AIP Conference Proceedings

scitation.org/journal/apc

Volume 2363

3rd International Conference on Earth Science, Mineral, and Energy

Yogyakarta, Indonesia • 25 November 2020

Editors • Tedy Agung Cahyadi, Madi Abdullah N, Ma Liqiang, Chih Hua Chang, Ismail Mohd Saaid, Mochammad Tanzil Multazam and Robbi Rahim

ICEMINE

INTERNATIONAL CONFERENCE ON EARTH SCIENCE, MINERAL AND ENERGY

AIP Publishing

Table of Contents

3RD INTERNATIONAL CONFERENCE ON EARTH SCIENCE, MINERAL, AND ENERGY

Conference Date: 25 November 2020
Location: Yogyakarta, Indonesia
ISBN: 978-0-7354-4154-5
Editors:
Tedy Agung Cahyadi, Madi Abdullah N, Ma Liqiang, Chih Hua Chang, Ismail Mohd Saaid, Mochammad Tanzil Multazam and Robbi Rahim
Volume Number: 2363
Published: Nov 23, 2021

PETROLEUM AND GEOTHERMAL ENGINEERING

Economic analysis of oil losses correction factor determination usage proportional and stratified methods in "LA" field

Cite as: AIP Conference Proceedings **2363**, 020003 (2021); https://doi.org/10.1063/5.0069566
Published Online: 23 November 2021

Luqman Arif, Dedy Kristanto and Dyah Rini Ratnaningsih

Economic Analysis of Oil Losses Correction Factor Determination Usage Proportional and Stratified Methods in "LA" Field

Luqman Arif [1)], Dedy Kristanto[2)] and Dyah Rini Ratnaningsih[3)]

[1]*PT. Pertamina EP Asset 4, Indonesia*
[2,3]*Petroleum Engineering Department, Universitas Pembangunan Nasional "Veteran" Yogyakarta,Indonesia*

[1]Corresponding author: luqmana19@yahoo.com

Abstract. The "LA" field carries out crude oil shipments simultaneously with several Business Partners using a shared pipeline through the Pipeline Handling and Transportation System. Due to the utilization of these shared pipes, the oil losses problems arise from the delivery point to the point of production storage as a sales point in Floating Storage Offloading (FSO). Based on these problems, the volume of correction factors of oil losses has been determined by proportional and stratified methods will affect on the volume of oil received at the FSO, hence also affecting of the company's revenue. This study aims to obtain an optimal correction factor method for companies based on the value of the economic parameter in the form of Pay Out Time (POT), Profit to Investment Ratio (PIR), Rate of Return (ROR/IRR), and Net Present Value (NPV) on the operational activities of the oil field. The evaluation results of oil losses are the range of individual total losses proportionally when all oil is producing according to typical production on the same day at the BS&W of each oil 0.00% is 0.148% - 0.739% and the stratified method is 0.076% - 0.739%. In comparison, the economic parameters with the sensitivity of the production parameters generated NPV value with the stratified method are 0.09% greater than the proportional method. Furthermore, the other economic parameters namely POT, IRR, and PIR are not too significant to the difference in value from the calculations with the two methods. Based on the study of economic parameters results, it is concluded that the determination of oil losses using the stratified method is more accurate and represents operational conditions in the 'LA" field and is more profitable for the company.

Keywords: Oil Losses, Proportional Method, Stratified Method, Economic Parameters

INTRODUCTION

The oil and gas fields generally produce petroleum fluid that can be classified into five categories: dry gas, wet gas, gas condensate, volatile oil, and black oil[1][2]. Since the fluids with those categories have different characteristics, the properties would thus change when they are mixed together. On the other hand, in an activity of pumping of petroleum (crude oil) from shippers in the oil field to the gathering station, shippers often use the same pipeline to transport the crude oil to a storage tank. The crude oils from shippers are mixed together either in the same temporary or final storage tank. This situation comes up the problem of oil losses; there is a different volume between shipper as a sending point and gathering station as a receiving point. The study of sharing oil losses is therefore very important to be done.

This difference in the amount of sending and receiving is called oil losses. The amount received at the final storage terminal is lower than the total amount delivered from several delivery points. Oil losses can be caused by several factors, namely emulsion, evaporation (flash), shrinkage, leakage, theft, and measurement losses, etc[3]. Several studies[4][5][6] have discussed about prediction of crude oil shrinkage losses. This study focuses on economic analysis based on the economical parameters of determination the oil loss correction factor using proportional and stratified methods due to mixing. The oil distribution of seven shippers in "LA" field would be taken as a case study.

3rd International Conference on Earth Science, Mineral, and Energy
AIP Conf. Proc. 2363, 020003-1–020003-11; https://doi.org/10.1063/5.0069566
Published by AIP Publishing. 978-0-7354-4154-5/$30.00

LITERATURE REVIEW

Oil Losses

Individual disadvantages include emulsion and evaporation losses. In 1981, Bradley[7]. Studied the costs of crude oil in storage tanks and soil; they generally classify losses that occur from evaporation and the presence of sediment and water. This work aims to calculate the emulsion correction factor (ECF) and the evaporation correction factor (FCF) occurring individually at 7 (seven) shippers in the "LA" field. The emulsion empirical equation will be used to calculate the ECF. Meanwhile, the calculation of evaporation using the Antoine equation was chosen to calculate FCF.

The phenomenon of mixing oil at a collection station is illustrated in **Figure 1**. In the activity of transporting crude oil from a shipper in the oil field to the collection station, the shipper often uses the same pipe to transport crude oil to the storage tank. Crude oil from the shipper is mixed together in a temporary or permanent storage tank. This situation raises the problem of oil losses.

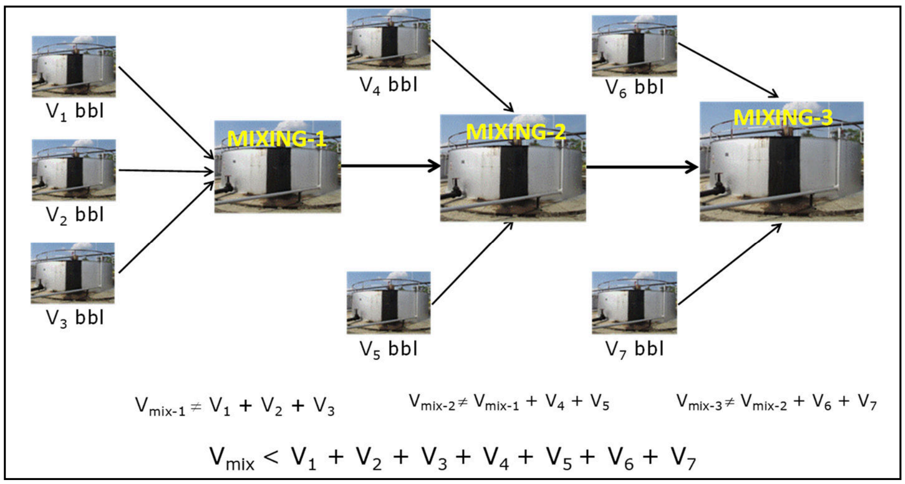

FIGURE 1. Oil Mixing Phenomenon at a gathering station[7]

Several studies in 1994, Erno et al[5]. Predicted the shrinkage equation of heavy oil/condensate mixture and stated that when condensate was added to heavy oil, the volume of the mixture was smaller than the sum of the volume of condensate and oil. In the most recent 2014, James[6] studied the losses caused by mixing liquid hydrocarbons. This work aims to calculate the shrinkage correction factor (SCF) in the oil blending phenomenon and to determine joint oil losses using the newly proposed proportional and stratification methods. The modified API 12.3 equation will be used to calculate the SCF in each mixing phenomenon in the tank.

The calculation of oil losses due to the emulsion event requires input data on the BS&W value (% vol) of each shipper. Hence, the calculation is individually from each shipper (not a mixture). Parameters a and b for emulsion calculations were obtained from observations and emulsion simulations in the laboratory. After obtaining the net oil flow rate for each shipper (Fneti), the net rate is used to calculate losses due to evaporation and depreciation events. The evaporation loss is calculated by the evaporation count method. The evaporation losses depend on the operating conditions, namely pressure (P) and temperature (T). Evaporation is indicated by the vapour fraction value nv[8]. The vapour fraction nv ranges from 0 to 1. nv = 0 and nv = 1 means that the fluid is in the liquid and gas phases if nv is between 0 and 1 (0 <nv <1), the fluid is in the liquid-mixed vapour phase; in other words, part of the light component in the fluid evaporates; this causes oil loss due to the flash phenomenon. The input data required for the flash calculation are the hydrocarbon composition (zj), pressure (Pi) and temperature (Ti) of each sending system. The intended pressure (Pi) is the fluid pressure in the storage tank, which is atmospheric pressure. The calculation of the bubble (Tb) and dew point (Td) at atmospheric pressure. Bubble and dew point are saturated conditions respectively at nv = 0 and nv = 1. The Antoine equation used in this calculation is:

$$P_{vap\ j} = \exp\left(a_j + \frac{b_j}{(T+c_j)} + d_j \ln(T) + e_j T^{f_j}\right) \tag{1}$$

Where $P_{vap\ j}$ is the vapour pressure of component j (in kPa), T is the system temperature (in K), and aj, bj, cj, dj, ej, fj are the Antoine parameters for each component j.

After calculating Tb and Td, we calculate the vapour fraction nv. Temperature T and pressure P of fluid (system) are input data in calculating nv. The evaporation correction factor (FCF) is then calculated as follows:

$$\mathrm{FCF} = n_v \text{ x } 100\% \tag{2}$$

Where is the FCF in % Volume.

Proportional Method

The proportional method is a standard method used in the petroleum industry to share oil losses. In this method, the total volume received is measured at the last station. This measured volume is the net-corrected-volume (Vnc) taken directly from the last storage tank at the last station (TANK-3 / FSO). The total shrinkage volume (Vsh-prop) is the volume difference between the total volume sent of all senders anD the corrected net volume:

$$V_{sh-\mathrm{prop}} = \sum_{i=1}^{n} V_i - V_{nc\ (\mathrm{TANK-3})} \tag{3}$$

Where Vi is the net volume corrected i shipper, and Vnc (TANK-3 / FSO) is the net corrected volume in TANK-3 / FSO. The proportional depreciation volume for each sender ($\xi\ \mathrm{prop}_i$) can be calculated as follows:

$$\xi_{\mathrm{prop}_i} = \frac{x_i\left(1/_{SG_i}\right)}{\sum_{i=1}^{n} x_i\left(1/_{SG_i}\right)} V_{sh-\mathrm{prop}} \tag{4}$$

where xi is the fraction of the volume of sender i as defined below:

$$x_i = \frac{V_i}{\sum_{i=1}^{n} V_i} \tag{5}$$

The proportional depreciation correction factor (SCF proi in% Vol) for each sender can then be calculated as follows:

$$\mathrm{SCF}_{\mathrm{prop}_i} = \frac{\xi_{prop_i}}{V_i} \text{ x } 100\% \tag{6}$$

Stratified Method

In the newly proposed stratification method, the corrected net volume is calculated incrementally from tank to tank. The shrinkage volume is calculated for each mixing phenomenon in TANK-1 / T-210A / B, TANK-2 / T-8001A / B, and TANK-3 / FSO. The following equation can calculate the depreciation volume for S-4 and S-5 shippers in TANK-1:

$$\xi_{\mathrm{st-I}_i} = \frac{x_i\left(1/_{SG_i}\right)}{\sum_{i=1}^{n} x_i\left(1/_{SG_i}\right)} V_{shg-\mathrm{I}} \tag{7}$$

where $\xi\ \mathrm{st\text{-}I}_i$ is the shrinkage volume for sender i (S-4, S-5) at TANK-1, and Vshg-I is the shrinkage volume for the group in TANK-1. The following equation can calculate the volume of shrinkage for S-3, S-6, S-7 and TANK-1 (S-4, S-5 mixture) shippers in TANK-2:

$$\xi_{\mathrm{st-II}_i} = \frac{x_i\left(1/_{SG_i}\right)}{\sum_{i=1}^{n} x_i\left(1/_{SG_i}\right)} V_{shg-\mathrm{II}} \tag{8}$$

Where ξ st-II$_i$ is the volume of shrinkage for sender i (S-3, S-6, S-7) and mixtures (S-4, S-5) in TANK-2, and Vshg-II is the depreciation volume of the group at TANK-2. Finally, the volume of shrinkage for S-1, S-2, and TANK-2 shippers (mix S-3, S-4, S-5, S-6, S-7) in TANK-3 can be calculated as follows:

$$\xi_{\mathrm{st-III}_i} = \frac{x_i\left({}^{1}/_{SG_i}\right)}{\sum_{i=1}^{n} x_i\left({}^{1}/_{SG_i}\right)} V_{shg-\mathrm{III}} \tag{9}$$

Where ξst-III$_i$ is the volume of shrinkage for sender i (S-1, S-2, and mixtures of S-3, S-4, S-5, S-6, S-7) in TANK -3, and Vshg-III is the group shrinkage volume in TANK-3. Total depreciation volume incremented ξst-tot$_i$ for S-4 senders, and S-5 is the sum of the shrinkage volumes at TANK-1, TANK-2, and TANK-3, for S-3, S- senders 6, S-7 is the one in TANK-2 and TANK-3; whereas for the sender of S-1 and S-2 only once in the last tank of TANK-3.

$$\xi_{\mathrm{st-tot}_i} = \xi_{\mathrm{st-I}_i} + \xi_{\mathrm{st-II}_i} + \xi_{\mathrm{st-III}_i} \tag{10}$$

where for S-3, S-6 and S-7 ξst-I$_i$ = 0, and for S-1 and S-2 ξst-I$_i$ = ξst-III = 0.

The graded depreciation correction factor (SCF_ (st_i) in% Vol) for each sender can then be calculated as follows:

$$\mathrm{SCF}_{\mathrm{st}_i} = \frac{\xi_{\mathrm{st-tot}_i}}{V_i} \text{ x } 100\% \tag{11}$$

Economic Indicators

The field provides economic value or not; it is necessary to do an economic analysis. In this study, an economic analysis was carried out using standard economic assessments in the petroleum industry by calculating the following parameters: Pay Out Time (POT), Net Present Value NPV), Profit to Investment Ratio (PIR), and Rate of Return (ROR). The equations to calculate of economic indicators is shown in **TABLE 1**.

TABLE 1. Economic Indicator Calculation

No.	Parameter	Formula
1	Pay Out Time (POT)	POT = Cn – Inv = 0
2	Net present value (NPV)	$\mathrm{NPV} = \sum_{t=1}^{n} C_0 + \frac{C_n}{(1+r)^n}$
3	Profit to investment ratio (PIR)	$\mathrm{PIR} = \frac{\text{Total Undiscounted Net Cashflow}}{\text{Investasi}}$
4	Internal Rate of Return (IRR)	$\sum_{t=0}^{t} \frac{(R_t - C_t}{(1+\mathrm{ROR})} = 0$

METHODOLOGY

The sharing oil loss calculation algorithm is shown in **FIGURE 2**. For calculating the total share oil loss, the individual losses such as emulsion and flash loss must first be calculated, and then the group losses in the mixing phenomenon are determined. The joint oil loss will be determined using two methods, namely the proportional method and the stratified method.

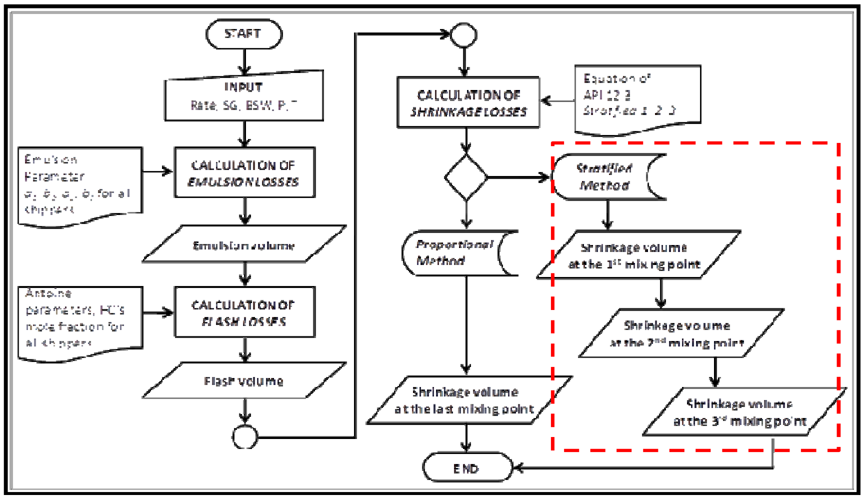

FIGURE 2. Sharing oil losses calculation algorithm

The scheme of oil/condensate distribution from CPA (Central Processing Area) to FSO (Floating Storage and Offloading) is shown in **FIGURE 3**. The stratification of the oil/condensate mixture can also be seen in **Figure 2**. Field Oil A and mixed condensate (LA and A) experienced 1 (one) mixing at the FSO. Oil Field LA, D, and Field E condensate experienced 2 (two) times of mixing, namely in T-8001A / B and FSO tanks. Meanwhile, Field Oil B and C mix experienced 3 (three) times of mixing, namely at T-210A / B, T-8001A / B, and FSO.

For calculate the integration of sharing losses based on emulsion, evaporation and shrinkage, it is necessary to input the sending data. The shipper's officer (operator) will input the shipment data, namely date, hour, gross rate, water cut (%), system pressure and temperature, BS&W, and SG. If the input is made several times (maximum 3 times), the value of the shipment data will be recapitulated so that 1 (one) shipment value appears in one day. An example of a shipment input is shown in **TABLE 1**.

Input data for economic analysis from the loss's correction factor are the volume of shipments, operational costs, oil prices and investment value. The changing parameters that will be used in calculating the sensitivity are data of shipment volume and oil price, while data on operational and investment costs are considered constant.

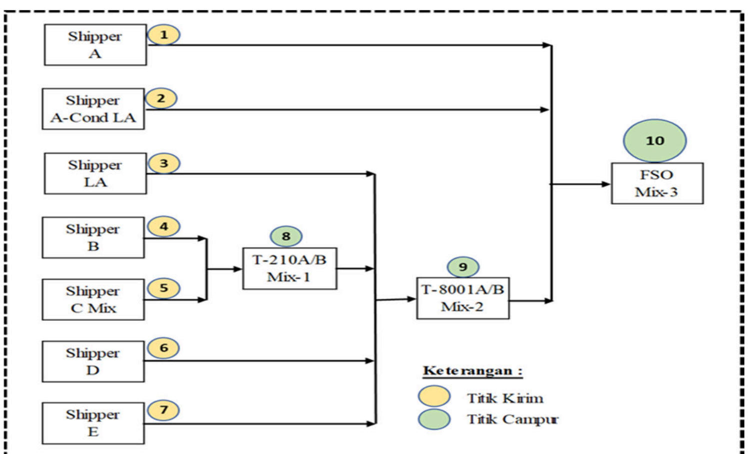

FIGURE 3. Distribution and Blending Diagram of Oil in the “LA” Field (PT Pertamina EP, 2019)

TABLE 2. Shipment Input Data (Pumping)

Date: 1 Jan 2019							
Shipper	**Jam**	**Gross**	**Water Cut**	**Press.**	**Temp.**	**BS&W**	**SG**
		(bbls)	**(%)**	**(psi)**	**(degC)**	**(%)**	
A	07:00	940	0	14.7	30	0	0.8438

Date: 1 Jan 2019							
Shipper	**Jam**	**Gross**	**Water Cut**	**Press.**	**Temp.**	**BS&W**	**SG**
		(bbls)	**(%)**	**(psi)**	**(degC)**	**(%)**	
Condensate Mix	07:00	150	0	14.7	30	0	0.7418
LA	07:00	9,000	0	14.7	30	0	0.8273
B	07:00	1,000	0	14.7	30	0	0.8427
C Mix	07:00	700	0	14.7	30	0	0.8715
D	07:00	300	0	14.7	30	0	0.8655
E	07:00	6	0	14.7	30	0	0.7369

RESULTS AND DISCUSSION

Oil Losses Due to Emulsion

Testing and calculation of mixing oil with formulated water in the laboratory illustrate that most of the oil when BSW = 0.00% do not experience losses because the emulsion is stable, water in oil. Shipper B and Shipper D oil had experienced losses due to water-in-oil emulsion when BSW = 0.00% with correction factors of 0.9991 and 0.9941, respectively. The mixture of Mixed-1, Mixed-2 and Mixed-3 oil also experienced losses due to a stable emulsion of water in oil when BSW = 0.00%, and the correction factors were 0.9994 for Mixed-1, 0.9996 for Mixed-2 and 0.9996 for Mixed-3 respectively. The value of water-in-oil stable emulsion with a BSW value is greater than 0.00 %, so that the volume of oil experiencing a correction factor can be calculated using the linear equation for each oil. Results of relationship between BS&W and emulsion Correction Factor is shown in **FIGURE 4**, and relationship between Vapor Pressure and Bubble Temperature is shown in **FIGURE 5**, respectively. Therefore, the result of emulsion correction factor parameters from laboratory is shown in **TABLE 2**.

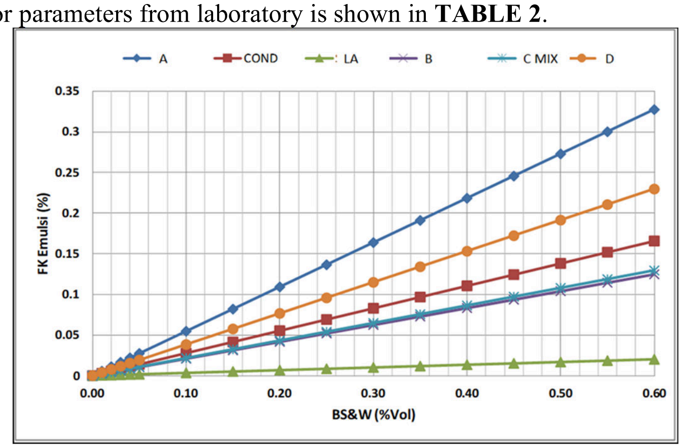

FIGURE 4. Relationship between BS&W and Emulsion Correction Factor

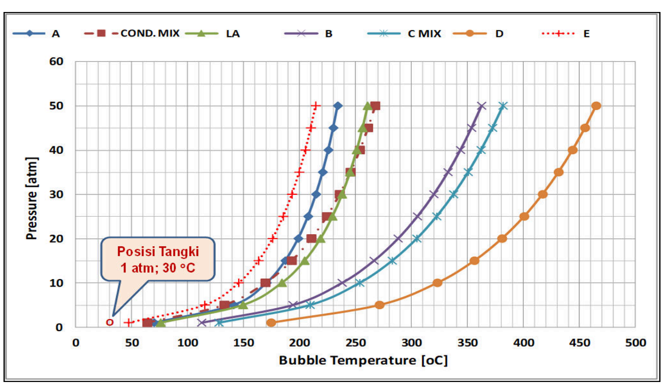

FIGURE-5. Relationship between Vapor Pressure and Bubble Temperature

TABLE 3. Emulsion Correction Parameters

No	SHIPPER	$Y_1 = a_1 X_1 + b_1$		$Y_2 = a_2 X_2 + b_2$	
		a_1	b_1	a_2	b_2
1	A	0.001748	0.8438	0.003845	0.8438
2	Condensat Mix	0.002788	0.7418	0.003851	0.7418
3	LA	0.001933	0.8273	0.002000	0.8273
4	B	0.001784	0.8427	0.002252	0.8427
5	C Mix	0.001492	0.8714	0.001902	0.8714
6	D	0.001784	0.8650	0.002889	0.8650
7	E	0.002757	0.7369		

Oil Losses Due to Evaporation

Under conditions of atmospheric pressure (about 1 atm), evaporation can occur if the fluid temperature is lower than the bubble point. The standard bubble point (Tb) and dew point (Td) resulting from the flash calculation are listed in **TABLE 4**. S7 oil is a typical condensate; it has the shortest span between Tb and Td. The correlation of vapour pressure and bubble point for all shippers is shown in **FIGURE 5**. Since the oil temperature in all tanks is lower than the bubble point (**FIGURE 5**), it is understandable that all shippers experience no loss of evaporation. The evaporation correction factor (FCF) of all senders is zero. During operation at the oil collection station, it is maintaining the oil temperature lower than the bubble point eliminates evaporation losses from the storage tank (Bhatia and Dinwoodie, 2004)**[3]**.

TABLE 4. Normal Bubble and Dew Points of Crude Oils

SHIPPER	T_{bubble} (DegC)	T_{dew} (DegC)
A	69.96	346.22
Condensate Mix	63.84	251.41
LA	75.71	325.19
B	112.36	313.55
C Mix	127.77	314.21
D	174.44	361.65
E	47.14	189.37

Oil Losses Due to Shrinkage

Based on the results of mixing testing of several compositions in the laboratory, the depreciation percentage of the Mixed-1 group was 0.0-0.06%, the Mixed-2 group was 0.04-0.10%, and the Mixed-3 group was 0.05-0.18%. Reformulation of equation API 12.3 against depreciation value for laboratories in "LA" Field area. for the Mixed-1 group, the value of a = 4.86 x 10-7, the value of b = 0.819 and the value of c = 2.58, for the Mixed-2 group obtained a value of a = 4.86 x 10-5, the value of b = 0.819 and the value of c = 0.14 and for The Mixed-3 group obtained a value of a = 4.86 x 10-5, a value of b = 1.089 and a value of c = 0.58 Total Losses due to mixing is 0.16% or 18.84 BOPD, as shown in **TABLE 5**.

TABLE 5. Individual Losses

SHIPPER	KIRIMAN DARI SHIPER			EMULSI		FLASH		SHRINKAGE		TOTAL	
	Volume (bbl)	SG	BS&W (%)	Volume (bbl)	% Em	Volume (bbl)	Vapor Fraction	Volume (bbl)	% Sh	Volume (bbl)	NSV
A	940.00	0.8438	0.00	0.00	0.00	0.00	0.00	1.44	0.15	1.44	938.56
Condensat Mix	150.00	0.7418	0.00	0.00	0.00	0.00	0.00	0.26	0.17	0.26	149.74
LA	9,000.00	0.8273	0.00	0.00	0.00	0.00	0.00	14.03	0.16	14.03	8,985.97
B	1,000.00	0.8427	0.00	0.00	0.00	0.00	0.00	1.53	0.15	1.53	998.47
C Mix	700.00	0.8715	0.00	0.00	0.00	0.00	0.00	1.04	0.15	1.04	698.96
D	300.00	0.8655	0.00	0.00	0.00	0.00	0.00	0.45	0.15	0.45	299.55
E	60.00	0.7369	0.00	0.00	0.00	0.00	0.00	0.10	0.17	0.10	59.90
TOTAL	**12,150.00**			**0.00**		**0.00**		**18.84**		**18.84**	**12,131.16**
								Volume terkoreksi (barrel)		**12,131.16**	
								Total Losses (barrel)		**18.84**	

Propositional Method of Oil Losses

The results of sharing oil losses from CPA to FSO using the Proportional method are shown in **TABLE 4**. This simulation also uses BS&W for all shippers to be the same as the results of laboratory observations (not equal to zero), resulting in losses due to emulsion. With a total flow rate of 7 (seven) shippers of 12,150 BOPD, resulting in total oil losses of 19.79 BOPD. 7 (seven) shippers bore the 19.79 BOPD oil loss with a percentage of sharing losses of around 0.16% - 0.18%, as shown in **TABLE 6**.

TABLE 6. Results of Sharing Proportional Losses

SHIPPER	KIRIMAN DARI SHIPER			EMULSI		FLASH		SHRINKAGE	
	Volume (bbl)	SG	BS&W (%)	Volume (bbl)	% Em	Volume (bbl)	Vapor Fraction	Volume (bbl)	% Sh
A	940.00	0.8438	0.000	0.00	0.00	0.00	0.00	1.44	0.15
Condensat Mix	150.00	0.7418	0.025	0.01	0.01	0.00	0.00	0.26	0.17
LA	9000.00	0.8273	0.000	0.00	0.00	0.00	0.00	14.03	0.16
B	1000.00	0.8427	0.050	0.10	0.01	0.00	0.00	1.53	0.15
C Mix	700.00	0.8715	0.100	0.15	0.02	0.00	0.00	1.04	0.15
D	300.00	0.8655	0.600	0.69	0.23	0.00	0.00	0.45	0.15
E	60.00	0.7369	0.000	0.00	0.00	0.00	0.00	0.10	0.17
TOTAL	**12,150.00**			**0.95**		**0.00**		**18.85**	

Volume terkoreksi (barrel)	**12,130.21**	
Total Losses (barrel)	**19.79**	

Stratified Method of Oil Losses

Oil from 2 (two) shippers, namely B and C-mix, experienced 3 (three) mixing events, namely mixing in the T-210A / B, T-8001A / B and FSO tanks. Therefore, if the Stratified method is applied, the shrinkage losses for the 2 (two) shippers will be 3 (three) times, namely shrinkage losses in the T-210A / B, T-8001A / B and FSO tanks. Oil from shippers LA, D and E experienced 2 (two) times of mixing, namely in the 8001A / B and FSO tanks, so that 2 (two) shippers were subjected to shrinkage losses 2 (two) times. Meanwhile, shipper A, A-Condensate LA experienced one mixing, namely at the FSO, so that the shrinkage loss calculation is only one time. While the simulation results using the Stratified and BS&W methods for all shippers are the same as the laboratory analysis results shown in **TABLE 7**. With a total flow rate of 7 (seven) shippers of 12,151 BOPD, resulting in total oil losses of 19.79 BOPD where the loss is borne by 7 (seven) shippers with a percentage of sharing losses around 0.08% - 0.38%, as shown in **TABLE 7**. The percentage of share losses shipper-D rose to 0.38% due to high BS&W (0.6%).

TABLE 7. Results of Sharing Stratified Losses

SHIPPER	KIRIMAN DARI SHIPER			Losses Individu		Mixed-1 (T-210A/B)				Mixed-2 (T-8001A/B)				Mixed-3 (FSO)				TOTAL	
	Volume (bbl)	SG	BS&W (%)	Emulsi (bbl)	Flash (bbl)	Sh. Vol. (bbl)	% Sh	Volume terkoreksi (bbl)	SG	Sh. Vol. (bbl)	% Sh	Volume terkoreksi (bbl)	SG	Sh. Vol. (bbl)	% Sh	Volume terkoreksi (bbl)	SG	Volume Losses (bbl)	% Loss
A	940.00	0.8438	0.000	0.00	0.00									0.72	0.08	939.28	0.8320	0.72	0.08
Condensat Mix	150.00	0.7418	0.025	0.01	0.00									0.13	0.09	149.86	0.8320	0.14	0.09
LA	9,000.00	0.8273	0.000	0.00	0.00					7.04	0.08	8992.96	0.8320	6.95	0.08	8986.01	0.8320	13.99	0.16
B	1,000.00	0.8427	0.050	0.10	0.00	0.51	0.05	999.39	0.8546	0.76	0.08	998.63	0.8320	0.77	0.08	997.86	0.8320	2.14	0.21
C Mix	700.00	0.8715	0.100	0.15	0.00	0.34	0.05	699.51	0.8546	0.53	0.08	698.98	0.8320	0.54	0.08	698.44	0.8320	1.56	0.22
D	300.00	0.8655	0.600	0.69	0.00					0.22	0.07	299.09	0.8320	0.23	0.08	299.86	0.8320	1.14	0.38
E	60.00	0.7369	0.000	0.00	0.00					0.05	0.09	59.95	0.8320	0.05	0.08	59.9	0.8320	0.10	0.17
Subtotal (bbl)						**0.85**		**1698.90**		**8.60**		**11049.61**		**9.39**					
TOTAL	**12150.00**															**12131.21**		**19.79**	

NSV: Net Standard Volume [barrel]; SCF: Shrinkage Correction Factor [%Vol]; SG: Specific Gravity

Comparison of Proportional and Stratified Methods

The comparison of the results of sharing losses using the Proportional and Stratified methods is shown in **TABLE 7** and **TABLE 8**. When compared between the Proportional and Stratified methods, the total oil losses that occur for both methods are the same, which is 18.84 BOPD (for BS & W = 0) and 19.97 BOPD (for BS&W = laboratory observations). However, the percentage of total sharing losses for 2 (two) shippers, namely Shipper B and Cmix, is higher than other shippers. This happens because the oil from the 2 (two) shippers has been mixed 3 (three) times so that the depreciation event also occurs 3 (three) times. Specifically, for the "LA" field, there is a difference in total losses between the proportional and stratified methods, namely 14.03 BOPD for proportional and 13.99 BOPD for stratified ((for BS & W = 0). Whereas for BS&W = laboratory observation results are 14.73 BOPD for proportional and 13.99 BOPD for stratified.

TABLE 8. Comparison of Proportional and Stratified BS&W Sharing Losses for All Shippers = 0

SHIPPER	KIRIMAN DARI SHIPER			Mixing Quantity	Proportional		Stratified	
	Volume (bbl)	SG	BS&W (%)		(bbl)	% Loss	(bbl)	% Loss
A	940.00	0.8438	0.00	1	1.44	0.15	0.72	0.08
Condensa	150.00	0.7418	0.00	1	0.26	0.17	0.13	0.09
LA	9,000.00	0.8273	0.00	2	14.03	0.16	13.99	0.16
B	1,000.00	0.8427	0.00	3	1.53	0.15	2.04	0.20
C Mix	700.00	0.8715	0.00	3	1.04	0.15	1.41	0.20
D	300.00	0.8655	0.00	2	0.45	0.15	0.46	0.15
E	60.00	0.7369	0.00	2	0.10	0.17	0.10	0.17
TOTAL	**12,150.00**				**18.85**		**18.85**	

NSV: Net Standard Volume [barrel]; SCF: Shrinkage Correction Factor [%Vol]; SG: Specific Gravity

TABLE 9. Comparison of Proportional and Stratified BS&W Sharing Losses for All Shippers not = 0

SHIPPER	KIRIMAN DARI SHIPER			Mixing Quantity	Proportional		Stratified	
	Volume (bbl)	SG	BS&W (%)		(bbl)	% Loss	(bbl)	% Loss
A	940.00	0.8438	0.00	1	1.51	0.16	0.72	0.08
Condensa	150.00	0.7418	0.03	1	0.27	0.18	0.14	0.09
LA	9,000.00	0.8273	0.00	2	14.73	0.16	13.99	0.16
B	1,000.00	0.8427	0.05	3	1.61	0.16	2.14	0.21
C Mix	700.00	0.8715	0.10	3	1.09	0.16	1.56	0.22
D	300.00	0.8655	0.60	2	0.47	0.16	1.14	0.38
E	60.00	0.7369	0.00	2	0.11	0.18	0.10	0.17
TOTAL	**12,150.00**				**19.79**		**19.79**	

Economic Indicators

For the determination of economic indicators, the production input data with oil losses factor correction is shown in **TABLE 10**, and **TABLE 11** is an economic parameter input data, respectively. From the existing economic indicators, namely NPV, POT, PIR and IRR, not all of them are significantly influenced by the variable sensitivity of production, investment, Opex, and oil price (ICP). The prices of NPV, IRR, and PIR are significantly affected by changes in the value of Production and ICP, while the investment and opex variables are not significantly affected by the prices of these three economic indicators. The price of POT is significantly affected by changes in investment value, while other variables, namely production, ICP and Opex are not significantly affected by the price of this economic indicator as shown in **FIGURE 6**.

Furthermore, the comparison between the proportional and stratified methods when viewed from the economic parameters, namely NPV, POT, PIR and IRR, it can be seen that the NPV value in the stratified method is more significant than 32.91 (US $ .000) compared to the proportional method. Meanwhile, other economic parameters, namely POT, PIR and IRR, have the same value between the proportional and stratified methods, as shown in **TABLE 12** and **TABLE 13**, respectively.

TABLE 10. Production Input Data with Oil Losses Correction Factor

No	Variable	Years		Proportional	Stratified
1	Production Rate	2018	bbls	2,947,940	2,950,066
			Mbbls	2,948	2,950
2	Production Rate	2019	bbls	3,270,985	3,273,343
			Mbbls	3,271	3,273

TABLE 11. Economic Parameters Input Data

No	Description		Value	Unit
1	Oil price	=	40	US$
2	Investment	=	40,000,000	US$
3	Opex	=	8.5	US$/BBL
4	DF	=	10%	
5	Qoi	=	8,219	BOPD
6	First year Oil prod	=	3,000	MBBLS
7	Di	=	30	%
8	Cont Split	=	30	%
9	Tax	=	40	%
10	FTP	=	10	%

TABLE 12. Propositional and Stratified Economic Sensitivity 2018

PARAMETER	PROPOTIONAL METHODE	STRATIFIED METHODE	DELTA
PROD MBBLS	2,947.94	2,950.07	2.13
NPV (US$.000)	35,460.75	35,493.66	32.91
IRR (%)	59.85%	59.89%	0.00
POT (Years)	0.81	0.81	0.00
PIR	1.89	1.89	0.00

TABLE 13. Propositional and Stratified Economic Sensitivity 2019

PARAMETER	PROPOTIONAL METHODE	STRATIFIED METHODE	DELTA
PROD MBBLS	3,270.98	3,273.34	2.36
NPV (US$.000)	40,462.41	40,498.92	36.52
IRR (%)	65.79%	65.84%	0.00
POT (Years)	0.78	0.78	0.00
PIR	2.01	2.01	0.00

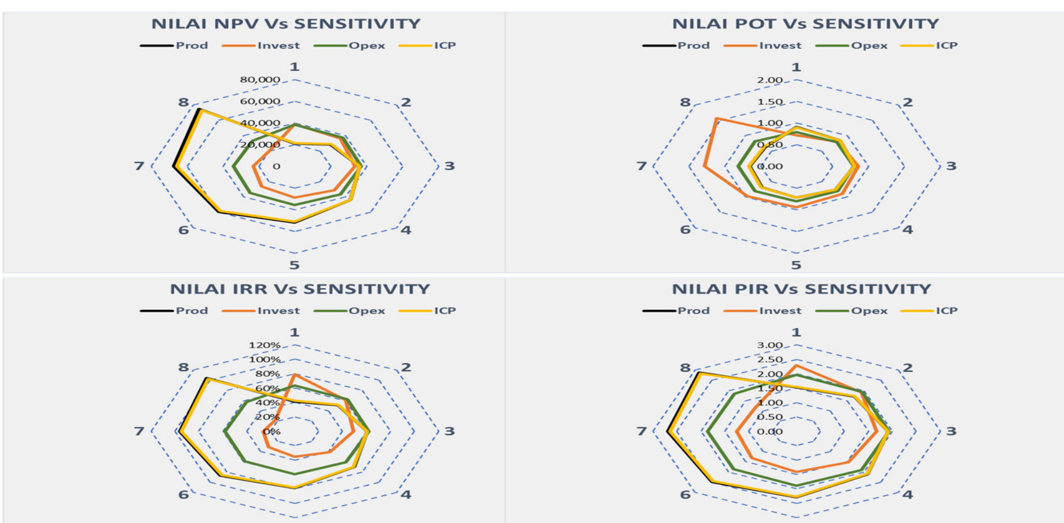

FIGURE 6. Sensitivity Results of Economic Indicators

CONCLUSION

1. Study of oil loss due to emulsion, evaporation and mixing phenomena in "LA" field has been carried out. Oil losses are classified into two types, namely individual losses, including emulsion and evaporation losses, and group losses that occur in the mixing phenomenon. Individual losses must be determined to obtain a net standard volume (NSV). NSV excluding sediment, water (and free water), and gases were then used to calculate group losses.
2. Range of individual total losses using the proportional method when all oil is producing according to typical production on the same day, and 0.00% BS&W of oil is 0.148% - 0.739% respectively. The range of individual total losses using the Stratified method when all oil is producing according to typical production on the same day, and 0.00% BS&W of each oil is 0.076% - 0.739%.
3. Comparison of the results of Sharing Losses in the "LA" field using the Proportional and Stratified methods is 14.73 BOPD or 0.16% for the Propositional method and 13.99 BOPD or 0.16% for the Stratified method.
4. Economically, it is found that the calculation of oil losses using the stratified method is more economical than the Propositional method. Namely, the Stratified method has an NPV value of 32.91 (the US $ .000) more significant than the Propositional method.
5. Companies based on the study and analysis are recommended in the "LA" field in implementing the oil transportation operational calculations using the oil loss correction factor using the Stratified method.

AKNOWLEDGEMENTS

The Authors would like to thanks to PT Pertamina EP Asset 4 for the facility and permission to publish the paper, and also to Petroleum Engineering Department UPN "Veteran" Yogyakarta for the support.

REFERENCES

[1] Whitson CH, Brule MR (2000), Volumetric and Phase Behavior of Oil dan Gas Systems, in Phase Behavior, Henry L. Doherty Memorial Fund of AIME, Society of Petroleum Engineers Inc. Richardson, Texas, pp. 1-13.

[2] McCain WD Jr. (1990.a), Component of Naturally Occurring Petroleum Fluids, in The Properties of Petroleum Fluids, Pennwell Books, PennWell Publishing Company, 2nd ed., Tulsa, Oklahama, pp. 1-45.

[3] Bhatia R and Dinwoodie J (2004), Daily oil losses in shipping crude oil: measuring crude oil loss rates in daily https://nfogm.no/wp-content/uploads/2014/04/Shrinkage-Loses-Resulting-from-Liquid-Hydrocarbon-Blending-by-James.pdf, April, 2014 [Accessed April 18, 2018].

[4] Nengkoda A (2018), The Role of Crude Oil Shrinkage in Heavy Mix Light Crude in Main Oil Pipeline: Case Study Oman", *SPE* 148925, December 2011, pp. 1-6, Internet: http://www.nioclibrary.ir/Reports/8898.pdf [Accessed April 18, 2018].

[5] Erno BP, Chriest J, Given R (1994), Equation Predicts Shrinkage of Heavy Oil/Condensate Blend, *Oil & Gas Journal*, May 12, 1994, Internet: https://www.ogj.com/articles/print/volume-92/issue-49/in-this-issue/production/equation-predicts-shrinkage-of-heavy-oil-condensate-blend.html [Accessed April 18, 2018].

[6] James H (2014), Shrinkage Loses Resulting from Liquid Hydrocarbon Blending, iMEC Cooperation, Internet:

[7] Bradley OU, Muskogee EM, Okla (1918), Losses of Crude Oil in Steel and Earthen Storage, Colorado Meeting, pp. 624-628.

[8] Tarek Ahmed, Ph.D., PE., 2007, *Equations of State and PVT Analysis: Applications for Improved Reservoir Modeling*, Gulf Publishing Company, Houston, Texas