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Calculation Of Evaporation Loss in Tank Y and Tank Z at SA Field PT X Prabumulih

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Abstract

One of the facilities that plays an important role in the petroleum industry both in the fields of upstream oil and gas, downstream oil and gas, shipping and commerce is fluid storage area which is better known as a storage tank. Storage tank is very influential on the petroleum production process. Storage has an important role to accommodate and store fluid in the process of fluid distribution or fluid delivery from the production collector to the next destination such as production collection centers, refineries, and shipping. The storage tank used in SA Field is a fixed tap type tank (fixed roof tank). Fixed roof tanks are the most common type of tank among all tank cylinder and have a fixed conical roof with / without roof structure. Oil in storage tanks can experience losses. Losses are the disappearance or shrinkage of petroleum. Losses in this tank are caused by evaporation loss which is influenced by the temperature of the petroleum as well as the temperature from the weather outside the tank and the amount of free space in the tank. If the larger the free space in the tank, the greater the potential for evaporation of crude oil in the tank. In this study, an analysis of the factors causing evaporation loss will be carried out, calculation of evaporation loss, and calculation of the number of financial losses caused by evaporation loss in Tank X and Tank Y. Briefly, this research will be useful as one of the important references for the industry to find out the number of financial losses caused by evaporation loss.

INTRODUCTION

One of the facilities that plays an important role in the petroleum industry both in the fields of upstream oil and gas, downstream oil and gas, shipping and commerce is a fluid storage area or storage tank (Burhanuddin, Alfurkaniati, & Agustin, 2020). Storage tank or commonly known as storage tanks or hoarders greatly affect the production process (Lichti, Steele, & Swihart, 2017). This storage tank functions and has an important role to hold and store fluid in the process of fluid distribution or fluid transfer from one production collection place to the next such as production collection centers, refineries, and shipping (Zai, 2021). The storage tank used in the SA Field is a Fixed Roof Tank. Fixed roof tanks are the most common type of tank among all cylinder tanks and have a fixed conical roof with/ without a roof structure.

Oil in storage tanks of the fixed roof tank type can experience losses. Losses are the disappearance or shrinkage of petroleum (Makruf et al., 2020). Losses in this tank are caused by evaporation loss which is influenced by the temperature of the crude oil as well as the temperature from the weather outside the tank and the amount of free space in the tank (ullage). Ullage is the free space in the tank, the greater the potential for evaporation of crude oil in the tank.

In a fixed roof tank, evaporation loss calculation is divided into breathing loss and working loss. Breathing loss is circulation losses due to depreciation due to the influence of environmental temperature, while working loss is circulation losses due to tank receipt and expenditure operations. Both calculation methods produce the amount of product lost due to evaporation, making it easier to calculate the loss of crude oil in fixed roof tanks in the SA Field.

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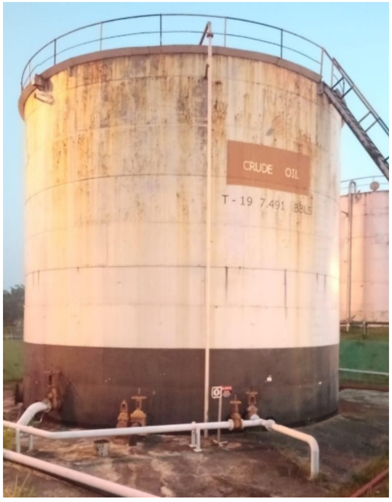
The purpose of this study is to find out the factors that cause evaporation loss, to find out the amount of evaporation loss, to find out the amount of financial loss due to evaporation loss, and to know how to overcome evaporation loss that occurs in Tank Y and Tank Z in the SA Field, PT X Prabumulih.

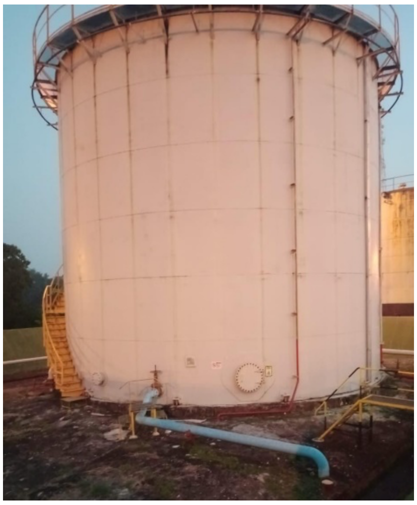
In general, there are several types of tanks, namely:

(a) Fixed roof tank is a type of tank used to store non-volatile fluid, fixed roof tank is further divided into two types of roof shapes, namely cone roof tank and dome roof tank (Burhanuddin et al., 2020).
(b) Fixed cone roof tank is used to stockpile or siphon various types of fluids with low vapor pressure or in other words non-volatile fluids (Fajar, 2019), this type of tank has a conical roof and is most common among all cylinder tank and has a fixed conical roof with / without a roof structure.
(c) A fixed dome roof tank is a fixed roof tank that has a roof that resembles a sphere and is only supported by the circumference of the dome which is usually used to store crude oil or other fuel products. Fixed dome roof tanks are used to store volatile products with internal pressure.
(d) A floating roof tank is a storage tank commonly used to store large quantities of petroleum products such as crude or condensed oil. This floating roof tank consists of an open cylinder steel shell equipped with a roof that floats and follows the rise and fall of the liquid stored in the tank. Unlike the fixed roof tank, this tank does not have an empty roar between the liquid level and the tank roof. In principle, this tank eliminates the breathing of the tank and greatly reduces losses due to evaporation from the liquid present in the tank.

The type of tank in SA Field is a fixed roof tank as shown in Figure 1.



(a)



(b)

Figure 1. Tank Y (a) dan Tank Z (b) PT X Prabumulih

Breather Valve

Breather valve is a breathing device or medium for a tank of oil deposits or other fluids, especially volatile ones (Arnold & Stewart, 2007). Its function is to adjust the balance of outside and inner pressure of the tank automatically and is useful in reducing losses due to evaporation and protecting against rupture/explosion of the storage tank.

The fixed roof tank requires a breather valve to reduce losses and avoid damage to the fixed roof tank. Without controlled openings or openings, tanks with fixed roofs will break or explode due to increased pressure caused by pumping liquid into the tank or as a result of changes in vapor pressure caused by temperature changes in the tank. Therefore the breather valve can reduce the excess pressure on the tank so that the pressure pallet will open and release excess pressure (over pressure) on the fixed roof tank.

On the other hand, if the continuous pump discharge process occurs at that time the tank needs to breathe air. If the vents are closed or there is no breathing valve, the tank will explode or break due to emptying of the tank. Therefore, a breather valve is needed when the tank is in a low-pressure condition, the vacuum pallet will open to maintain the pressure in the tank by circulating the air outside into the storage tank.

Losses

Losses in the oil and gas world are the loss of a product or crude oil that is very detrimental to a company. Losses in petroleum can occur from the field to the consumer. Losses or losses can occur due to evaporation, leakage, seepage, damage to tools, contamination, and others. Losses can occur due to evaporation, leakage,

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seepage, damage to equipment, contamination, and others. Losses can occur due to losses to users caused by storage errors and unracial use (Setiorini et al., 2021). The slightest loss must be prevented and needs to be taken seriously in order to minimize the loss of a company.

Evaporation Loss in Fixed Roof Tanks

Evaporation Loss is the loss of petroleum due to evaporation, where this evaporation can occur in any oil and gas industry activity. One of them is in a fixed roof tank type tank. Evaporation loss can cause huge losses to the company. The parameters needed to reduce evaporation loss are as follows:

1. Daily Temperature Difference. As we know, the temperature on daily basis can change significantly during the day and night. Therefore, to determine the evaporation loss in the tank is very necessary daily temperature difference (ΔT).
2. True Vapor Pressure, which is the actual vapor pressure of crude oil products at a temperature of 100 ° F, at which temperature crude oil has boiled and produced steam, an alternative method for measuring steam pressure that is very often used is Reid vapor pressure. Reid vapor pressure applies to crude oil, condensate, and petroleum distillation.
3. Adjustment Factor. Evaporation in tanks depends on the size of the diameter of the tank, where small diameter tank has less evaporation than larger diameter tank.
4. Paint Factor. Evaporation in the tank is also influenced by the color of the paint contained in the tank where the dark color tends to absorb more sunlight which causes the temperature in the tank to increase and increase the evaporation that occurs in the liquid in the tank.
5. Turnover Factor, which is the annual rotation of fluid in the tank. If the value of Kt is taken as a whole represents the loss resulting from the displacement of the volume of the saturated air-steam mixture equal to the volume of liquid pumped into the tank.

Breathing Loss

Breathing Loss is the partial evaporation of petroleum as a result of the expansion and thermal contraction of petroleum vapors with air caused by daily temperature changes (Varec, Chilingarian, & Kumar, 1987). This loss cannot be affected by changes in the height of petroleum in the tank. The factor that affects breathing loss is the amount of heat of sunlight radiation absorbed by petroleum during the day.

Under daytime conditions, the ambient heat is absorbed by the tank and partially passed on to the petroleum present in the tank. The increasing temperature in the tank causes an increase in the pressure of petroleum vapors that are above the liquid, so that petroleum vapors will find a way out through the vent hole (Kaiser & McAllister, 2023). Based on the field survey, the main hole of the oil holding tank is left open or not closed tightly so that petroleum vapor can freely escape. With the petroleum vapor escaping, at the confluence of the petroleum vapors layer maintains equilibrium and the presence of part of the liquid is into steam.

Working Loss

Working Losses are expressed as losses as a result of evaporation that occurs due to changes in the level of liquid in the tank. This change in fluid level can be caused by the process of filling the tank or emptying (pumping) petroleum. During the process of filling petroleum into the tank, the liquid level will increase and force the oil vapor to come out of the tank (McRae, Van Ness, & Khandekar, 2023; Stewart, 2021). The magnitude of the oil vapor in the outgoing tank is proportional to the magnitude of the volume of liquid added to the tank. For tanks that have pressure vent control, steam will come out when it exceeds the vent setting pressure so it is necessary to consider condensation that may occur.

METHODS

Stages of Data Collection:

a. Primary Data:
   1. Daily volume of throughput on the tank
   2. Daily temperature data on the tank
   3. The height of free space in the tank
b. Secondary Data:
   1. Specification data of Tank Y and Tank Z
   2. Liquid level data on tanks

Data Analysis Techniques

Fixed roof tank evaporation loss consists of:

a. Standing Storage Tank Loss, where the tank is stationary, or the tank level is fixed (fixed ullage)
b. Withdrawal Loss, where the tank is withdrawn or reduced Stages of Data Processing.

- **Stages of Data Processing:**
  1. Adjustment Factor
  2. Paint Factor, can be determined based on the color of Tank Y and Tank Z.
  3. True Vapor Pressure (TVP)
  4. Daily temperature differences this daily temperature difference can be found by:

$$\Delta T = T_{TI} - T_{RE} \qquad (1)$$

Where:
ΔT = Daily temperature difference
T_{TI} = Daily temperature occurring during the day (^{O}F)
T_{RE} = Daily temperature occurring at night (^{O}F)

5. Adjustment factor to calculate the adjustment factor, you can use the following equation:

$$C = 0.0771D - 0.0013D^2 - 0.1334 \qquad (2)$$

Where:
D = Diameter of the figure

6. Turnover Factor
7. Determination of Breathing Loss
   In API Bull 2523 - First Edition, November (1969), for the determination of breathing loss can use the following equation:

$$Ly = \left[\frac{24}{1000} \text{ x } \left(\frac{p}{14{,}7 - p}\right)^{0{,}68} \text{ x } d^{1{,}73} \text{ x } H^{0{,}51} \text{ x } T^{0{,}50} \text{ x Fp x C}\right] \qquad (3)$$

Where:
p = True Vapor Pressure, psi
d = Tank Diameter, ft
H = Ullage, ft
T = Different daily temperature, °F
Fp = Pain Factor
C = Turnover Factor

8. Working Loss
   In API Bull 2523 - First Edition, November 1969, for the determination of Working Loss can use the following equation:

$$\text{Working loss} = \left[\frac{(3Pv)}{10000}\right] \qquad (4)$$

Where:
P = True Vapor Pressure, psi
v = Throughput, bbl/year

9. Evaporation Loss
   For evaporation loss on a fixed roof tank consisting of breathing loss and working loss, you can use the following equation:

   Evaporation Loss = Breathing Loss + Working Loss (5)

   Where:
   Breathing Loss = Evaporation of some petroleum due to the expansion and thermal contraction of oil vapor with air caused by changes in daily temperature, bbl/year
   Working Loss = Losses due to evaporation that occurs due to changes in fluid levels in the tank, bbl/year
10. Calculation of financial losses

RESULTS AND DISCUSSION

Evaporation Loss Calculation

Evaporation loss calculation is carried out from January 1st, 2022. There are several stages carried out.

1. Tank type = Fixed roof Tank
2. Color = Gray

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3. Determination of paint factor. The paint factor value obtained based on the color of the tank is gray, In API Bull 2523, the color is gray and paint in good condition, then the paint factor value = 1.30, can be seen in Table 1 below.

Table 1 Tank Color vs Paint Factor

Tank Color		Paint Factor	
Roof	Shell	Paint in Good Condition	Paint in Poor Condition*
White	White	1.00	1,15
Aluminium (specular)	White	1,04	1,18
White	Aluminium (specular)	1,16	1,24
Aluminium (specular)	Aluminium (specular)	1,20	1,29
White	Aluminium (diffuse)	1,30	1,38
Aluminium (diffuse)	Aluminium (diffuse)	1,29	1,46
White	Gray	1,30	1,38
High gray	High gray	1,33	
Medium gray	Medium gray	1,46	

4. Determination of True Vapor Pressure (TVP). True Vapor Pressure (TVP) obtained from laboratory testing at PT X Prabumulih.

Table 2 TVP Values Tank Y

Date	Liquid Temperature, °F	RVP, psi	TVP, psi
1/ 01/ 2022	79	9	8,5
2/ 01/ 2022	82	9	8,9
3/ 01/ 2022	82	9	8,9
4/ 01/ 2022	86	9	9,8
5/ 01/ 2022	79	9	8,5
6/ 01/ 2022	81	9	8,8
7/ 01/ 2022	83	9	9

Table 3 TVP Values Tank Z

Date	Liquid Temperature, °F	RVP, psi	TVP, psi
1/ 01/ 2022	83	10	10,3
2/ 01/ 2022	82	10	10,2
3/ 01/ 2022	83	10	10,3
4/ 01/ 2022	83	10	10,3
5/ 01/ 2022	85	10	10,5
6/ 01/ 2022	81	10	10,1
7/ 01/ 2022	83	10	10,3

5. Determination of daily temperature difference.

T_{TI} and T_{RE} data obtained from measurements made by field operator PT X Prabumulih Tank Y and Tank Z from January 1, 2022, to January 7, 2022. Average daily temperature difference is 12,71 (°F).

Table 4 Calculation result of daily temperature difference Δ T (°F)

Date	TTI (°F)	TRE (°F)	ΔT (°F)
1/01/22	93	80	13
2/01/22	93	79	14
3/01/22	94	81	13
4/01/22	89	80	9
5/01/22	90	80	10
6/01/22	93	79	14
7/01/22	95	79	16
Average	92,42	79,71	12,71

6. Determination of Adjustment Factor = 1
7. Determination of Turnover Factor = 0.5
   To determine the value of Turnover Factor, it is necessary to know annual turnover Tank Y and annual turnover Tank Z. According to Robert Weller (1989), turnover factor from 0 to 40, Kt =1.0, turnover factor between 40 and 60, Kt = 0.8, and turnover factor of 60 - 100, Kt = 0.5. From the data Annual Turnover Tank Y is 88 times and Annual Turnover Tank Z is 76 times. Turnover Factor Tank Y dan Tank Z per year is 0.5.

Table 5 Specifications of Tank Y and Tank Z

No	Specification	Tank Y	Tank Z
1	Net Volume	1.190.151 liters	1.415.251Liters
2	Tank Diameter	11,975 mm	12,988 mm
3	Measuring Hole Height of measuring table	10,927 mm	10,880 mm
4	Measuring hole height from base	10,962 mm	11,345 mm
5	Tank Height	10.900 mm	11,000 mm
6	Net Volume Maximum Height	10,600 mm	10,700 mm
7	Table Height Measure	35 mm	465 mm
8	Tank Base Height	0 mm	0 mm

Table 6 Evaporation Loss Calculation Data in Tank Y and Tank Z

No	Variable	Tank Y	Tank Z
1	Types of tanks	Fixed Roof Tank	Fixed Roof Tank
2	Paint Factor	1.30	1.30
3	Tank Diameter	19,28 Ft	42,61 Ft
4	Tank Height	35,76 Ft	36,08 Ft
5	Reid Vapor Pressure (psi)	9 psi	10 psi
6	Daily Temperature Difference (°F)	13 °F	13 °F
7	Liquid Temperature (°F)	79 °F	83°F
8	True Vapor Pressure (psi)	8,5 psi	10,3 psi
9	Adjustment Factor	1	1
10	Throughput (bbl/day)	400,762	413,289
11	Turnover Factor (Kt)	0,5	0,5
12	Ullage (ft)	11,66 Ft	15,43 Ft

8. Determination of Breathing Loss, using Equation 3, then gets:
   a. Breathing Loss Tank Y:

$$Ly = \left[\frac{24}{1000} x \left(\frac{8,5}{14,7 - 8,5}\right)^{0,68} x\ 19,28^{1,73}\ x\ 11,66^{0,51}\ x\ 13^{0,50}\ x\ 1,30\ x\ 0,5\right]$$

   = 139,74 bbl/ year

   b. Breathing Loss Tank Z:

$$Ly = \left[\frac{24}{1000} x \left(\frac{10,3}{14,7 - 10,3}\right)^{0,68} x\ 42,61^{1,73}\ x\ 15,43^{0,51}\ x\ 13^{0,50}\ x\ 1,30\ x\ 0,5\right]$$

   = 226,96 bbl/year

9. Determination of Working Loss, using Equation 4, then gets:
   a. Working Loss Tank Y
      Throughput (V) = 400.762 x 365 days = 146278.13 bbl/year
      Turnover (Kt) = 35 times/year = 1 "Turnover Effect"
      True Vapor Pressure (P) = 8.5 psi

$$Working\ loss = \left[\frac{(3x\ 8,5\ psi\ x\ 146278,13\ bbl/year)}{10000}\right]$$

   = 373,00 bbl/ year

   b. Working Loss Tank Z
      Throughput (V) = 413.289 x 365 = 150850.49 bbl/year
      Turnover (Kt) = 36 times/year = 1 "Turnover Effect"
      True Vapor Pressure (P) = 8.5 psi

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$$Working\ loss = \left[\frac{(3x\ 8{,}5\ psix\ 150850{,}49\ bbl/year)}{10000}\right]$$
= 466,12 bbl/ year

10. Determination of Evaporation Loss, using equation 5, then gets:
    a. Evaporation Loss Tank Y
       Evaporation Loss = Breathing Loss + Working Loss
       = 139,740 bbl/year + 373,009 bbl/year
       = 512.75 bbl/ year
    b. Evaporation Loss Tank Z
       Evaporation Loss = Breathing Loss + Working Loss
       = 266.968 bbl/ year + 466.128 bbl/ year
       = 733.097 bbl/year

Based on the calculation results, the average evaporation loss from January 1, 2022, to January 7, 2022, Tank Y is 537,631 bbl/year and Tank Z is 723,778 bbl/year.

Table 7 Evaporation Loss Calculation Results Tank Y

Date	Ullage (ft)	Temp (oF)	Throughput (bbl/day)	Breathing Loss (bbl/year)	Working Loss (bbl/year)	Total Evaporation Loss (bbl/year)	Total Evaporation Loss (bbl/day)
1/1/22	11,66	13	400,762	139,740	373,009	512,750	1,40
2/1/22	11,10	14	400,521	152,694	390,328	543,022	1,49
3/1/22	10,37	13	400,521	142,114	390,328	532,441	1,46
4/1/22	10,89	9	400,645	145,178	429,932	575,110	1,58
5/1/22	11,67	10	400,724	122,595	372,974	495,568	1,36
6/1/22	12,01	14	400,829	155,918	376,715	532,633	1,46
7/1/22	12,40	16	400,598	176,116	395,775	571,891	1,57
Average evaporation loss in Tank Y						537,631	1,47

Table 8 Evaporation Loss Calculation Results Tank Z

Date	Ullage (ft)	Temp. (oF)	Throughput (bbl/day)	Breathing Loss (bbl/year)	Working Loss (bbl/year)	Total Evaporation Loss (bbl/year)	Total Evaporation Loss (bbl/day)
1/1/22	15,43	13	413,289	266,968	466,128	733,097	2,01
2/1/22	15,07	14	414,981	267,794	463,492	731,286	2,00
3/1/22	14,79	13	413,527	214,180	466,396	727,707	1,99
4/1/22	14,36	9	410,443	240,475	462,918	677,099	1,86
5/1/22	14,89	10	413,424	264,412	475,334	715,810	1,96
6/1/22	15,33	14	411,842	264,412	455,477	719,889	1,97
7/1/22	15,55	16	411,580	297,359	465,201	761,560	2,09
Evaporation Loss Average Tank Z						723,778	1,98

- Calculation of financial losses of Tank Y and Tank Z

If current price of crude from the Indonesian Crude Oil Price (ICP) is taken into, US$ 117.62/barrel, and US$ 1is Rp.14,893.30, then

1. Financial losses on Tank Y = Evaporation loss x current crude oil price
   = 537,631 bbl/year x US$ 117.62
   = US$ 63,236.15/year
   = Rp. 941.795.075/ year
2. Financial losses on Tank Z = Evaporation loss x current crude oil price

= evaporation loss x US$ 117.62

= 723,778 bbl/year x US$ 117.62

= US$ 85,130.76 /year

= Rp. 1.267.878.072/ year

3. Total Company Loss

The company's total losses caused by evaporation losses Tank Y and Tank Z amounted to Rp. 2,209,762,045 in a year.

DISCUSSION

The calculation of free space (ullage) in Tank Y and Tank Z is the result of research in the SA Field when the liquid level condition is at rest or not in working condition. High losses in low ullage tanks are during working loss, which is when crude oil in the tank is pumped or when it is pumped. Because when pumping crude oil or when filled, the crude oil content in the tank rises gradually or decreases gradually so that ullage cannot be regulated. The gradual change in ullage causes the crude oil in the tank to fluctuate which causes the temperature of the liquid to increase and the entry of outside air into the tank, to fill the empty space left by petroleum. This is what triggers high losses.

Based on the calculation of evaporation loss, in Tank Y with ullage tanks ranging from 11.10 ft - 12.40 ft, the avarage amount of evaporation loss is 537.631 bbl/year while in Tank Z with ullage tanks ranging from 14.36 ft - 15.55 ft, the average amount of evaporation loss is 723.778 bbl/year. It can be said that low free space (ullage) affects the value of evaporation loss in a tank. The higher the free space in the tank, the higher the evaporation potential in the tank. Losses are inevitable but controllable (Setiorini, I., &; Faputri, A., 2021).

When viewed from the calculation of financial losses caused by evaporation losses, Tank Y experienced financial losses of Rp. 941,795,075 per year and Tank Z suffered financial losses of Rp. 1,267,878,072 per year. This loss can be said to be a very large loss because the company's total losses caused by evaporation losses in both tanks, namely Tank Y and Tank Z amounted to Rp. 2,209,673,147 (two billion two hundred nine million six hundred seventythree thousand one hundred fortyseven rupiah) per year. Therefore, evaporation loss must be prevented or minimized so that the loss can be overcome. That way the company must install a Vapor Recovery Unit (VRU) which is useful for reducing evaporation loss and recovering steam loss.

CONCLUSIONS

From the results of calculations and analysis of discussions that have been carried out, the author draws several conclusions as follows:

1. There are several factors that influence the occurrence of evaporation loss:
    a. Temperature, both the temperature of the crude oil itself during storage, the temperature around the tank, as well as the average daily temperature of the tank.
    b. The higher the empty space (ullage), the greater the potential for oil evaporation in the tank.
    c. Properties/ characteristics of crude oil materials or products stored/ stockpiled, these properties are determined by Reid Vapor Pressure (RVP) and True Vapor Pressure (TVP) analysis where the higher the value of both, the greater the potential for evaporation.
    d. The color of the tank, the paint from the walls of the tank or the roof of the tank need to be considered as well. Because dark colors tend to absorb more heat, while light colors can reflect the sun's heat so that the temperature inside the tank is maintained.
2. The average evaporation loss in Tank Y from January 1 to January 7, 2022, has a value of 537.631 bbl/year, while the evaporation loss in Tank Z has a value of 723.778 bbl/year. The total annual evaporation loss is 1,261,409 bbl/year equivalent to 200,564,031 liters per year.
3. Based on the current per-barrel crude oil price of the Indonesian Crude Price (ICP) is US$ 117.62/ bbl, the total loss incurred by evaporation losses in Tank Y is US$ 85,130.76 per year equivalent to Rp. 941,795,075 per year, while evaporation losses in Tank Z are US $ 85,130.76 per year equivalent to Rp. 1,267,878,072 then the total loss of the company caused by evaporation from the two tanks is Rp. 2,209,673,147 per year.
4. To prevent such a large loss due to evaporation losses, the company must install a Vapor Recovery Unit (VRU) device that is useful for taking lost steam from the tank and will be injected back into the tank.

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