

# Main Engine Fuel Oil Consumption by Using Flow Meter on Tug Boat

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**Abstract**— Fuel oil is one of natural resources owned by land where the stock is very limited so caused many companies was trying to efficiency the use. Vessel requires fuel oil enough to move a main engine properly. Today with stores of fuel oil prices depleting and the fuel price increases make a company used a flow meter to control the fuel consumption so can be checked the real fuel oil used on ships while operating. Expected after using flow meter discharging fuel controllable and can be reduced to be more efficient in use. Issues discussed is the number of fuel consumption in real used when a vessel is in operation, the way which the control of fuel better used manually or used by flow meters , and finally we got the outcome of the comparison of fuel consumption manually and when using used a flow meter. Methodology research conducted is the descriptive method and quantitative analysis of data processing literature and from the vessel operation data. The result is after using the flow meter there is efficiency of fuel oil consumption Titan 03 is 9.833 % and Titan 05 is 21.220%.

**Keywords**— flow meter, fuel oil consumption, main engine, tug boat.

## I. INTRODUCTION

**F**UEL or commonly called fuel oil is one goods important need for residents and holding, also have a very vital role in all our activities economy. There are three main users of fuel oil: for household, industrial and transportation. Fuel used humans for the process of combustion where fuel will release heat after being reacted with oxygen in the air. Process another to release energy from fuel is through isothermal reaction and nuclear reaction (as nuclear fission or nuclear fusion). Hydrocarbons (including those gasoline and solar) is the fuel type which often used by human being. Other fuel which can also worn is radioactive metallic. The need for consumption of fuel is powerful for life, where fuel plays an important role in

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human life, moreover in order to run a supersized machines like a vessel. These limitations was caused by various factors, but one discharging fuel uncontrolled, the fuel largely uncontrolled in a long period of time very limited fuel prompted.

Basically fuel is one of the most important used on the ship propulsion system .About 50 % from fuel used to propulsion system, the remaining used to another system as auxiliary engine, lighting, engine room heating and so on. The cost used to fulfil fuel requirements have a big portion for ship operations. Because of the high cost for the fuel, there are several ways needed to improve the efficiency of fuel consumption. That can be done by controlling the use of fuel using flow meter as did some shipping company.

Flow meter is an instrument for measuring the quantity or rate of fluid flow that flows in a pipe or connection open. This device consisting of primary device, called as a measuring instrument primary and secondary device. Flow meter commonly consists of two parts, instrumental and secondary aids. Instrumental produce a signal that respond to the flow because the rate of flow has been interrupted. The main instrument is an annoying flow, orifice rate which is causing the occurrence of decrease the pressure. Secondary aids receives signals and displays, of instrumental record and / or transmitted as measurement result of the flow.

## II. LITERATURE REVIEW

Fuel oil (Fuel) is one of the items that are important to society and play a role very vital in all economic activities. There are three main users i.e. household FUEL, industry and transportation. Human use through fuel combustion process (redox reaction) where the fuel will release heat after reacted with oxygen in the air. Hydrocarbons (including petrol and diesel) so far is the type of fuel used most often humans (Tomo, 2013).

There are 2 classified of fuel oil in the ship:

1. Marine Diesel Oil: is the type of fuel oil, consisting of a mixture of fuel oil, gas oil and residue, suitable for diesel engines piston four measures and having of low viscosity. Marine Diesel Oil (MDO) is one of fuel oil that most often usage while the amount of the less. MDO having the characteristics of viscosity which is not too viscid when compared with the HFO. The application in a ship, usually fuel stored in the fuel tank.
2. High Fuel Oil (HFO): is fuel oil which not among the distillate, but is the residue that more condensed at room temperature and the color is black. Basically HFO having

viscosity very high so that it should be heated first when going to use it. This system fuel in general consists of fuel oil transfer, filter & purifying, fuel oil supply, and heater. In a ship HFO kept in storage tanks. There are coil heating in the tank bunker to prevent that oil not coagulated.

The type of flow meter (Arifin, 2011):

1. Ultrasonic flow meter: this type is much popular especially those who want a kind of flow meter moveable or in other words can be taken everywhere or it may be said as portable flow meter. How to operate also quite simple just fastened to the pipe that is to be measured the flow. For output of the flow meter could have just read on the display and others furnished with printer so that the result of measurements can be directly kept of hard copy and there are also the measurement result are kept on memory card of soft copy which can directly be read on a computer by using card readers.

Ultrasonic flow measurement is not a new technology. However it has recently become something of a hot commodity among other well represented technologies in the industrial flow meter market (Lie, et al, 2005). The measurement of slow rate fluid flow velocity is one of the most actual problems of modern industry. It is concerned with the wide use of such fluid flows in various technological process of industry and when creating the systems demands to measure small velocity of fluid motion (Lie, et al, 2007).

Ultrasonic methods due to their simplicity and cheapness are widely applied in the fluid flow velocity measurement, but in the range of slow rate flow they are investigated insufficiently Lie Ioan, et al, 2008).

2. Glass tube flow meter: Used for the application of a mounting with vertical system and the flow rate can directly read in a tube glass which the material of glass good enough that is made of Pyrex glass. A kind of glass tube flow meter is much used when installation pipe have no liquid area horizontal adequate so they do not really need a wide area. The application glass tube flow meter is just a kind of liquid and gas. Whereas if we want to pressure working higher at a range by 60 bar can be used a kind of metal tube flow meter.
3. Turbine flow meter: in flow meter there are vane or turbine or impeller will revolves when fluid flowing into flow meter.
4. Electromagnetic flow meter: has the highest flow meter used to measure fluid flow in the form of both water or other fluid both the corrosive, dirty and mud. Electromagnetic flow meter most commonly used in the application of measuring the flow of water, waste and chemical.
5. Orifice flow meter: this type of working on the principle of using pressure difference and can be used for the high temperature and high pressure. Orifice flow meter besides can be used for measuring the flow liquid, gas also be able to apply to the flow of a steam. This flow meter is match perfectly to the application of the chemical that corrosive. On type orifice flow meter

is also applied for liquids material heavy / viscous or measuring of gas have humidity high.

Example application installation of main engine:

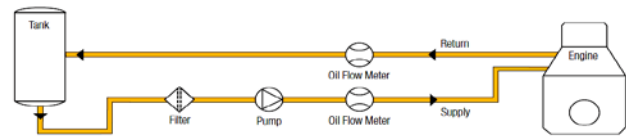


Fig. 1 The application installation of main engine

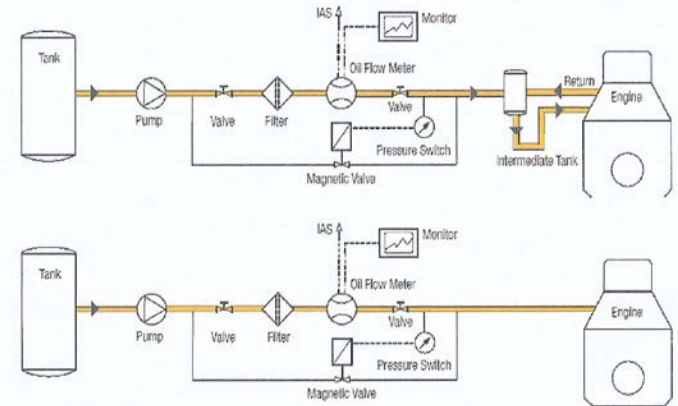


Fig. 2 The The application installation of main engine by using the web design

Picture explanation:

- tanks = to accommodate of fuel used on a Main Engine (M/E)
- filter = serves to screens out dirt before emptying into M/E
- pump = serves to flow the flow of tank to M/E
- oil flow meters (at the supply pipe) = serves to know how much fuel that goes to M/E
- oil flow meters (to the pipe return) = serves to know how much fuel not used down in M/E and return to tank

### III. PROBLEM FORMULATION

PT. Titan group is a company that moves in information technology, resources, energy, mining logistic & services. PT. Titan group owned company shareholder in systems integration, ranging from Information Technology business process outsourcing / employment, services logistician / carting, business oil and coal mining. One of subsidiary of PT Titan is PT Nusantara Terminal Terpadu (NTT). One large project of NTT have established cooperation with the government for transporting coal to nuclear power plant (PLN) in Pelabuhan Ratu, West Java.

A fleet of ships owned: MV. Titan 70, MV. Titan 42, TB. Titan 01, TB. Titan 03, TB. Titan 05, TB. Titan 07, TB. Titan 09, TB. Titan 11, TB. Titan 13.

PT. NTT had asked the offer price to some contractors censorship flow meter on the market, but the price is very expensive (already includes a tool and installation flow meter system). For the flow meter it is not too expensive, but the installation system is very expensive. Therefore PT. NTT devise a system design installation itself and cheap, and also can contribute to discharging fuel on ships efficiently.

The beginning of the ship operation in March 2011 even had several months to applied discharging fuel per package and had very high reaching 200 liters per hour. It is expected to allow the speed of ships can be based on target, but in December 2011 they made changes to decline the discharging fuel to become 150 liters per hour. After 4 months running, it occurs the protest by ship crew due to the absence of reference rules by using of fuel discharging size. In April 2012, they made the second change by raising a little discharging fuel to be 160 liters per hour and walked till May 2014. From June 2014, the flow meter already existing in most of the PT. NTT's ship and the data collection was recorded from July until November 2014.

Table 1. Ship Main Engine Fuel Oil Consumption per-hour History

History of ME FO Consumption Per-Hour				
2011	3	Mar	200	
	4	Apr	200	
	5	May	200	
	6	Jun	200	
	7	Jul	200	
	8	Aug	200	
	9	Sep	200	
	10	Oct	200	
	11	Nov	200	
	12	Dec	150	
	2012	1	Jan	150
		2	Feb	150
3		Mar	150	
4		Apr	160	
5		May	160	
6		Jun	160	
7		Jul	160	
8		Aug	160	
9		Sep	160	
10		Oct	160	
11		Nov	160	
12		Dec	160	
2013	1	Jan	160	
	2	Feb	160	
	3	Mar	160	
	4	Apr	160	
	5	May	160	
	6	Jun	160	
	7	Jul	160	
	8	Aug	160	
	9	Sep	160	
	10	Oct	160	
	11	Nov	160	
	12	Dec	160	
2014	1	Jan	160	
	2	Feb	160	
	3	Mar	160	
	4	Apr	160	
	5	May	160	
	6	Jun	140	
	7	Jul	140	

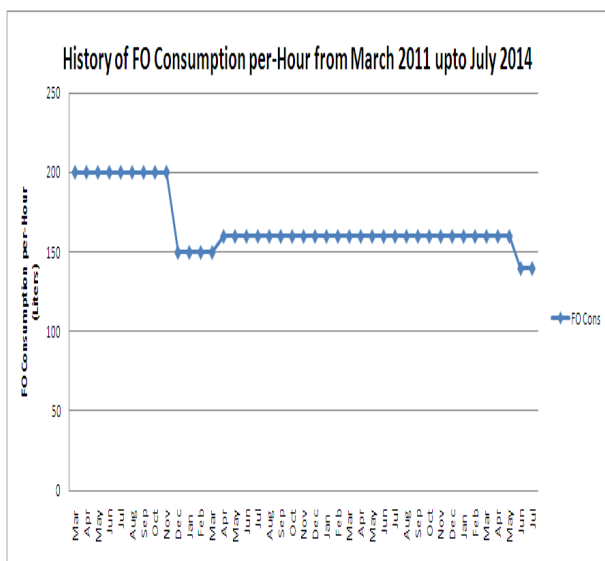


Fig.3 History of FO Consumption per hour from March 2011 till July 2014

Methods used in this research was descriptive methods described a phenomenon, events, incidents happened and focus on actual problem. The analysis was quantitative analysis with doing a calculation use of fuel before and after using flow meter on tugboat. Because almost the tugboat have the same main engine, in this research only 2 tugboat which done for the calculation.

**DATA OF THE SHIP:**

Ship Name no. 1 : TITAN 03  
 Ship type : Steel Tug Boat  
 Owner : PT. NTT  
 Flag : Indonesia  
 Ship Class : BKI  
 GRT / NRT : 255 GT / 77 GT  
 Length (LBP) : 26,04 m  
 Length (LOA) : 28,05 m  
 Breadth : 8,60 m  
 Depth : 4,30 m  
 Total Crew : 11 crews  
 Shipyard : PT. Bandar Abadi, Tanjung - Uncang, Batam  
 Main Engine : Mitsubishi S6R2-MPTK, 1030 HP/1450 rpm x 2 units  
 Effective H.P : 2 x 759 KW  
 Auxiliary Engine : Marine gen set HUANG FENG 50 KW x 2 units  
 Fresh Water Tank : capacity 59 Ton  
 Fuel Oil Tank : capacity 185 Ton  
 Ballast Water Tank : capacity 93 Ton  
 Daly Tank : capacity 5000 liters  
 Fuel oil type : High Speed Diesel

Ship name no. 2 : TITAN 05  
 Ship type : Steel Tug Boat  
 Owner : PT. NTT  
 Ship Class : BKI  
 GRT / NRT : 255 GT / 77 GT  
 Length (LBP) : 25,12 m  
 Length (LOA) : 28 m  
 Breadth: : 8,6 m  
 Depth : 4,30 m  
 Total Crew : 11 crews  
 Shipyard : PT. Bandar Abadi, Tanjung- Uncang, Batam  
 Main Engine : Mitsubishi S6R2-MTK3L, 1030 HP/1450 RPM x 2  
 EffectiveH.P : 2 x 759 KW  
 Auxiliary Engine : Marine gen set HUANG FENG 50 KW x 2 units  
 Fresh Water Tank : capacity 59 Ton  
 Fuel Oil Tank : capacity 185 Ton  
 Ballast Water Tank : capacity 93 Ton  
 Daily Tank : capacity 5000 liters  
 Fuel oil type : High Speed Diesel

IV. PROBLEM SOLUTION

For measuring the efficiency, shipping route is one of the important thing where fuel consumption could be set with the length of time of sailing vessel. The route is from Bengkulu (Sumatera) to Pelabuhan Ratu (West Java).

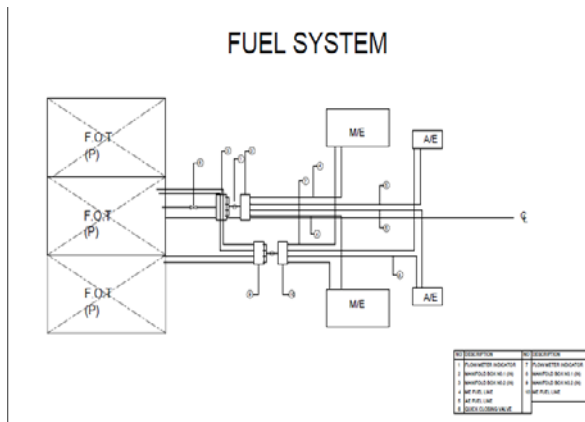


Fig. 4. Installed flow meter on Titan 03 & Titan 05 fuel system

On Fig. 4, at this stage, the main engine check on manually using daily tank that has been designed to know the capacity of the average rate of the flow (flow rate). Flow rate measured for rotation per minute (rpm) on maximum and minimum machine condition. A tank artificial has installed for measuring instrument to know how much fuel capacity which already exist at the daily tank. Fuel from the tank artificial enter to play the engine then the fuel that were not burned enter into overflow shelter.



Fig. 5 Daily tank



Fig. 6 Daily tank pipe to Main Engine (M/E)



Fig. 7 Overflow from M/E to daily tank

Table 2. Flow rate on Titan 05

Start Hour	Finish Hour	Rpm	Speed	Inlet (liters)	Overflow (liters)	Consumption (liters)
11.48 am	12.48 am	700	2,5	48 liters	42	6
13.04 am	14.04 am	900	3,90	53 liters	31	22
14.49 am	15.59 am	1200	5,30	82 liters	48	34

From above table, an inlet minimum on 700 rpm with an overflow as many as 42 liters /hour. While overflow maximum happened on the 1200 rpm as many as 82 liters/hour so specification for flow meter needed a minimum flow rate under 42 liters/hour and maximum flow rate above 82 liters/hour. Temperature at the outlet when rpm maximum is 43° C.

Specification of flow meter that used for:

- Name : Contoil vzo 8
- Brand : Aqua Metro
- Max flow & Min flow : 200 l/h & 4 l/h
- Temperature : 60° C



Fig. 8 Erection of flow meter (before)



Fig. 9 Erection of flow meter (after)

To know the movement and fuel consumption on Titan 03 and 05 everyday crew sent the data to a company. For the data prior before using the flow meter recorded from March till May 2014, and for the data after using flow meter taken from period of August till November 2014.

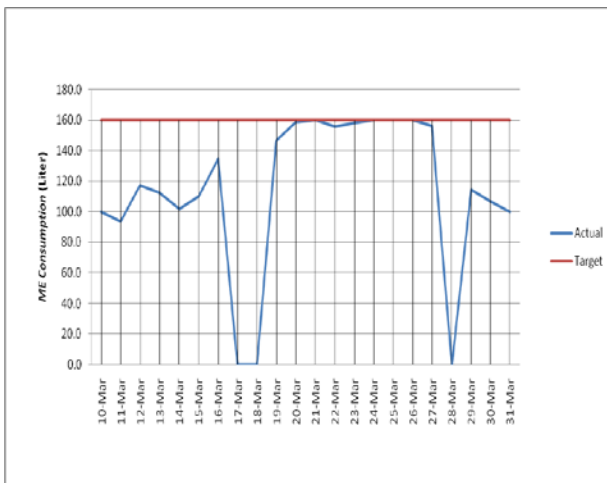


Fig. 10 Graph of Titan 03 Fuel Oil M/E Consumption on March 2014

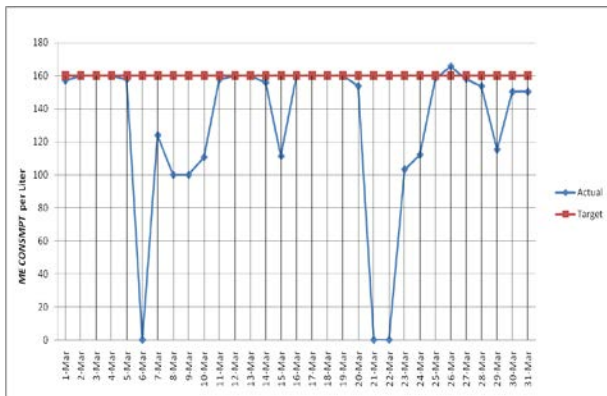


Fig. 11 Graph of Titan 05 Fuel Oil M/E Consumption on March 2014

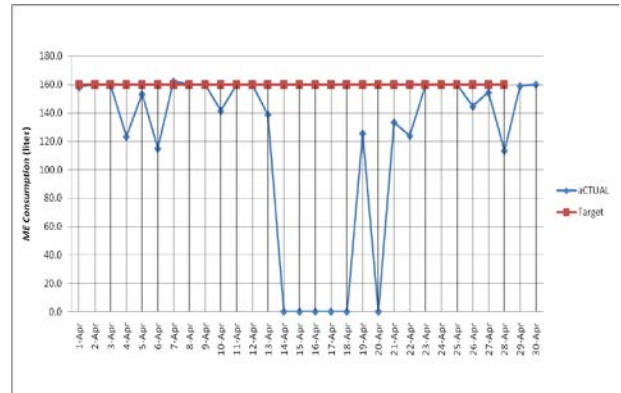


Fig. 12 Graph of Titan 03 Fuel Oil M/E Consumption on April 2014

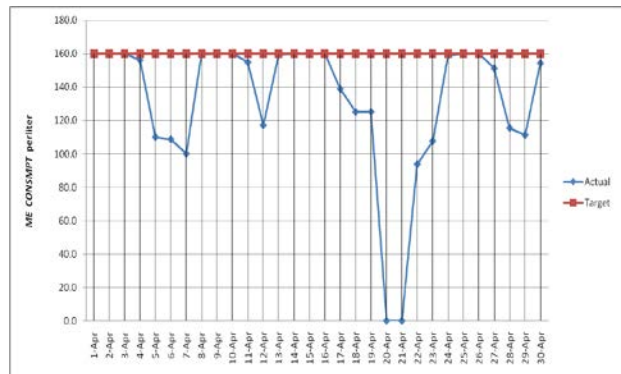


Fig. 13 Graph of Titan 05 Fuel Oil M/E Consumption on April 2014

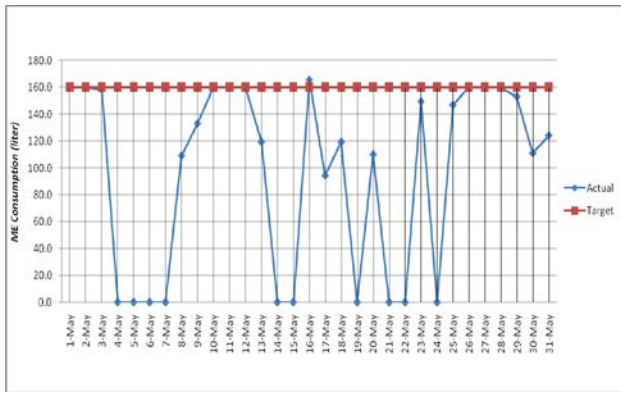


Fig. 14 Graph of Titan 03 Fuel Oil M/E Consumption on May 2014

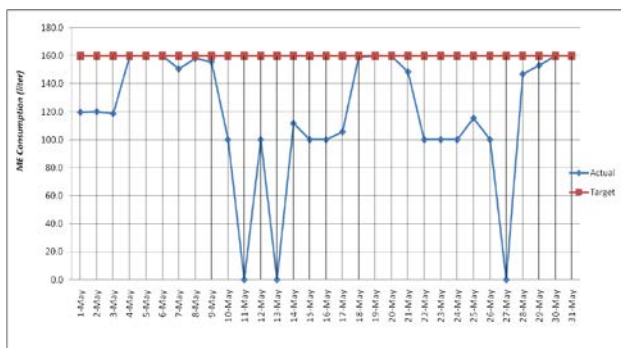


Fig. 15 Graph of Titan 05 Fuel Oil M/E Consumption on May 2014

PT. NTT in July started using flow meter to know the consumption of fuel used in. Based on result of the survey observed of the company, they determined discharging fuel consumption 140 liters/hour on sail condition and 60 liters/hour on condition of the ship in the harbor by setting max rpm on ships worth 950 rpm.

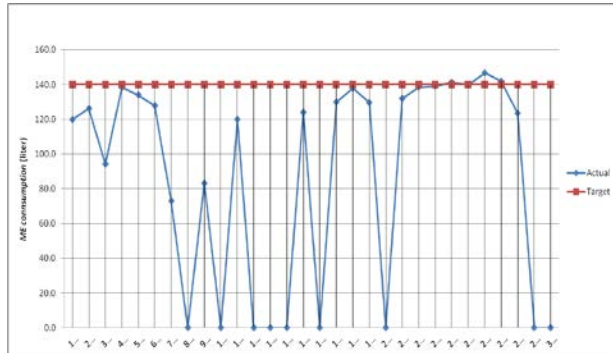


Fig. 16 Graph of Titan 03 Fuel Oil M/E Consumption on Sept 2014

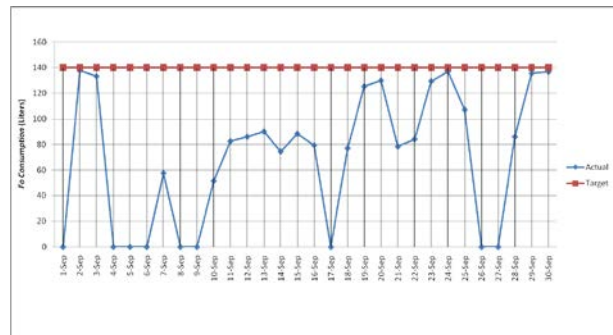


Fig. 17 Graph of Titan 05 Fuel Oil M/E Consumption on Sept 2014

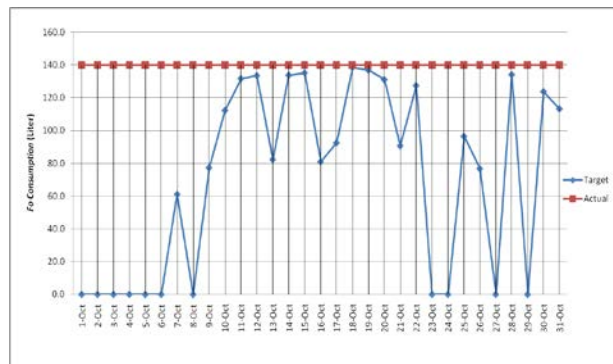


Fig. 18 Graph of Titan 03 Fuel Oil M/E Consumption on Oct 2014

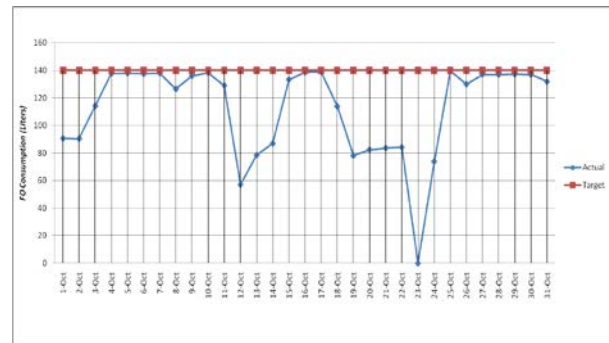


Fig. 19 Graph of Titan 05 Fuel Oil M/E Consumption on Oct 2014

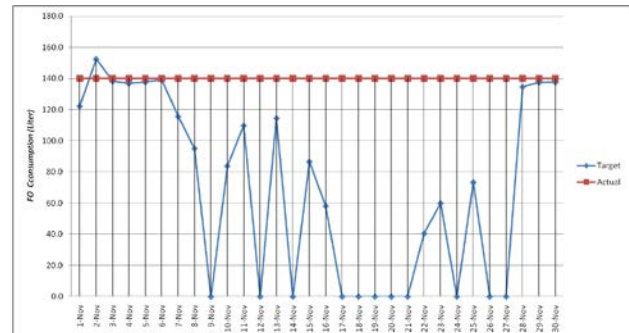


Fig. 20 Graph of Titan 03 Fuel Oil M/E Consumption on Nov 2014

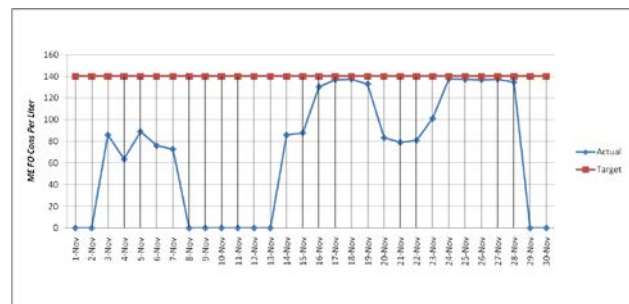


Fig. 21 Graph of Titan 05 Fuel Oil M/E Consumption on Nov 2014

Table 3. Fuel Oil Consumption before flow meter erection

Ship Name	Shipping Trip	Start	Finish	Actual		
				Shipping Length	FO Consumption	
Titan 03	Bengkulu-Pel.Ratu-Bengkulu	28-Apr	23-May	26 Days	38.285	Liters
Titan 05	Bengkulu-Pel.Ratu-Bengkulu	3-May	28-May	25 Days	41.327	Liters

Table 4. Fuel Oil Consumption after flow meter erection

Ship Name	Shipping Trip	Start	Finish	Actual		
				Shipping Length	FO Consumption	
Titan 03	Bengkulu-Pel.Ratu-Bengkulu	1-Nov	30-Nov	29 Days	34.501	Liters
Titan 05	Bengkulu-Pel.Ratu-Bengkulu	26-Oct	20-Nov	26 Days	32.557	Liters

Total efficiency discharging fuel after using the flow meter:

$$\text{Titan 03: } \frac{38.285 - 34.501}{38.285} \times 100 \% = 9.883 \%$$

$$\text{Titan 05: } \frac{41.327 - 32.557}{41.327} \times 100 \% = 21.220 \%$$

## V. CONCLUSION

1. Fuel consumption before using flow meter for Titan 03 shipping trip Bengkulu-Pelabuhan Ratu-Bengkulu from April to May worth 38,285 liters and Titan 05 shipping trip the same worth 41,327 liters.  
Fuel consumption after using flow meter for Titan 03 shipping trip Bengkulu-Pelabuhan Ratu-Bengkulu from April to May worth 34,501 liters and Titan 05 shipping trip the same worth 32,557 liters.
2. For controlling the fuel consumption before using the flow meter with sounding test on the tank, after using the flow meter we can used the authorized picture of oil consumption which list on the flow meter.
3. The efficiency of fuel oil consumption after using the flow meter:  
Titan 03 is 9.833 %  
Titan 05 is 21.220%

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