the optimization of the ship's PMS (Sudaryono, 2022; Zidane Shevchenko et al., 2023).

III. RESULT AND DISCUSSION

Description of Research Variables

Table 1. Research Variables

	type	Conceptual Definition	Operational Definition	Unit/scale	Key Indicators
Refrigerant Pressure	Free (X)	The amount of refrigerant fluid pressure in the cooling system	Manometer reading results on the pressure side and suction side of the system	Bar/psi	Pressure before compressor, pressure after compressor
Cooling System Performance	Bound (Y)	The level of effectiveness of cooling accommodation spaces on ships	Room temperature difference during cooling, power consumption, system COP	°C, min, COP	ΔT, time to set point temperature, COP, compressor power

Data analysis

1. Observation Data

Fig 1. High and low pressure manometer

Source :(Author, 2024)

When the researcher conducted direct observations on the cooling machine unit, the author periodically recorded the refrigerant pressure, both the pressure before the compressor and the pressure after the compressor, and also the temperature in the accommodation space in order to determine the relationship between refrigerant pressure and the accommodation temperature on the ship.

2. Interview

Table 2. Interview with Second Engineer

NO	QUESTION	ANSWER
1	Can you please explain the basic principles of a ship's accommodation cooling system?	The ship's cooling machine uses the principle of heat exchange by pressurized freon from inside the room to outside the room.
2	Can you explain the components of a cooling machine and how it works?	In general, there are 4 components in the AC system, namely the compressor that functions to compress the gas freon from low pressure to high pressure, the condenser that changes the gas refrigerant into a liquid refrigerant with a condensation process and usually uses sea water as a medium, the expansion valve that functions to spray the liquid freon towards the evaporator and make the liquid freon from high pressure to low pressure, then the evaporator that functions to absorb the heat in the accommodation with the help of a blower motor, so that the liquid refrigerant turns into a gas due to the evaporation process
3	What are the common problems with accommodation cooling systems on ships?	Damage that often occurs in the cooling system in the accommodation space of the MV. Meratus Medan 1 ship includes a dirty condenser which results in the freon not being condensed perfectly, which results in heavy compressor performance and damages the compressor components themselves, resulting in the temperature in the accommodation increasing periodically, and if left untreated will cause other components to be damaged.
4	What is the standard pressure before the compressor and the pressure after the compressor in the cooling system on board a ship?	The pressure before the compressor and the pressure after the compressor in the accommodation cooling system on the MV.Meratus Medan 1 ship according to the manual book is 17 bar for high pressure and 2.0-3.5 bar for low pressure using Freon type R22,
5	What is the normal temperature of accommodation rooms on board a ship?	The accommodation room temperature according to the manual can be reached at 27 degrees Celsius with sea water temperature of around 32 degrees Celsius, it can be colder or hotter depending on the sea water temperature conditions at that time.
6	Can you perform regular maintenance according to the manual?	According to the manual, regular maintenance on a ship's accommodation cooling system is divided into two categories: planned and emergency. Planned maintenance is performed on a scheduled basis, including weekly (manual defrosting), monthly (cleaning the condenser of sludge), or annually (replacing the filter dryer). Emergency maintenance is performed when the cooling system experiences a sudden decrease in performance (such as a sudden drop in freon pressure).
7	Can you repair the accommodation cooling system on ships?	Repairs to the cooling system on board the ship are carried out if there is damage to the cooling system on board the ship, such as filling too much freon which can cause the compressor valve to break so that an overhaul of the AC system compressor is necessary.

NO	QUESTION	ANSWER
8	Can you restore the refrigerant pressure to standard?	Reduced refrigerant pressure can affect the performance of the cooling system, requiring additional freon to achieve the ideal pressure. However, before adding freon, ensure the type of freon you're adding matches the one already in the system. This is to prevent damage to the ship's cooling system components.
9	Can you return the temperature of the accommodation rooms on board to standard?	The temperature in the ship's accommodation space can be returned to the comfort standards of the ship's crew by carrying out regular maintenance, in addition to that, replacement of parts of the cooling system is required when working hours or the specified time have been reached.

Source :(Author's Documentation, 2025)

3. Documentation

In addition to using observational data and interviews with the Second Engineer, this study also utilized documentation in the engine room logbook to support this research. Data collection through documentation in the engine room was carried out within a certain period of time adjusted to the actual conditions and circumstances on board the ship. Typically, the logbook journal was collected every watch or every four hours. With this logbook, engineers can analyze and quickly detect damage and take action to ensure the condition of auxiliary machinery, especially the cooling engine, continues to function optimally.

Table 3. Engine Room Logbook

Month	Room temperature (C)	Compressor Pressure (PSi) before	Compressor Pressure (PSi) after	LO Pressure (Psi)	Sea water (C)
1	22	52	290	90	30
2	22	52	285	90	30
3	23	50	285	90	30
4	26	50	280	90	30
5	26	50	275	90	30
6	28	50	275	90	30
7	28	40	275	90	30
8	30	40	270	90	30
9	31	35	265	90	30
10	32	35	260	90	30
11	35	30	260	90	30
12	25	52	290	90	30

Source :(Author's Documentation, 2025)

Discussion

Table 4. Table of Standard Sizes of Cooling Systems According to the Manual Book

High Pressure (Kg/cm2)	Low Pressure		Normal accommodation temperature (C)	Sea water temperature ©
On/Off	On	Off		
Manual 17	2.5	3.5	27	32
REFRIGERANT PRESSURE DATA AFTER CONVERTING TO Kg/Cm2				
month	Room temperature (C)	Compressor Pressure (Kg/cm2) before	Compressor Pressure (Kg/cm2) After	average compressor pressure (Kg/Cm2)
1	22	3.6	20.3	11.95
2	22	3.6	20	11.8
3	23	3.5	20	11.75
4	26	3.5	19.6	11.55
5	26	3.5	19.3	11.4
6	28	3.5	19.3	11.4
7	28	2.8	19.3	11.05
8	30	2.8	18.9	10.85
9	31	2.4	18.6	10.5
10	32	2.4	18.2	10.3
11	35	2.1	18.2	10.15
12	22	3.6	20.3	11.95

Source :(Imbari Ship Building Co., 1996)

1. Variable test

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	X2, X1[b]	.	Enter

a. Dependent Variable: Y

b. All requested variables entered.

In the study, the dependent variable or Y variable is the ship's accommodation temperature, and the independent variables consist of the pressure before (X1) and the pressure after (X2). Regression analysis was carried out using the enter method, where all variables are entered simultaneously without a selection stage.

2. R2 Test

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.980[a]	.960	.951	.96774

a. Predictors: (Constant), X2, X1

Based on the analysis results in the model summary table, the R value reached 0.980, indicating a very strong relationship between the dependent variable and the independent variable. The R square value of 0.960 indicates that 96% of the variation in the ship's accommodation temperature can be explained by the pre-pressure (X1) and post-pressure (X2) variables, while the remaining 4% is influenced by other variables outside the model. In addition, the adjusted R square value of 0.951 indicates that the regression model used has a high level of accuracy after adjusting for the number of variables in the study.

3. f test

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	200.488	2	100.244	107.039	.000[b]
	Residual	8.429	9	.937		
	Total	208.917	11			

a. Dependent Variable: Y

b. Predictors: (Constant), X2, X1

Based on the ANOVA table or F test, the calculated F value reached 107.039 with a significance of 0.000. Because the significance value is smaller than 0.05 (0.000 < 0.05), the regression model in this study is declared significant and appropriate for use. Simultaneously, the pressure variables before (X1) and after (X2) have a significant effect on the ship's accommodation temperature (Y).

4. f test

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	122.644	14.559		8.424	.000
	X1	-1.435	1.216	-.187	-1.180	.268
	X2	-4.712	.926	-.807	-5.091	.001

a. Dependent Variable: Y

According to the results of simultaneous testing in the ANOVA table, a positive constant value of 122.644 is obtained, indicating that if the independent variables (X1 and X2) are assumed to be constant or zero, then the value of the dependent variable (Y) reaches 122.644. Each increase in variable X1 will cause a decrease in Y of 1.435, but because the significance value is large (0.268), this effect is considered insignificant. Meanwhile, an increase in variable X2 will cause a significant decrease in Y, which is around 4.712. This effect is very significant (real) because the significance value is only 0.001. This means that the higher the value of X2, the lower the value of Y will be. Thus, the multiple linear regression equation obtained is as follows:

$$Y = 122{,}644 - 1{,}435\ X1 - 4{,}712\ X2$$

Refrigerant pressure significantly affects the temperature in the ship's accommodation space. Therefore, to restore the temperature in the ship's accommodation space, checks and maintenance must be carried out according to the manual. Therefore, during sea practice on board the ship, the author carried out maintenance according to the manual on the cooling system components as follows.

1. Condenser

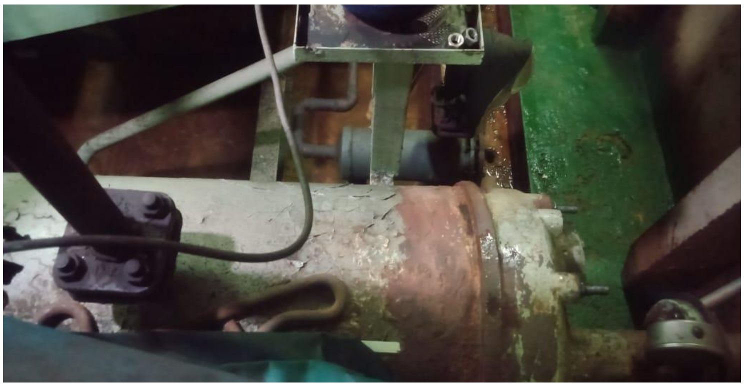

Fig 2. Condenser

Source :(Author, 2024)

Checking the condenser aims to ensure that the seawater cooler can condense the refrigerant perfectly. This check is carried out by ensuring that the pressure and temperature of the seawater are in accordance with the standards and provisions. If the seawater pressure is insufficient, it can be ascertained that the filter or condenser is dirty and the condenser needs to be cleaned.

2. Expansion valve

Fig 3. Expansion valve

Source :(Author, 2024)

Refrigerant pressure can also be affected by the expansion valve, which functions to expand high-pressure liquid freon into low pressure which then flows to the evaporator, the performance of the expansion valve is also affected by the capillary tube in the evaporator which functions as a timer for opening and closing the expansion valve based on the temperature in the evaporator.

3. Evaporator

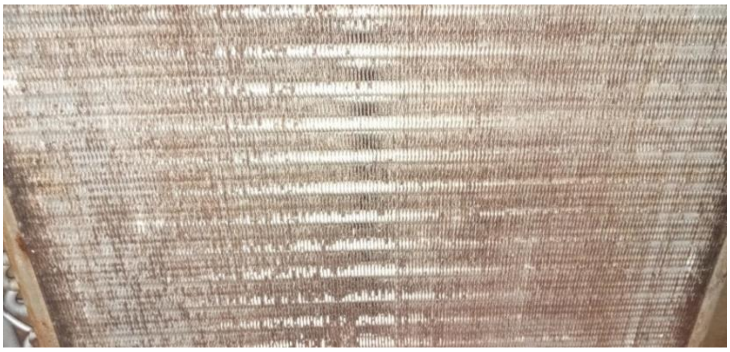

Fig 4. Evaporator

Source :(Author, 2024)

The next part to be inspected is the cooling system's evaporator. Evaporator maintenance is performed once a month by manually defrosting and washing the evaporator with soapy water to remove dirt from the evaporator fins. This ensures the air supply to the blower motor is not obstructed by frost buildup on the evaporator, which can significantly increase the temperature in the accommodation.

4. Compressor

Fig 5. AC compressor

Source :(Author, 2024)

The compressor plays a crucial role in a refrigeration system, converting low-pressure freon gas into high-pressure gas for distribution to the central AC system. Compressor performance is influenced by several factors, including the electrical supply. A lower coefficient of performance (COP) indicates a weaker compressor rotation, resulting in less than optimal freon pressure. Therefore, periodic merger tests are necessary to ensure the compressor's condition.Furthermore, compressor performance is also affected by the lubricating oil level. As the lubricating oil level decreases, compressor performance decreases, and it can even cause the piston inside the compressor to jam, affecting refrigerant pressure.

5. Oil Separator

Fig 6. Oil Separator

Source :(Author, 2024)

Checking the oil separator is also necessary to ensure optimal cooling performance. The oil separator's function is to separate the refrigerant from the oil carried by the compressor. An oil separator that hasn't been replaced for a long time can cause ice to form on the oil separator body. This can hinder the flow of freon due to the malfunctioning oil separator, which is supposed to return the oil to the compressor and circulate the freon.Because oil buildup can impede the flow of refrigerant and cause the freon pressure to fall below the specified level, ensure the oil separator is installed according to the manual to avoid future problems.

6. Filter dryer

Fig 7. Filter dryer
Source :(Author, 2024)

Considering its function as a filter for dirt and water carried by freon, it requires checking and maintenance.*filter dryer*The cooling system is serviced every six months by replacing the filter dryer. During the installation of the new component, an electrician discovered a human error, namely the loose fastening of the connecting nut on the pipe, resulting in the gradual loss of freon, resulting in a gradual decrease in refrigerant pressure in the system, followed by a change in temperature in the accommodation. Furthermore, after finding the cause of the decrease in refrigerant pressure, repairs were made to the connection of the filter dryer's binding nut with the pipe, then the next step was to restore the refrigerant pressure by adding refrigerant according to the Instruction manual book standard, namely 17 bar (246.5 Psi) for high pressure and 3.5 bar (50.7 Psi) for low pressure.(Imbari Ship Building Co., 1996)

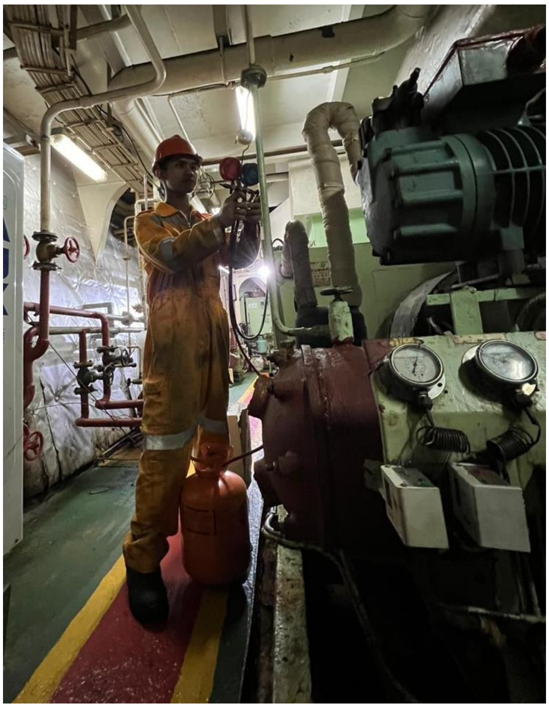

Fig 8. Adding refrigerant
Source :(Author, 2024)

IV. CONCLUSION

This study found that refrigerant pressure has a significant influence on the performance of the accommodation cooling system on the MV. Meratus Medan 1, with an R^2 value of 0.960 explaining 96% of the room temperature variation influenced by low (X1) and high (X2) pressure, as well as the F test (sig. $0.000 < 0.05$) and t (X2 sig. 0.001) which confirmed a strong simultaneous and partial relationship, as the regression equation $Y = 122.644 - 1.435\ X1 - 4.712\ X2$. Damage such as loose filter dryers and dirty condensers caused a decrease in pressure from the standard 17 bar (high) and 2.0-3.5 bar (low), increasing the accommodation temperature above 27°C, which was addressed through PMS maintenance such as cleaning, defrosting, and refilling R22.

The practical implications are periodic maintenance recommendations to optimize COP, reduce downtime, and ensure crew comfort according to the 22-28°C standard.However, the study's limitations lie in its purposive sampling of limited daily measurements over a one-year sea practice period, which does not include extreme weather variations or full vessel loads, thus limiting generalizability to normal sailing conditions. Suggestions for future research include a mixed-methods approach with a broader sample size, real-time integration of seawater cooling and COP variables via IoT, and longitudinal testing on multiple vessels to validate the regression model. These findings support Indonesia's maritime safety policy through improved operational efficiency.

REFERENCES

[1] Creswell, J. W., & Creswell, J. D. (2023). Research design: Qualitative, quantitative, and mixed methods approaches (6th ed.). SAGE Publications.

[2] Emzir. (2021). Qualitative research methodology: Quantitative. Pustaka Setia.

[3] Habli, MH, Siregar, PI, & Harahap, FG (2021). Analysis of damage to the accommodation space cooling system that can cause temperature changes on board the MT. Prima Lautan I. Database Conference Series A, 3(1), 61–71.https://doi.org/10.36101/pcsa.v3i1.171

[4] Imbari Ship Building Co., Ltd. (1996). Instruction Manual Book Refrigerant System.

[5] Government Regulation of the Republic of Indonesia Number 31 of 2021 concerning the Implementation of the Shipping Sector. (2021). https://peraturan.bpk.go.id/Details/161880/pp-no-31-tahun-2021

[6] Siregar, MS, Wiweko, A., & Zidane Shevchenko, R. (2023). Optimization of central AC maintenance and repair on the MV. Tanto Bersinar. Altair: ***Journal of Marine and Fisheries Sciences***, 2(1), 1–10.

[7] Sujarweni, VW (2021). Quantitative research methods. Pustaka Baru Press.

[8] Sukmadinata, NS (2022). Educational research methods. Rosdakarya Youth.

[9] Suyanto, A., & Riyanto, B. (2024). Calculation of cooling load in ship accommodation spaces. Maristec, 7(1), 45–56.

[10] Syafrida Hafni Sahir. (2022). Research methodology. Medan Area University.

[11] Sugiyono. (2022). Quantitative, qualitative, and R&D research methods. Alfabeta.

[12] Sudaryono. (2022). Educational research methods. Student Library.

[13] Triyono, A., Rozi, F., & Dai Robbi, S. (2024). Evaluation of the operational performance of public terminals at the Port of Gresik. ***Journal of Shipping and Transportation Dynamics***, 15(1), 26–36. https://doi.org/10.34001/jdpt

[14] Zidane Shevchenko, R., Wiweko, A., & Sapril Siregar, M. (2023). Causes of declining cooling engine performance on the MV. Vancouver. ***Mutiara: Indonesian Multidisciplinary Scientific Journal***, 1(2), 45–56. https://jurnal.tiga-mutiara.com/index.php/jimi