INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH AND ANALYSIS

ISSN(print): 2643-9840, ISSN(online): 2643-9875

Volume 08 Issue 12 December 2025

DOI: 10.47191/ijmra/v8-i12-02, Impact Factor: 8.266

Page No. 6599-6606

Efficiency Analysis of Refrigeration Performance in Cold Storage at PT Lautindo Synergy Sejahtera Muncar Banyuwangi East Java

Achmad Syarifudin[1], Basino[1], I Ketut Daging[1], Marsono[1], Ismunandar[1], Mustopa Kamal[1], Bayu Ari Darmawan[2]

[1]Lecturer of fishery machinery, Jakarta tehnical university fisheries, Jakarta, 12520, Indonesia

[2]Student of fishery machinery, Jakarta tehnical university fisheries, Jakarta, 12520, Indonesia

ABSTRACT: The refrigeration system was originally only used for ice production, with the development of refrigeration system technology plays an important role in the distribution and storage of foodstuffs, both raw food and foodstuffs that are ready to be consumed, there are some materials such as vegetables, fruits, meat, or materials that are ready to be consumed such as frozen food, ice cream, milk, and so on. The importance of the refrigeration system can be a major key in the preservation, storage, and distribution of foodstuffs so that consumers get products that are maintained quality and quality. This study was conducted to determine the value of the efficiency of a refrigeration unit that functioned as storage of foodstuff products in the form of frozen tuna loin at PT Lautindo Synergy sejahtera and as a reference that the products distributed have maintained their quality and quality to consumers, this is based on actual calculations using ASHRAE standard equations so that the value obtained can be a reference for the company in improving the quality and quality of products.

KEYWORDS: cooling system, P-H Diagram, COP, cooling efficiency, temperature

I. INTRODUCTION

Refrigeration system is an effort to maintain the temperature level or temperature of a material or room at a lower level than the temperature of the material or space (Ilyas, 1993). Refrigeration machine or also called cooling machine is a machine that can cause the effect of the refrigeration, while the refrigerant is a substance used as a working fluid in the process of heat absorption (Pasek, 2007 in the word & Anshar, 2013). This technology has an important role in the world of Fisheries, considering that fish is a product that has a low level of resistance and easy to rot at room temperature. This fish cooling system is used to store fish and cool it at a certain temperature so that the fresh fish can last a long time up to several weeks and can even last up to several months (Siagian, 2017). In the fishing industry has a special room that is used as storage of small-scale and large-scale products this space is commonly referred to as Cold Storage. Cold Storage is a refrigeration machine used to store a product at a certain temperature, so that the quality of the product is maintained and is a state of the art invention that makes it easy for some people who want to keep their goods to stay in a fresh state. This storage room is made with the aim to put a variety of foodstuff products and so on so that the freshness can last longer. This special storage is generally made based on specific needs and building area available on site.

Related matters when discussing storage temperature and product quality is the efficiency of the cooling system performance or refrigeration efficiency. Refrigeration efficiency is the ratio between the actual coefficient of Performance and the Carnot coefficient of Performance. (Fianti, 2023). These circumstances make the cooling system work optimally and optimally so that the product reaches the desired standard based on the SOP that has been set. This affects the quality of a product, engine life, and operating costs of a company.

II. RESEARCH METHODS

The things that will be implemented are direct observation in the field and systematic and detailed recording of a study object or problem being researched. This method is carried out by participating in maintenance activities that aim to observe and understand the machine from the machine name, specifications, how it works, maintenance to repair, starting from the main components of the cooling machine, supporting components of the cooling machine, and the overall cooling machine installation at PT Lautindo Synergy Sejahtera. The activities that will be carried out are as follows:

a. Measuring the compressor pressure, measuring the working pressure of the refrigerant in the system, and knowing the type of refrigerant used in the system;
b. Understanding the operation of the company's cold storage unit;
c. Journaling the compressor to determine suction and discharge pressures, as well as oil pressure;
d. Participating in the operation, maintenance, and repair of the refrigeration unit.

A. Research Design

Research design, broadly speaking, encompasses all the processes involved in planning and implementing research. The conceptual framework for this research can be seen in the following figure.

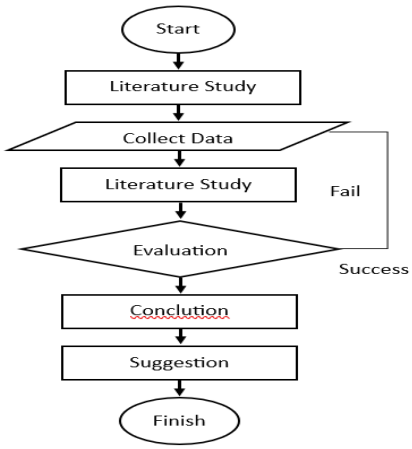

Figure 1. Eancangan Penelitian

B. Research Variables and Indicators

According to Sugiyono (2006), research variables are basically anything in any form that is determined by the researcher to be studied so that information about it can be obtained, and then conclusions can be drawn. The variables in research are; Independent variables, which include Compressor inlet and outlet temperatures. Dependent variables, which include Refrigeration efficiency values. And Control variables, Control variables are widely used when researchers conduct pure experiments, serving to control the implementation of the experiment so that it runs according to the research design (Soesilo, 2019). The control variables in this study are:

1. Cold Storage 1.
2. Cold Storage refrigeration machine components 1.

Meanwhile, research indicators are measures or criteria used to assess or quantify research variables. Examples of indicators in this study are as follows:

1. Refrigeration efficiency percentage (COP);
2. Average room temperature.

C. Data Collection Techniques

According to Herdayati & Syahrial (2019), data collection techniques are the most important part of research design. Data collection techniques are mandatory because they will later serve as the basis for developing research instruments. The data collection techniques used to achieve the research objectives are as follows:

1. Field study. The field experiment method is a research study conducted in a real-life situation by manipulating one or more independent variables under conditions carefully controlled by the experimenter, to the extent possible (Widi, 2018). Field study involves direct data collection from the research object to obtain data that will be used for calculations.
2. Literature study: Studying source books to obtain theories and concepts that support the design implementation (Rahmat, 2015).

D. Data Processing Method

Data processing includes tabulation and sorting. After being tabulated and selected, the data is then processed according to the theme or topic and the objectives of the practice. Data processing uses descriptive theory, which systematically describes the facts from observations or research as a whole as the primary source of information. This description is then analyzed by linking it to existing theoretical foundations or literature relevant to the object of observation.

According to Djojodiharjo (1987) in Murtono et al., 2015, exploratory descriptive methods aim to describe the state or status of a phenomenon. This research is generally non-hypothetical, so it does not require formulating hypotheses. According to Sudjana (2001) in Purnomo (2015), data processing aims to transform raw data from measurement results into more refined data, thus providing direction for further study.

The author reviews the efficiency of refrigeration performance in the Cold Storage room. The data collection conducted during the final practice was through direct field observation of the target object. The data collected during the final practice consisted of primary and secondary data.

E. Data Analysis Methods

According to Siyoto & Sodik (2015), data analysis stems from the results of data collection. If collected data is not analyzed, it becomes meaningless, meaningless, and dead data. Therefore, data analysis serves to provide meaning, significance, and value to the data. After data collection, the collected data is immediately analyzed with the aim of reviewing the results of discussions during the fieldwork. Data are analyzed using the following methods:

1. Descriptive: A method used to identify the elements, characteristics, and properties of a phenomenon. This method begins with data collection, analysis, and interpretation (Suryana, 2010). The descriptive method presents data by explaining what occurs in the field during practice, with the aim of analyzing and processing the data, and then reviewing it with existing references in accordance with the stated objectives and benefits.
2. Quantitative: Research that emphasizes testing theories by measuring research variables numerically and analyzing the data using statistical procedures (Huda, 2012). Quantitative research analyzes the obtained data using comparative analysis formulas found in the literature review.

The application of the formulas or theories to be used is explained in the discussion below.

a. COP *Carnott*

COP Carnott = $\frac{Te}{Tc-Te}$

Description :

Te = Evaporator Temperature (K)

Tc = Condenser Temperature (K)

b. COP *Actual*

COP *Actual* = $\frac{Qe}{P}$

Description:

Qc = Condenser work (kW)

P = Compressor mechanical power (kW)

c. Effective COP (efficiency)

Efficiency (ɳ) *refrigeration* = $\frac{COP\ Aktual}{COP\ Carnot}$

This is also supported by the acquisition of valid data through journaling, direct temperature measurement, and application to the P-h diagram according to the refrigerant material Ammonia (R-717), as in the following image;

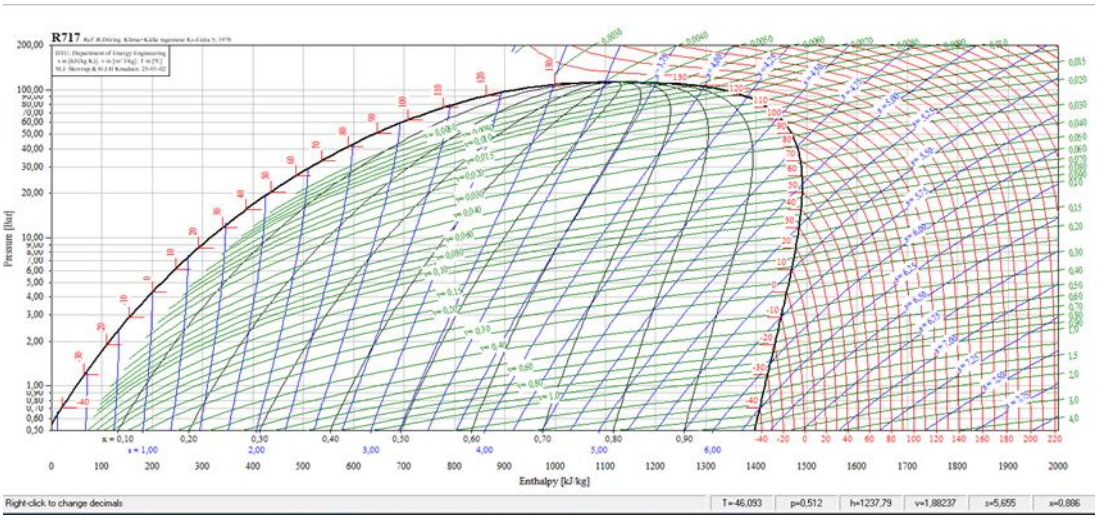

Figure 2. Diagram P-h (R-717) (Sumber: coolpackapp,2025)

III. RESULTS AND DISCUSSION

PT Lautindo Synergy Sejahtera has 2 Cold Storage rooms, 3 Air Blast Freezer rooms, 2 Antee rooms, 2 Air lock rooms, and 1 Deblock room. Data retrieval room in this study using Cold Storage Room 1 and compressor 1 as a medium of calculation of refrigeration efficiency analysis. Data collection is carried out every Monday, starting from 08.00-12.00 WIB for 12 times starting from January 12, 2025 to April 10, 2025.

In calculating the value of the efficiency of the refrigeration unit performed data collection temperature, and pressure (pressure) on the compressor. In this study the authors took data every 10 minutes for 4 hours, starting from 08.00-12.00 WIB. And take the value of the efficiency of each 4 hours for 12 times as a comparison of the value of efficiency in each week.

Before analyzing the value of refrigeration efficiency, we need to know first about the COP (Coefficient of Performance). Simply put, COP is the ratio of the ratio between the cooling power produced by a machine with the energy consumed by the machine. The higher the COP value, the higher the efficiency value of the machine (Wiharjo, 2019).

A. Efficiency Analysis

The use of efficiency analysis is to determine the level of efficiency of existing refrigeration systems. To determine the level of efficiency of the facility required condition data should be. The Data is used as a basis for the calculation of the efficiency level of the refrigeration system based on ASHRAE guidelines (American Society of Heating, Refrigerating, and Air-Conditioning Engineers), as follows;

Table 1. Range of Efficient COP Values According to ASHRAE

No	System type	Efficient COP range
1.	*AC split Inverter*	3,0 – 4,5
2.	*AC Non-Inverter*	2,5 – 3,2
3.	*Air Cooled Chiller*	2,5 – 3,5
4.	*Water Cooler Chiller*	4,5 – 6,5
5.	*Industrial Refrigeration*	1,8 – 3,5

B. COP Calculation Result

Here are some actual data obtained during the implementation of the practice on January 13, 2025;

Table 2. Actual Analysis Results

Time	P Discard (Bar)	P Suction (Bar)	T Condenser (°C)	T Suction (°C)	T Evaporator (°C)	T CS2 (°C)
08.00	10.36	-0.03	63,1	0.9	-19.2	-17.4
08.10	10.36	-0.03	63.2	0.9	-19.2	-17.4
08.20	10.24	0.18	62.2	0.6	-15.6	-17.4
08.30	10.21	-0.04	60.2	1.5	-11.4	-18.6
08.40	10.21	-0.05	59.9	1.9	-11.4	-18.4
08.50	10.21	-0.05	60.1	1.9	-11.4	-18.4
09.00	10.42	0.01	60.1	1,6	-16,1	-18,5
09.10	10.43	0.01	61.1	1,2	-18,3	-18,6
09.20	10.58	0.01	62.3	-1,7	-20,4	-18,7
09.30	10.47	-0.04	63,2	-1,3	-21	-17,9
09.40	10.61	-0.02	64,7	-0,6	-21,4	-17,3
09.50	10.42	-0.06	62,1	-0,2	-21,1	-16,4
10.00	10.63	-0.06	60,6	0,3	-21,4	-15,8
10.10	10.64	-0.06	60,4	0,3	-21,5	-15,7
10.20	10.90	0.01	60,1	4,1	-22,3	-15,6
10.30	10.23	0.03	59,1	8,8	-22,5	-15,5
10.40	10.13	0.01	58,6	9,1	-22,5	-14,3
10.50	10.09	0.01	58,2	9,4	-22,5	-11,9
11.00	10.25	0.27	56,4	10,9	-22,7	-11,1
11.10	10.29	0.23	55.8	12,7	-22,4	-11,1

11.20	10.46	-0.02	57,9	4,5	-21,9	-16,8
11.30	10.49	0.01	58,4	-2,6	-21,1	-17,8
11.40	10.45	0.04	59,3	-2,8	-20,4	-18,1
11.50	10.35	-0.05	60,1	-3,2	-19,6	-18,3
12.00	10.34	-0.04	60,9	-2,9	-18,6	-18,5
Average	10.39	0.010	60,50833	2,212	-19,436	-16,62
Max	10.90	0.27	64,7	12,7	-11,4	-11,1
Min	10.09	-0.06	56,4	-3,2	-22,8	-18,7

From the above table data obtained the final heat value of the condenser 60.9°C and evaporator temperature value - 18.6°C. So it can be depicted on the P-h diagram and get the value of h1, h2, h3, and h4.

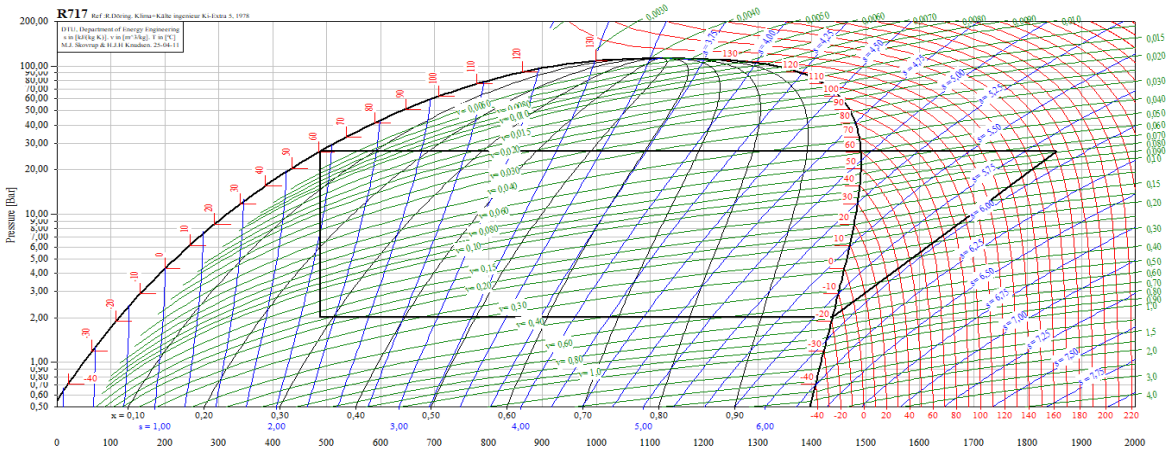

Figure 3. p-h Diagram of actual analysis results

From the above diagram P-h has been known ;

h1 = 1438,3 J/kg

h2 = 1853,9 J/kg

h3 = 488,9 J/kg

h4 = 488,9 J/kg

P compresor = 220 kW atau kJ/s

From the existing data, then before calculating the value of the COP we can calculate the fluid flow period (m) first by using the equation;

P compresor = m (h2 - h1)

m = P compresor / (h2 - h1)

m = 220 / (1853,9 – 1438,3)

m = 220 / 415,6

m = 0,52 kg/s

Furthermore, the value of fluid flow (m), used to calculate the value of the coolant capacity in the evaporator by using the equation;

Q evaporator = m (h1 – h4)

= 0,52 (1438,3 – 488,9)

= 0,52 (949,4)

= 493,6 kW

After we obtain the value of the coolant capacity in the evaporator (Qev), then we will calculate the value of the actual Coefficient of Performance and the value of the Carnot Coefficient of Performance using the equation;

$$COP_{Actual} = \frac{Q\ evaporator}{P\ kompresor} = \frac{493,6}{220} = 2,24$$

To use the carnot COP equation the temperature value needs to be converted first from Celsius to kelvin, this is because Carnot COP is based on absolute temperature (absolute) and Celsius is not an absolute scale. So -18.6°C is converted to 254.5 K, and 60.9°C is converted to 333.9 K. Then the equation is used;

$$COP_{Carnot} = \frac{T\ evaporasi}{T\ Kondensasi - Tevaporasi} = \frac{254,5}{333,9-254,5} = \frac{254,5}{79,4} = 3,07$$

The value of the actual Coefficient of Performance and the value of the coefficient of performance Carnot obtained, then used to calculate the refrigeration efficiency using the equation;

$$\eta_{refrigeration} = \frac{COP\ Aktual}{COP\ Carnot} \times 100\ \%$$

$$\eta_{refrigeration} = \frac{2,24}{3,07} \times 100\ \%$$

$$\eta_{refrigeration} = 0,72 \times 100\ \%$$

$$\eta_{refrigeration} = 72\%$$

Based on the calculation of the results and the discussion obtained the value of Coefficient of Performent (COP) and refrigeration efficiency, it can be concluded that:

On January 13, 2025, the data collection obtained an actual COP value of 2.24 and a carnot COP value of 3.07 and a refrigeration efficiency of 72%, the Cold Storage 1 refrigeration room has been properly utilized according to ASHRAE standards based on Table 2. So, the efficiency value obtained for 1x data retrieval is 72%. For further efficiency calculations using the above method and the overall results can be seen in:

Table 3. Results of Efficiency Analysis

No	Date	T kond (°C)	T evap (°C)	COP A	COP C	Efficiency (%)
1	13/01/2025	60,9	-18,6	2,24	3,07	72
2	20/01/2025	61,1	-18,2	2,28	3,21	71
3	27/01/2025	60,6	-18,4	2,29	3,22	71
4	03/02/2025	60,3	-18,6	2,29	3,22	71
5	10/02/2025	59,5	-18,2	2,34	3,28	71
6	17/02/2025	59,5	-12,6	2,62	3,61	72
7	24/02/2025	64,6	-12,5	2,43	3,38	71
8	03/03/2025	61,5	-18,7	2,23	3,17	70
9	10/03/2025	62,5	-18,1	2,22	3,16	70
10	17/03/2025	60,7	-18,3	2,29	3,22	71
11	24/03/2025	60,1	-19,5	2,25	3,18	70
12	07/04/2025	60,5	-18,7	2,29	3,21	71
	Avarege	**60,983**	**-17,533**	**2,314**	**3,244**	**70,91**

C. Graph of Cop Value and Refrigeration Effeciency

In the graph below shows the graph of the actual COP value, Carnott, and the value of refrigeration efficiency at PT Lautindo Synergy Sejahtera conducted data collection for 12 times.

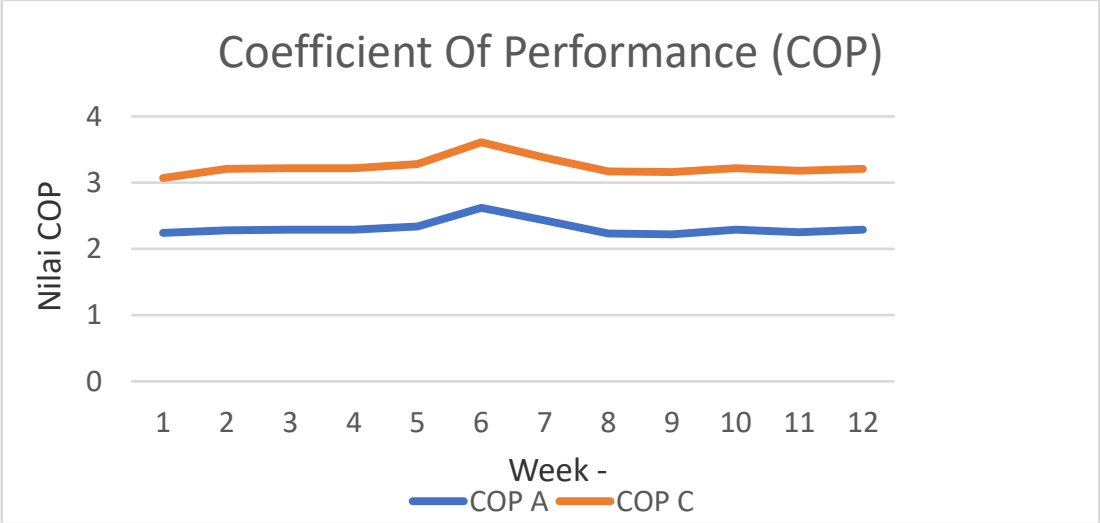

Figure 4. Graph of actual and Carnott'S COP values

In the graph above shows the value of actual COP and Carnott contained in the Cold storage unit 1 at PT. Lautindo Synergy Sejahtera for 12 times data collection began on January 13, 2025 until April 7, 2025. In the data collection, the highest COP Actual and COP Carnott values were obtained on February 17 with an Actual COP value of 2.62 and a COP Carnott value of 3.61, while the lowest COP Actual value was on March 10, 2025 with a value of 2.22 and the lowest COP Carnott on January 13, 2025 with a value of 3.07.

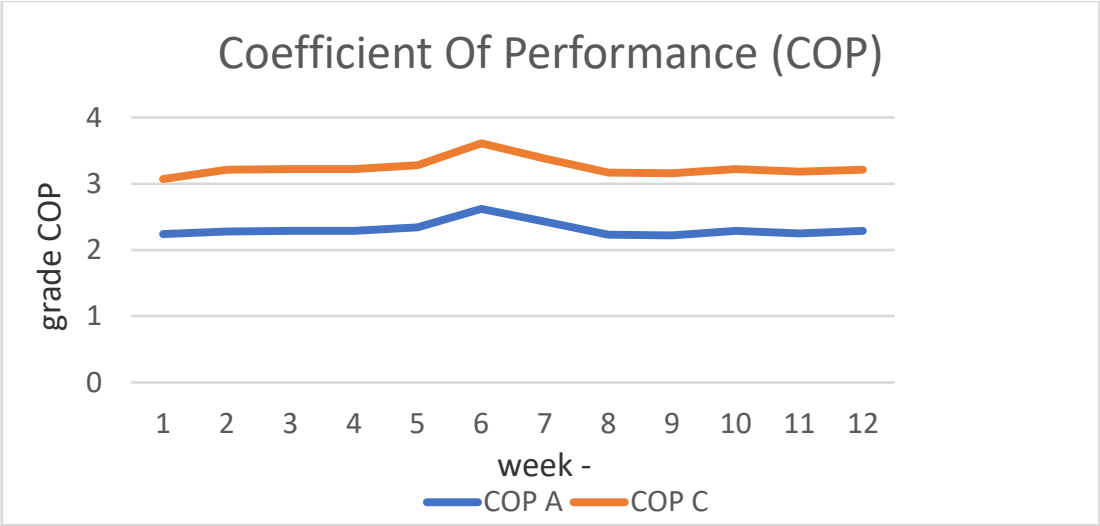

Figure 5. Efficiency Value Graph

In the graph above shows the percentage of efficiency and COP values contained in the Cold storage unit 1 at PT Lautindo Synergy Sejahtera. It can be concluded from the average value of refrigeration efficiency is very close to the range of 70%-72% for 12 times the data collection, the average value of the actual COP of 2.31, and the average value of cop carnot of 3.24 based on these data can be stated that the refrigeration unit is efficient according to ASHRAE standards related to industrial refrigeration in Table 10. Actual COP value, COP Carnott, and refrigeration efficiency are also influenced by other factors, such as temperature and power of the compressor. The efficiency value can reach maximum efficiency (72%) due to the lack of demolition activities or open and close the door so that cold storage does not experience a significant decrease in temperature due to product demolition work or work in the cold storage room. Therefore, the temperature in the cold storage room and the load received by the compressor is very important to consider so that the efficiency value becomes better and the product quality will be maintained properly.

IV. CONCLUSIONS AND ADVICE

From the observations, data retrieval and the results of the discussion that the author has done in the Cold Storage Room 1 for 12 times the data retrieval at PT Lautindo Synergy Sejahtera, conclusions can be drawn;

1. The average temperature before the compressor (T1) for 12 times of data retrieval is -17.5°C with the lowest temperature of -19.5°C and the highest temperature of -12.5°C, while the temperature after the compressor (T2) for 12 times of data retrieval is 60.9°C with the lowest temperature of 59.5°C and the highest temperature of 64.6°C.
2. The results of the analysis for 12 times the data collection shows the average value of the actual COP of 2.31 with the lowest value of 2.22 and the highest value of 2.62, while the average value of the COP Carnott value of 3.21 with the lowest value of 3.07 and the highest value of 3.61.

The results of the calculation of the efficiency value for 12 times showed an average value of effective COP (efficiency) of 70.9% with the highest efficiency value of 72% and the lowest efficiency value of 70%. Based on this value, the unit is declared efficient based on the ASHRAE standard

REFERENCES

1) ASHRAE. (2019). ANSI/ASHRAE Standard 90.1 – Energy Standard for Buildings Except Low-Rise Residental Buildings. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
2) ASHRAE. (2022). Ashrae handbook inch-pound edition. New York: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
3) Bimantara, Y. S. (2017). Perancangan sistem serfrigerasi kompresi uap cascade untuk aplikasi pada hybrid reefer container.

Institut Teknologi Sepuluh Nopember (ITS).
4) Defriadi, R. (2010). Perancangan sistem refrigerasi dengan single condensing unit dan double evaporator. Universitas Indonesia.
5) Dirja. (2004). Dasar-dasar mesin pendingin. Departemen Pendidikan Nasional.
6) Dossat, Roy, J. 1981." Principle of Refrigeration" SI Edition. Jhon Willey and Son.1981
7) Fajarani, R. M., Handoyo, Y., & Rahmanto, R. H. (2019). Analisis beban pendinginan pada Cold Storage untuk penyimpanan daging. Universitas Islam "45" Bekasi.
8) Fianti. (2023). *Coefficient of Performance* pada *Coldstorage* PT IMPD/PT WIFI Sorong. Universitas Kristen Papua.
9) Firman. & Anshar, M. (2019). Refrigerasi dan pengkondisian udara. Makassar: Garis Putih Pratama.
10) Harianto. & Yawara, E. (2013). Efektivitas penggunaan thermostatic expantion valve pada refrigerasi ac split. Sekolah Tinggi Teknologi Nasional.
11) Hasbi, G.A., Budiarto, U., Amiruddin, W. (2016). Analisa unjuk kerja desain sistem refrigerasi kompresi uap pada kapal ikan ukuran 5 GT di wilayah rembang. Universitas Diponegoro. Semarang.
12) Herdayati. & Syahrial. (2019). Desain penelitian dan teknik pengumpulan data dalam penelitian.
13) Huda, F. N. (2012). Efektifitas fitur bagi pengguna handphone Nokia tipe E-72 & 5800 xpress music.
14) Ilyas, S., 1993. Teknologi Refrigerasi Hasil Perikanan Jilid I Teknik Pendinginan Ikan. Pus. Penelit. Dan Pengemb. Perikan. Jkt.
15) Mardiyono, M., & Fadillah, H. (2020). Perhitungan Beban Refrigerasi Terhadap Hasil Tangkapan Pada Km. Harapan Sri Jaya Juwana, Pati, Jawa Tengah. *Jurnal Rekayasa Mesin*, *15*(3), 171–175.
16) Murtono, A., Kalangi, P.N.I., Kaparang, F.E. (2015). Analisis beban pendingin cold storage PT. Sari Tuna Makmur Aertembaga Bitung, Sulawesi Utara. Universitas Sam Ratulangi. Manado.
17) Nugroho, F. S. A. (2017). Unjuk Kerja Mesin Penyejuk Udara dengan Siklus Kompresi Uap Menggunakan Daya Kompresor 1/6 dan Ice Pack. 136.
18) Nurhasanah, R., Prayudi, P., Suhengki, S., Hendri, H., Andika, A., Luqman, L., 2023. Pelatihan Ahli Refrigerasi Tingkat 1 Bagi Para Guru Dan Siswa Smk Negeri 3 Pariaman. Terang 2, 1–9. Publishing.
19) Purnomo, D. (2015). Faktor-faktor yang mempengaruhi hasil belajar siswa pada mata pelajaran menggambar teknik di smk.
20) Raharjo, S. (2020). Efisiensi penggunaan refrigeran pada mesin pengkondisian udara split. Semarang: Universitas Diponegoro.
21) Rahma, R. (2016). Rancang bangun termometer suhu tubuh dengan tampilan digital dan indikator getaran serta output suara.
22) Rahmat, M.R. (2015). Perancangan Cold Storage untuk produk reagen.
23) Ramadhan, R. (2017). Pengaruh temperatur lingkungan dan beban produk terhadap performansi refrigerator untuk penyimpanan whole blood. Politeknik Negeri Bandung.
24) Riyadi, M., Budiarto, U., & Santosa, A. W. B. (2016). Analisa teknis dan ekonomis penggunaan sistem pendingin refrigerated sea water (RSW) pada kapal ikan tradisional. 4, 12.
25) Saputra, E. & Budihadi, A. (2020). Analisa beban udara sebagai media pendingin kondensor pada traineer Cold Storage. Universitas Mercu Buana Jakarta.
26) Siagian, S. (2017). Perhitungan beban pendingin pada Cold Storage untuk penyimpanan ikan tuna pada PT.X. UPN Veteran Jakarta.
27) Siyoto, S.& Sodik, A. (2015). Dasar metode penelitian. Yogyakarta: Literasi Media
28) Soesilo, T. D. (2019). Ragam dan prosedur penelitian tindakan. Satya Wacana
29) Suarnadwipa, I.N. (2016). Refrigerasi. Universitas Udayana. Bali.
30) Sugiyono. (2006). Metode penelitian pendidikan kuantitatif kualitatif dan R&D. Bandung: Alfabeta.
31) Suryana. (2010). Metode praktis penelitian kuantitatif dan kualitatif. Universitas Pendidikan Indonesia. Bandung.
32) Tampubolon, D. & Samosir, R. (2005). Pemahaman tentang refrigerasi. Politeknik Negeri Medan. Medan. Universitas Islam 45. Bekasi. University Press.
33) Widi, R. K. (2018). Menggelorakan Penelitian Pengenalan dan Penuntun Pelaksanaan Penelitian.pdf. DEEPUBLISH (Grup Penerbitan CV BUDI UTAMA).
34) Wiharjo., & Agus B. (2019). Analisa Efisiensi Daya Kompresor Pada Mesin Trainer Cold Storage. Jurnal Teknik Mesin, Vol. 08, No.2, Juni 2019.