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Analysis of the Impact of Coating System Delays on Cargo Oil Tank: Case Study of the Oil Tanker Ship Pancaran M242

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ABSTRACT

The Pancaran M242 tanker has encountered obstacles in the coating process within the cargo oil tank (COT). Factors hindering the ship's coating process. This thesis analyzes the delays in the coating process using the Fault Tree Analysis (FTA) method with cut sets and their probabilities, and determines the critical path using the Critical Path Method (CPM). From the analysis results, the intermediate events obtained are the work preparation probability (0.93779), the work process probability (0.99998), and the work outcome probability (0.64000). For the basic event of delay, there are 3 main factors: the long procurement of materials (0.6), poor material coordination (0.8), and unfavorable weather (0.8). Therefore, the need for a dehumidifier must be determined, which has resulted in the need for 1 tank and 1 dehumidifier with a total requirement of 79.95 kWh and a total dehumidifier capacity of 93.6 kW. The result of the rescheduling and determining the critical path showed that the planned schedule was reduced from 60 days to 43 days, and the actual schedule of 90 days could be expedited to 64 days by following the critical path

INTRODUCTION

In the case of painting the cargo oil tank rooms of the Pancaran M242 ship, there was a delay from the planned schedule. The Pancaran cargo oil tank itself consists of 12 tanks (Portside & Starboard Side). The planned schedule for each tank was to be completed in 2 months. In reality, painting each Pancaran M242 cargo oil tank took 3 months, which means that compared to the initial planned schedule, the painting was delayed by 1 month. The delay of a cargo oil tank painting project on the Pancaran M242 ship is caused by multiple factors, both internal and external. Therefore, this study is proposed to analyze the impact of coating system delays on the cargo oil tank of the Pancaran M242 Oil Tanker. Based on the description above, ways to analyze the causes of coating system delays, determine the dehumidifier requirements, and reschedule the delayed coating on the cargo oil tank can be established. Analyzing the factors causing delays in the coating system of cargo oil tanks. To determine the required number of dehumidifiers and analyze ways to revise the delay schedule by providing an alternative schedule for the completion duration of the coating system on cargo oil tanks. The benefits of this study are to provide information on the accurate duration for the painting process on cargo oil tanks based on the factors causing delays and the acceleration of work carried out, which will later be used for the painting process on other cargo oil tanks. The scope of the problem covers aspects related to the corrosion rate, weather conditions during the work period, tank sampling, paint brand, use of dehumidifier methods, and focuses on one ship without any comparative vessels. Oil Tanker Ship; According to IMO (2002:405), An oil tanker is a ship built or constructed primarily to transport bulk oil cargo in its cargo spaces, including combined carriage and product tankers as described in Annex II of MARPOL 73/78, when the ship carries cargo or part of the cargo in bulk.

Ship coating systems are processes of applying layers or paint used to protect the ship's surface from corrosion and damage caused by the surrounding environment, including temperature, seawater, humidity, chemicals, and so forth. According to ISO (4618-1) and (Miftahuddin, 2016), humidity is the amount of water vapor concentration in the air. During the day, relative humidity decreases. From evening until early morning, relative humidity increases. To calculate specific humidity, refer to the ASHRAE Handbook Fundamentals equation below.

Empirical psychometric formula:

$W = 0.622 \times P_w/(P-P_w)$ ………….......…………… (1)

The Antoine equation is the relationship between vapor pressure and the temperature of a pure substance. There is also the Antoine equation for air in the equation

$\mathrm{Log}_{10} P_{SAT} = A - B/(C+T)$ ....………………………(2)

According to the ASHRAE Handbook Fundamentals, to calculate the moisture load, the following equation is commonly used;

$m_w = m_{da} \times (W_1 - W_2)$ ....(3)

$m_{da} = P \times V$

The PosiTector dew point meter (DPM) is a tool for measuring, calculating, and recording climate readings quickly and accurately. Meanwhile, the PosiTector can measure RH or relative humidity. According to the Principles of HVAC, drying to calculate the amount of energy required in a dehumidifier or dryer can generally use the formula below.

Q = m x h ....(4)

Risk Management; To analyze a risk, there are two ways to solve the problem: by erforming Qualitative and Quantitative Risk Analysis. Cardinal scale values are numbers expressed between 0 and 1.0 in probability. To achieve more precise results in probability, the following values can be used:

Very High = 0.80 Low = 0.20
High = 0.60 Very Low = 0.05
Medium = 0.40

Fault Tree Aanlysis; It is an analysis technique, where there is an undesired event that occurs in a system, and this system is then analyzed under the existing environmental and operational conditions to identify all possible ways in which the undesired event can occur (U.S. Nuclear Regulatory Commission: 1981:34)

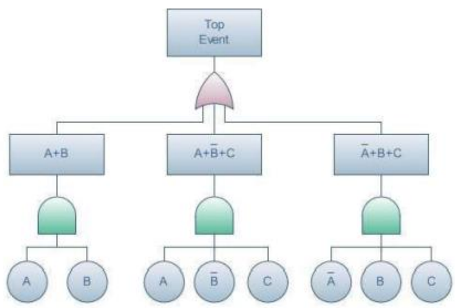

Figure 1. Fault Tree Concept

LITERATURE REVIEW

Critical Path Method; It is a project management technique that uses only one time factor per activity and is the fastest path to complete a project. In this method, every project activity on this path is not given any pause or rest time for its execution. It is based on the assumption that the estimated time for each project activity and its dependencies are known.

METHODOLOGY

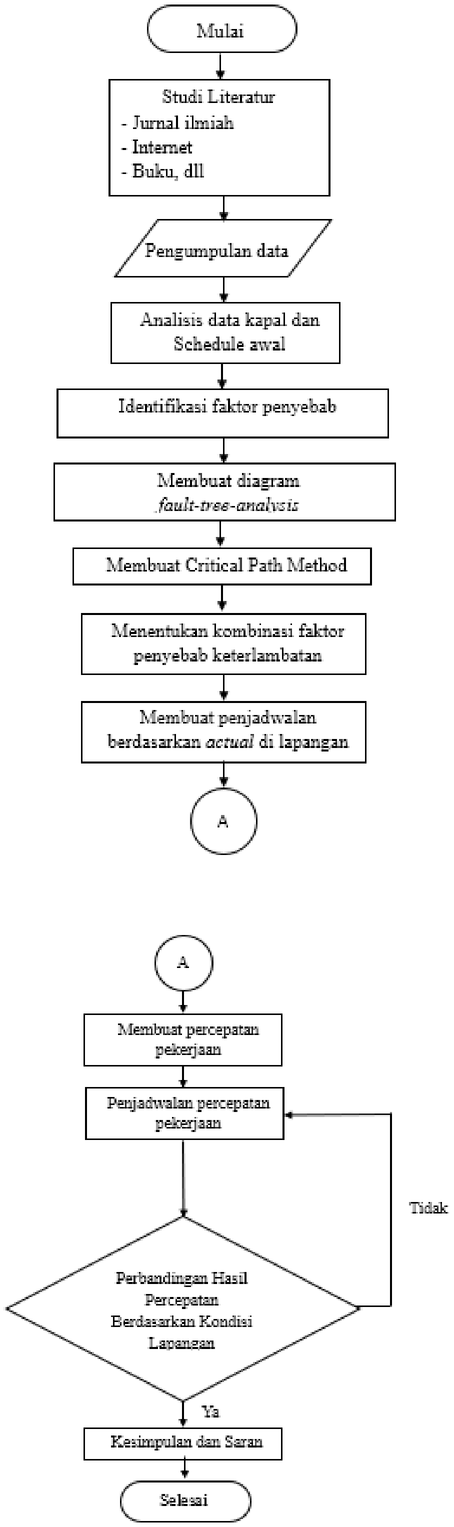

Figure 2. Research Flow Diagram

RESULTS AND DISCUSSION

In the research, a case study was conducted on the painting process of the cargo oil tank space on the Oil Tanker Pancaran M242.

Table 1. Ship Particulars Data of Oil Tanker Pancaran M242

LOA	170,00 m
LBP	162,00 m
Breadth	27,40 m
Dept	13,00 m
Draft	7,50 m
Classification	RINA

Figure 3. FTA Diagram of Delay in the Cargo Oil Tank Coating SystemWork

Preparation; is a factor that hinders the painting process of the Pancaran M242 cargo oil tank. These factors were identified based on direct interviews (On Board) with employees and subcontractors involved in the work.Work Process; includes the main tasks in the cargo oil tank coating system of the Pancaran M242. In carrying out the work, there are delay factors, such as poor management, availability of materials, equipment facilities, unfavorable weather, work quality results, and limited workforce. These factors were obtained from interviews and questionnaires with subcontractors and company employees.

Work Results; this is the final result of the painting process on the cargo oil tank. At this stage, there is a delay in conducting a joint quality check. The quality check at this stage not only involves the QC team but also the Owner Surveyor and the class representative, where invitations to the class party must be properly arranged to avoid time conflicts with other appointments. After all parties are involved in the joint inspection, the Quality Control team will create a report, which will later be jointly approved, confirming that the painting of the ship's cargo oil tank has been accepted, as evidenced by signatures on the created report.

No	Kode Kejadian	Nama Kejadian
1	A1.1	Koordinasi PIC & SPV kurang baik
2	A2.1	Kebutuhan pompa dan dehumidifier tidak tercukupi
3	A3.1	Material covering yang tidak cukup
4	A4.1	Pengadaan material blasting tidak tercukupi
5	A5.1	Akses cleaning pasir yang susah
6	A6.1	Reinspection karena tidak berterima hasil quality check
7	B1.1.1	Koordinasi owner surveyor dan owner kurang baik
8	B1.1.2	Koordinasi owner surveyor dan PIC kurang baik
9	B1.1.3	Koordinasi PIC shipyard dengan PIC subcontractor kurang baik
10	B1.1.4	Koordinasi PIC shipyard dan subcontractor kurang baik
11	B1.1.5	Koordinasi SPV subcontractor dengan timnya kurang baik
12	B1.2.1	Koordinasi PPIC dengan pihak lapangan kurang baik
13	B2.1.1	Pengadaan material lama
14	B2.1.2	Koordinasi material buruk
15	B3.1	Keterbatasan jumlah peralatan
16	B4.1	Cuaca yang berubah-ubah
17	B5.1.1	Skill pekerja kurang
18	B5.1.2	Peralatan kurang memadai
19	B5.1.3	Cuaca kurang mendukung
20	B6.1	Jumlah tenaga kerja kurang
21	B6.2	Regenerasi pekerja buruk
22	B6.3	Kurang rekruitmen subcontractor
23	C1.1	Undangan untuk class melakukan inspeksi mundur
24	C2,1	Pembuatan laporan lama

Figure 4. Tabel Basic Event FTA

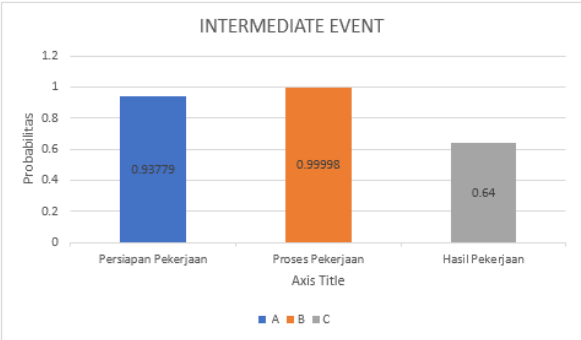

Figure 5. Bar Chart Basic Event FTA

" "The work process and work preparation" have a higher probability than "Work results." This is because in the cargo oil tank coating system, extra preparations are needed; if the preparations are not extra, it will affect the coating work process on the cargo oil tank. For example, if there is a delay in the material preparation, it will disrupt the continuity of the work process.

a. Calculating Specific Humidity (W)

Empirical psychrometric formula:

$$W = 0.622 \text{ x } \frac{Pw}{P-Pw}$$

Where :

W = Specific humidity

P = Air atmospheric pressure (101.325 kPa)

Pw = Partial pressure of water vapor

$Pw = RH \text{ x } P_{SAT}$

Looking for W1 (Actual)

$$W1 = 0.622 \text{ x } \frac{Pw}{P-Pw}$$

$$Pw = RH \text{ x } P_{SAT}$$

Looking for the P_{SAT} at 32.2 °C from the Antoine equation for water

$$\text{Log}_{10}P_{SAT} = A - \frac{B}{C+T}$$

A = 8.07131

B = 1730.63

C = 233.426
T = 32,2 ^{O}C

$Log10\ P_{SAT} = 8{,}07131 - \frac{1730{,}63}{233{,}426+32{,}2}$

$= 8{,}07131 - 6{,}515$

$Log10\ P_{SAT} = 1{,}556022$

$P_{SAT} = 10^{1.556022}$

$P_{SAT} = 35{,}97$ mmHg

$P_{SAT} = 4{,}796$ kPa

$Pw = RH\ x\ P_{SAT}$

$= 0{,}637 \times 4{,}796$

$= 3{,}055$ kPa

$W1 = 0.622 \times \frac{3{,}055}{101{,}325-3{,}055}$

$= 0.622 \times \frac{3{,}055}{98{,}270}$

W1 = 0,0193 kg water vapor/kg dry air

Finding W2 (Target)

$$W2 = 0.622 \times \frac{Pw}{P-Pw}$$

$Pw = RH\ x\ P_{SAT}$

Loking for the P_{SAT} for 32.1 ^{o}C

From the Antoine equation for water

$$Log_{10}\ P_{SAT} = A - \frac{B}{C+T}$$

A = 8.07131
B = 1730.63
C = 233.426
T = 32,1 ^{O}C

$Log10\ P_{SAT} = 8{,}07131 - \frac{1730{,}63}{233{,}426+32{,}1}$

$= 8{,}07131 - 6{,}521$

$Log10\ P_{SAT} = 1{,}5503$

$P_{SAT} = 10^{1.5503}$

$P_{SAT} = 35{,}5$ mmHg

$P_{SAT} = 4{,}737$ kPa

$Pw = RH\ x\ P_{SAT}$

$= 0{,}387 \times 4{,}737$

$= 1{,}833$ kPa

$W2 = 0.622 \times \frac{1{,}833}{101{,}325-1{,}833}$

$= 0.622 \times \frac{1{,}833}{99{,}492}$

W2 = 0,0115 kg water vapor/kg of dry air

Humidity difference

= W1 – W2
= 0,0193 - 0,0115
= 0,0078 kg/kg

a. Calculating Moisture Load. Calculating Moisture Load

$m_w = m_{da} \times (W1 - W2)$

$m_{da} = P\ x$ V

Where
m_w = Mass of water vapor emitted (kg)
m_da = Mass of dry air (kg)
P = Air density (1.2 kg/m^3)
V = Room volume
W1 = Actual humidity
W2 = Target humidity
m_{da} = 1,2 x 12.300 x 0,0078
= 115.128 kg
a. Calculating the Required Energy
Q = m x h
Where :
m (water) = Mass of water vapor released (kg)
h: = Enthalpy (Temperature 32,2 ^{O}C)
Q = 115.128 x 2500
= 287.820 kJ/kg
= 79,95 kWh

Dehumidifier Capacity

Dehumidifier Capacity: 93.6 kWEnergy required to remove water vapor: 79.95 kWhWhere 1 unit of a 6P tank room dehumidifier with a capacity of 93.6 kW can remove water vapor for 1 hour using 79.95 kWh of energy.So, for 2 tank capacities (Portside & Starboard side), a total of 2 dehumidifiers are required.

The critical path focuses on the trade-off between time and cost. The critical path consists of activities that, if delayed, will result in a delay in completion, and if any of them are accelerated, it will affect the duration of other tasks overall. For the critical path, there is no slack, meaning the slack value is 0.

Table 2. Calculation of EET & LET for Coating Cargo Oil Tank

Notation	*Activity*	*Duration*	*Proceeding Activity*	EET	LET	Slack
A	*Washing*	1 *Day*	-	1	1	0
B	*Cleaning/Drying 1*	3 *Day*	A	4	11	7
C	*Covering*	3 *Day*	A	4	11	7
D	*Blasting*	13 *Day*	A	11	11	0
E	*Cleaning 2*	4 *Day*	A	5	11	6
F	*Inspection 1*	1 *Day*	A,B,C,D,E	12	12	0
G	*Spray 1 Coat*	1 *Day*	F	14	20	7
H	*Stripe Coat & Touch Up*	8 *Day*	F	20	20	0
I	*Inspection 2*	1 *Day*	G,H	21	21	0
J	*Spray 2 Coat*	1 *Day*	I	22	31	9
K	*Strip Coat & Touch Up*	11 *Day*	I	29	29	0
L	*Inspection 3*	1 *Day*	J,K	30	30	0
M	*Spray 3 Coat*	1 *Day*	L	31	38	7
N	*Touch Up*	15 *Day*	L	38	38	0
O	*Final Inspect 1*	1 *Day*	M,N	39	39	0
P	*Open Scaffolding*	4 *Day*	O	42	42	0
Q	*Cleaning 3*	2 *Day*	O	41	42	1
R	*Preparation*	2 *Day*	O	41	42	1
S	*Final Inspect 2*	1 *Day*	P,Q,R	43	43	0

From the calculations in the table above, the path that has no slack or a value equal to 0 is the path consisting of activities A-D-F-H-I-K-L-N-O-P-S. Meanwhile, in Figure 6 below, there is a network diagram from the calculation of Earliest Event Time (EET), Latest Event Time (LET), and its critical path.

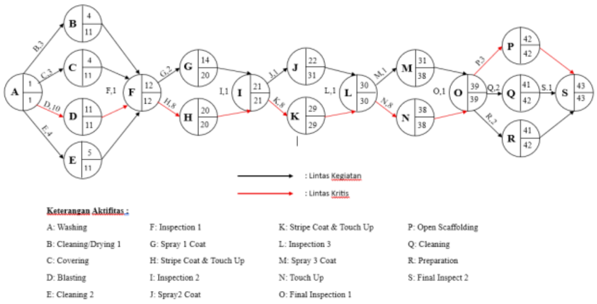

Figure 6. Network Diagram EET & LET

From the calculation above, it is concluded that the path with no slack or a value equal to 0 is the path consisting of activities A-D-F-H-I-K-L-N-O-P-S. Figure 6 above shows the network diagram from the calculation of Earliest Event Time (EET), Latest Event Time (LET), and its critical path.

Table 3. Comparison of Actual Schedule EET Coating Cargo Oil Tank.

Notation	Activity	Duration Plan	Delay (Day)	EET Plan	EET Actual
A	Washing	1 Day	0	1	1
B	Cleaning/Drying 1	3 Day	1	4	5
C	Covering	3 Day	1	4	5
D	Blasting	10 Day	4	11	15
E	Cleaning 2	4 Day	1	5	6
F	Inspection 1	1 Day	0	12	16
G	Spray 1 Coat	2 Day	1	14	18
H	Stripe Coat & Touch Up	8 Day	1	20	25
I	Inspection 2	1 Day	1	21	29
J	Spray 2 Coat	1 Day	1	22	39
K	Strip Coat & Touch Up	8 Day	4	29	39
L	Inspection 3	1 Day	1	30	41
M	Spray 3 Coat	1 Day	1	31	43
N	Touch Up	8 Day	7	38	57
O	Final Inspect 1	1 Day	1	39	62
P	Open Scaffolding	3 Day	2	42	62
Q	Cleaning 3	2 Day	1	41	41
R	Preparation	2 Day	1	41	41
S	Final Inspect 2	1 Day	1	43	64

From Table 3 above, it can be concluded that for every delayed task, there is an achievable early completion time, and by also observing the critical paths, these can be used to guide task completion. The critical paths can be used either as a reference to speed up tasks or to maintain the time on the critical path to prevent delays along it. For example, the task with the greatest delay is touch-up work, which experienced a 7-day delay, extending from 8 days to 15 days, where the actual EET according to the table is on day 57. By looking at the critical path, we can anticipate and create a reference for which tasks to monitor closely to avoid delays and identify which tasks need to be expedited if they experience delays.

CONCLUSION AND RECOMMENDATION

Based on the results of the study conducted, the following conclusions can be drawn:

1. To analyze the factors causing delays in the cargo oil tank system, we can start by collecting initial data, either internal or external. Then, the data is processed according to the method used. The methods employed are fault tree analysis (FTA) and critical path method (CPM). These two methods will

create a problem tree that will later be used to identify the minimal cut sets and the probability of each task. This will then be used as the critical path in the cargo oil tank coating system work.

2. A Cargo Oil Tank with a volume capacity of 12,300 m^3 and a relative humidity (RH) of 63.7, when reduced to an RH of 38.7, requires a total energy of 79.95 kWh per tank. Therefore, one dehumidifier can help remove moisture from only one tank, and for the portside and starboard side tanks, a total of 2 dehumidifiers are needed. The total capacity of this dehumidifier also depends on the volume and the environmental temperature. 1. From the initial plan schedule for the coating system process on the cargo oil tank, it required 60 days. There was a 30-day delay from the initial plan schedule, making it 90 days. After performing calculations using the critical path method to determine the critical path that must be monitored to avoid delays in work or to accelerate work that has experienced delays along the critical path, the results are as follows:a. If following the initial plan schedule and calculating the critical path, the original 60-day schedule can be accelerated to 43 days.b. If following the actual schedule and calculating the critical path, the actual 90-day schedule can be accelerated to 64 days.

Thus, it is concluded that point "a" can be used and applied to tanks where work has not yet been done, and the schedule must be considered for critical path activities that need to be monitored to avoid delays. Meanwhile, point "b" can be applied if work is still in progress and not finalized, and the schedule must be revised and accounted for in the critical path to accelerate the work.

In this study, it is hoped that future researchers who choose a similar topic or a topic regarding project delays can study the impacts of delays in terms of the costs that must be incurred to address such delays. For example, adding manpower to catch up on lost time will certainly incur additional costs in order to meet the agreed-upon timeline.

FUTHER STUDY

This research still has delays, so it is necessary to conduct further research related to the topic Analysis of the Impact of Coating System Delays on Cargo Oil Tank: Case Study of the Oil Tanker Ship Pancaran M242 in order to improve this research and add insight for readers.

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