THE EFFECT ADDITION OF LSWR INTO FUEL OILS AGAINST ALTERATION ITS PHYSICALS AND CHEMICALS PROPERTIES

by
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ABSTRACT

To fulfill yearly increase National demand for fuel oils (FO), therefor this paper conducted to researched the posibility added low sulfur wax residue (LSWR) into National fuel oil comersial to some percentage volume againts its characteristic changes.

Base on its pour point, the fuel oils modification formula, named FO-90 that has pour point 90°F, this formula content 6% volume LSWR.

The laboratory test result, shown that nearly all characteristic fuel oils modification is conform with current domestic fuel oils specification 2, issued by Directorate General Oils and Gas on behalf of Indonesian goverment in their SK No. 03/P/DM/MIGAS/1986 dated April 14, 1986.

This paper proposes fuel oils specification, as input for government policy in reformulation of Indonesian fuel oils specification which confirm with international fuel oil specification.

Key words: Pour point, viscosity, LSWR.

I. INTRODUCTION

A. *Backgroud*

As the National industries grow the demand for fuel oils increases yearly. In fiscal year of 2006 National fuel oils demand for industries, transportation and power generator was 4.784.502 KL, but national fuel oils production only 3.840.915 KL; it is mean a shortage of fuel oils 943.587 KL.(nearly 20 % of demand). The idea is how to keep in touch with those raising demand of fuel oils growth by adding a certain amount of low sulfur wax residue (LSWR) mixed with industrial fuel oils. This procedure should be done to optimize fuel oils supply without new refinery as there are a lot of unused LSWR in Pertamina Refinery.

Add some LSWR into National fuel oils with a certain volume percentage will influence some properties such as specific gravity, viscosity, flash point, sulfur content, heating value, water content, sediment content, acid number, and conradson carbon residue. This paper wills discus how far the properties of National industrial fuel oils influenced by LSWR.

The evaluation will be base on compare result test of physicals and chemicals properties against specification of National fuel oils, standard decided by Directorate General Oils and Gas on behalf of Indonesian goverment in their SK No. 03/P/DM/MIGAS/1986 dated April 14, 1986.

B. *Elements requisites for experiment*

1. Fuel Oils

Fuel oils also known as marine fuel oil it is not distillation fuel, but it is come from residue fuel, its color dark black. The usage of fuel oils in general are for fuel at direct combustion in big industrial furnaces, the steam power generation and marine transportation. Fuel oils also refered as marine fuel.

The fuel oil used in this experiment came from Rifinery Pertamina Unit IV, that its properties confirm with domestic fuel oil specification, presented in Table 2 and Figure 2.

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2. Low Sulfur Wax Residue

Low sulfur waxy residue is a bottom product from Crude Distilling Unit (Fuel Oils Complex, FOC II) Pertamina UP IV Cilacap. LSWR use for raw material that will be further process to be come fuel oils and non fuel oils products. In countries with winter season, LSWR use as heating oils.

C. *Purpose*

The course of this paper are:

1. To examine the influence of addition LSWR into National fuel oils againts its chemicals and physicals properties changes with respect to National fuel oils specification, standard decided by Directorate General Oils and Gas on behalf of Indonesian goverment in their SK No. 03/P/DM/MIGAS/1986 dated April 14, 1986, which limited pour point in fuel oils not more than 90°F (Specificaton 2).
2. Data elected from this research hopefully for beneficial of goverment policy in reevaluation properties of fuel oils in future specification.

II. METODOLOGY

The chemicals and physicals properties of low sulfur wax residue and commercial industrial fuel oils were tested, then formulation of modification fuel oils was formulated conducted by mixing of fuel oils and low sulfur wax residue at certain proportion (2, 4, 6, 8, 10, 12 % volume) each modification formula will be tested for its pour point to choose which fuel oils modification has pour point 90°F that will be futher evaluate.

Those sample of fuel oils modification with pour point 90°F tested futher its chemicals and physicals properties, than its result compare againts National fuel oils specification, decided by Directorate General Oils and Gas on behalf of Indonesian goverment in their SK No. 03/P/DM/MIGAS/1986 dated April 14, 1986.

Beside, this taks conducted reformulation of domestic fuel oil specification in relation to update internal fuel oil specification.

III. EXPERIMENTAL

A. *Scope of Work*

Scope of this research including : literature study, fuel oils reformulation, physical and chemical of fuel oils laboratory test, evaluation and propose a new domestic residual fuel oil.

Table 1
Effect of LSWR added into commercial fuel oils against its Pour Point

Sample Code [1)]	FO (% volume)	LSWR (% volume)	Pour Point (°F)	Remark
(1)	(2)	(3)	(4)	(5)
BBM-01	100	-	80	**FO-R**
BBM-02	-	100	120	Sample of LSWR
BBM-03	98	2	80	
BBM-04	96	4	90	
BBM-05	94	6	90	**FO-90**
BBM-06	92	8	95	**FO-95**
BBM-07	90	10	95	

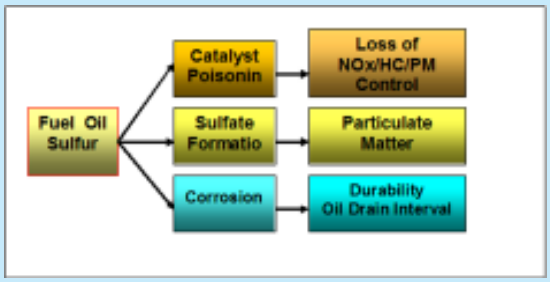

Figure 1
Direct environmental impact of sulfur

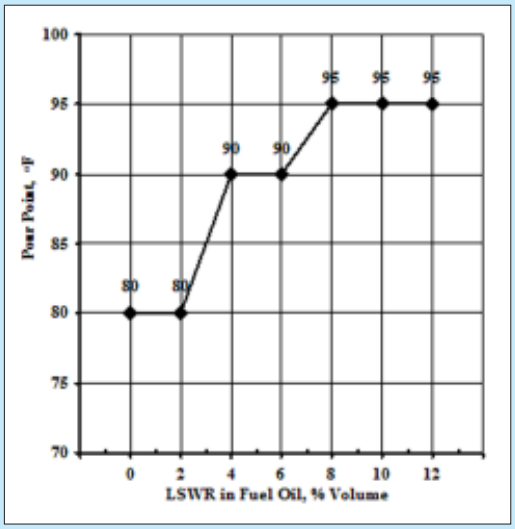

Figure 2
LSWR vs pour point

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Table 2
Test result for samples FO-R and FO-90
compared with domestic fuel oils specification

Characteristics	Test result		Limits of fuel oil Specification 2[1]		Test method ASTM
	FO-R [3]	FO-90 [4]	Min.	Max.	
(1)	(2)	(3)	(4)	(5)	(6)
Specific gravity at 60/60°F	0.9350	0.9430	-	0,99	D 1298
Viscosity redwood I/100 °F, secs	1,293	1,454	400	1,5	D 445 [2]
Pour point, °F	80	90	-	90	D 97
Calorific value gross, BTU/lb	19,225	19,23	18	-	D 240
Sulfur content, % mass	0.928	1,27	-	3.5	D 1551
Water content, % volume	Trace	0.05	-	0.75	D 95
Sediment content, % mass	0.010	0.030	-	0.15	D 473
Neutralization value: strong acid number, mg KOH/gr	Nil	Nil	-	Nil	D 974
Flash point P.M.cc, °F	210	210	150	-	D 93
Conradson carbon residue, % mass	5.75	6.70	-	14	D 189

Remark:

1). Specification of domestic fuel oils, standard decided by Directorate General Oils and Gas, SK No. 03/P/DM/MIGAS/1986 dated April 14, 1986
2). Conversion from kinematic viscocity.
3). FO-R is commercial fuel oils.
4). FO-90 is fuel oils modification, pour point 90°F.

B. *Fuel Oils Formulation*

1. In open air, National fuel oils with 80°F pour point are in liquid phase, whereas LSWR residue with 120°F pour point in massive shape. In order to get homogeny solution, National fuel oils mixed with LSWR perform at temperature140°F. The aim of this study is to get fuel oils modification formula with addition low sulfur wax residue into National fuel oils.
2. The outcome of the influence of LSWR added into National fuel oils, presented in Table 1. Base on data of Table 1, that obtained the formula as follow;

   Fuel oils modification with 90°F pour point got from 94% FO-R added by 6% low sulfur wax residue (LSWR).

C. *Chemical and Physical Test*

1. The course of this study is to examine the influence of addition LSWR into National fuel oils againts its chemicals and physicals properties changes with respect to National fuel oils specification curent standard.
2. The chemicals and physicals properties test result of fuel oils typical (FO-R) and sample fuel oils modification FO-90 presented in Table 2 column 2 and column 3.

D. *Fuel oils Development in Indonesia*

Considering some aspects and present condition such as advance engine technology, current international fuel oil specification, domestic refineries capability, consumen needs and environment concern, domestic residual fuel oil specification shall be renew.

IV. RESULT AND DISCUSSION

Comparing the test result of sample commercial fuel oils (FO-R) againts Ditjen Migas specification for fuel oils, tabulated at Table 2 column 2. On Table 2 column 3 please find the result test of modification fuel oils sample (FO-90).

A. *Evaluation of Physicals and Chemicals*

Evaluation of physicals and chemicals test result on sample fuel oils, it happened that all physicals and

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chemicals characteristic conform with fuel oils specification.

1. Specific Gravity

Specific gravity is related to the fuel quality due to the fact that cranked products have the higher carbon content, are more aromatic, and thus are hevier. Therefore, fuels with high density are also high in conradson carbon and asphalt. The water separation ability of the fuel oil is ensured by limiting the specific gravity for reasons of centrifuging as stated in the specification.

National fuel oils specification point out maximum boundry for specific grafity 0.990 as appear in Table 2, but fuel oils sample FO-R has specific gravity 0.9353 (see Table 2 column 2), while specific gravity of FO-90 is 0.9430 that can be find at Table 3 column 3. So, the specific gravity of fuel oils modification a litle bit higher from original fuel oils (FO-R). How ever, those specific gravity still comply with current National fuel oils specification rule by goverment.

2. Viscosity

Viscosity can only partly be considered as a quality criterion for fuel oils. The viscosity is stated mainly for handling, transport, fuel pumping, delivery through calibrated jets, size of dropplets, pulverization angle and has consequence quality of the combustion.

Examination result of viscosity of fuel oils FO-R sample is 1293 secs. (see Table 2 column 2) where as fuel oils sample of FO-90 is 1480 secs.(see Table 2 column 3). So, the viscosity of fuel oils modification higher than the viscosity of original fuel oils (FO-R). However, only viscosity of fuel oils FO-90 that conform with current fuel oils specification issued by Directorate General Oils and Gas on behalf of Indonesian.

The deviation of viscosity value of FO-95 sample that beyond the maximum limit viscosity of fuel oils specification, and the use of this kind fuel oils will be influence the current operating system.

3. Pour Point

Fuel filter clogging by cold weather can be provoked by paraffinic filter crystals which are separated from liquid phase. This characteristic is know as pour point.

The pour point of sample fuel oils FO-R is 80^{o}F, mean while aditional 6% volume of LSWR into FO-R increase the pour point to 90^{o}F and additional 8% volume of LSWR into FO-R produce pour point 95^{o}F that tabulated at Table 1. In such a way, only pour point of FO-90 sample comply with fuel oils specification 2, where as pour point of FO-95 sample deviate from maximum limit pour point of fuel oils specification 2.

Table 3
Specification of Marine Fuel Residual Oils (ISO 8217: 2005/ BS MA 100: 1996)

Characteristics	Limit	RMA 30	RMB 30	RMD 80	RME 180	RMF 180	RMG 380	RMH 380	RMK 380	RMH 700	RMK 700
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Density at 15^{o}C, kg/m^{3}	Max.	960.0	975.0	980.0	991.0		8991.0		1010.0	991.0	1010.0
Viscosity at 50^{o}C, mm^{2}/sec.	Max.	30.0		80.0	180.0		380.0			700	
Pour point, ^{o}C(^{o}F)	Max.	6	24	30	30		30.0			30	
Sulfur content, % mass	Max.	3.5		4.00	4.50		4.5			4.5	
Water content, % volume	Max.	0.5		0.5	0.5		0.5			0.5	
Sediment content, % mass	Max.	0.10		0.10	0.10		0.10			0.10	
Flash point P.M.cc, ^{o}C (^{o}F)	Min.	60		60	60		60			60	
Carbon residue, % mass	Max.	10		14	15	20	18	22		22	
Ash content, % mass	Max.	0.10		0.10	0.10	0.15	0.15	0.15		0.15	
Vandium content, mg/kg	Max.	0		350	200	500	300	600		600	
Aluminium + silicon, mg/kg	Max.	80		80	80		80			80	

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The deviation of pour point value of FO-95 sample that higher than maximum limit pour point of current fuel oils specification, will effected additional pre-heat if this kind fuel to be use, so the cost of operation will be higher unless the price is lowest.

4. Calorific Value Gross

The calorific value on weight ratio of hydrocarbons does not very much different from one chemical family to another. In Indonesia fuel oils specification, the calorific value is above 18,000 BTU/lb.

The caloric value of fuel oils FO-R sample shown 19,225 BTU/lb (see Table 2) and fuel oils FO-90 is 19 230 BTU/lb presented at Table 3. So, the calorific value of fuel oils modification higher than calorific value of original fuel oils (FO-R). The calorific value confirm with curent national fuel oils standard.

5. Sulfur Content

The corrosive effect of sulfuric acid during combustion is countered by adequate lube oils and temperature control of combustion chamber walls, however sulfur content has negligible effect on the combustion process.

Regarding the industrial use of the fuel oils, sulfur content is interfering on atmospheric pollution problems, and on furnaces/marine engines destruction problems.

Sulfur in fuel oils could be deterriorated catalyst and limiting their effectivity until low sulfur fuels are available. Sulfur in fuel oil also become sulfate that promotes the formation of particulate matter. Reducing the aromatic content in sulfur has a significant impact in minimized the particulate emission level. As already discussed, sulfur from the fuel contributes to corrosion by-product which could be harmful to the engine. Reducing the sulfur level will improve durability and maximized oil drain interval (see Figure 1).

From test result of sulfur content of fuel oils FO-R sample is 0.928 % mass (see Table 2 column 2) and sulfur content of fuel oils FO-90 in order is 1.27 % mass, present at Table 2 column 3. There for, the sulfur content of fuel oils modification increase form sulfur content value of original industrial fuel oils (FO-R). How ever, as maximum limit sulfur content specification 2 is 3.5 % mass (see Table 2 column 5), so those sulfur content of fuel oils modification sample are comply with sulfur conten of fuel oils specification issued by Directorate General Oils and Gas.

6. Water Content

Although water can provoke corrosion in fuel piping and storage tanks, Indonesian specification allow 0.75% mass of water in national fuel oils.

Water content in fuel oils sample FO-R is traceable (see Table 2 column 2) and fuel oils FO-90 sample each is 0.05 % volume as tabulated in Table 2 column 3. Even so, water content of fuel oils modification more than the water content of fuel oils FO-R, however those water content of fuel oils far away bellow allowable value, so those samples conform with water content of fuel oils specification issued by Directorate General Oils and Gas.

7. Sediment Content

Sediments in fuel oils are harmful, couse its present will increase wear of plunger in fuel pumps, so its content shall be limited. Tthe sediment content of Indonesian fuel oils specification, is below 0.15% mass (Table 2 column 5).

Fuel oils FO-R sample has sediment content of 0.010 % mass (see Table 2 column 2) and sediment content of fuel oils FO-90 is 0.030 % mass, presented on Table 2 column 3. So, as result of addition LSWR in fuel oils FO-R, its sediment content increase from its original value, however those sediment content in accordance with current National fuel oils specification.

8. Strong Acid Number

According to current National fuel oils specification strong acid number shall be nil, as test result of fuel oils FO-R, FO-90 each sample in Table 3 is nil, so the strong acid number of those fuel oils modification comply with National fuel oils, specification issued by Directorate General Oils and Gas.

9. Flash Point

In the utilization of the fuel oils, flash point has a very important parameter, for safety reason in fuel handling and storage point of view, in Indonesia fuel oils specification flash point minimum requiredment is 150^{o}F.

Test result from fuel oils sample FO-R has flash point 210^{o}F (see Table 2 column 2) it is above the minimum flash point requiredment and flash point of fuel oils sample FO-90 is 210 ^{o}F that presented in Table 2 column 2. There for, FO-R has the same flash point with fuel oils sample FO-90 has flash point higher than those samples, but all flash point of fuel

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oils samples in accordance with national fuel oils, specification issued by Directorate General Oils and Gas.

10. Conradson Carbon Residue

The test result of conradson carbon residue fuel oils FO-R sample is 5.75 % mass (see Table 2 column 2) and fuel oils FO-90 sample has 6.70 % mass tabulated in Table 2 column 2. Although conradson carbon of fuel oils modification higher than conradson carbon of original fuel oils, however those conradson carbon values lower than maximum requiredment of specification issued by Directorate General Oils and Gas.

B. *The Progression of domestic residual fuel oil*

Domestic residual fuel oil produce in Indonesia has pour point higher from diesel oil pour point. Residual fuel oil is also refered as Marine Fuel Oil. Domestic fuel oil specification in Indonesia presented in Table 5. National fuel oils specification, decided by Directorate General Oils and Gas on behalf of Indonesian goverment in their SK No. 002/P/DM/MIGAS/1979 dated Mei 25, 1979.

Domestic Fuel oil spesification of 1979 reviced in 1986 became fuel oil specification 1 and specification 2, declared by Directorate General Oils and Gas on behalf of Indonesian goverment in their SK No. 03/P/DM/MIGAS/1986 dated April 14, 1986.

Characteritics boundry of fuel oil specification 1986 is the same with fuel oil specification 1979. However the differencies between fuel oil specification 1 and fuel oil specification 2, it is in pour point boundry from 80^{o}F became 90^{o}F and maximum boundry of viscosity Redwood from 1,250 secs became 1,500 secs, as seen oin Table 5.

1. The Progression of International fuel oil Spesification.

The Progression of International fuel oil Spesification, with respect to three residual fuel oil specification (Table 3). International Standard Organization ISO 8217 : 2005 Standard for petroleum product – fuels (class F) – specification of marine fuels

a. British Standard BS MA 100 : 1996 British Standard Marine Series: Spesification for petroleum fuels for marine oil engine and boilers.
b. Counseil International des Machines a Combustion CIMAC : 1990 Recomendations Regarding Fuel Requirement for Diesel Engines, third edition.

Spesification ISO:2005 developed for diesel engines that devided into two catagories, that are distillate grade and residual grade. The residual grade consist of 10 grades with respect to its viscosity, tabulated in Table 3 and its similarity with BS MA : 1996 presented in Table 4.

Spesification BS MA 100 : 1996 developed for marine engines that devided into two catagories, that are, distillate grade and residual grade. The residual grade presented in Table 4.

Spesifikasi CIMAC : 1990 developed for industrial and marine engines. Those recomendation use by diesel engine manufactures in theirs operation manual, but the user has its own choice to decided wich fuel suitable for its diesel engine. Proposal of a new domestic fuel oil specification.

Table 4
ISO 8297/ BS MA: 100-1996 Vs CIMAC

No.	International Standard Organization (ISO) and British Standard Institution (BS)		International Council on Combustion Engines (CIMAC)
	ISO 8217 -1996/ BS MA 100: 1996	ISO 8217: 2005	CIMAC:1990
(1)	(2)	(3)	(4)
1	RMA 10	RMA 30	A 10
2	RMB 10	RMB 30	B 10
3	RMC 10	-	C 10
4	RMD 15	RM D 80	D 15
5	RME 25	***RME 180***	***E 25***
6	RMF 25	RMF 180	F 25
7	RMG 35	***RMG 380***	***G 35***
8	RMH 35	RMH 380	H 35
9	RMK 35	RMK 380	K 35
10	RMH 45	-	H 45
11	RMK 45	-	K 45
12	RML 45	-	-
13	RMH 55	RMH 700	H 55
14	RMK 55	RMK 700	K 55
15	RML 55	-	-

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Table 5
The progression of domestic fuel oils specification

Characteristics	Limit	Specification of Domestic Fuel Oils, issued by Directorate General Oils and Gas		
		SK No. 002/P//DM/ Migas/ 1979 dated Mei 25, 1979	SK No. 03/P/DM/MIGAS/1986 dated April 14, 1986	
			Specification 1	Specification 2
(1)	(2)	(3)	(4)	(5)
Density at 15°C, kg/m^3	Max.	990	990	990
Viscosity redwood I/100 °F, secs	Min.- Max	400 – 1250	400 -1,250	400 -1,500
Viscosity at 50°C, mm^2/sec.	Max.	-	-	-
Pour point, °F (°C)	Max.	80 (26.67)	80 (26.67)	90 (32.22)
Calorific value gross, BTU/lb	Min.	18	18	18
Sulfur content, % mass	Max.	3.5	3.5	3.5
Water content, % volume	Max.	0.75	0.75	0.75
Sediment content, % mass	Max.	0.15	0.15	0.15
Neutralization value: strong acid number, mg KOH/gr	Max.	Nil	Nil	Nil
Flash point P.M.cc, °F (°C)	Min.	150	150 (65.5)	150 (65.5)
Carbon residue, % mass	Max.	10	14	14

Table 6
Domestic fuel oils specification and suggest reformation of residual fuel oils specification

Characteristics	Limit	National Fuel Oils Indonesia[1)]		Suggest Reformation of Residual Fuel Oils Specification	
		Specification 1	Specification 2	Specification 1	Specification 2
Reference: Specification ISO 8217: 2005 (Class F)	-		-	**RME 180[2)]**	**RMG 380[3)]**
Density at 15°C, kg/m^3	Max.	990	990	991	991
Viscosity redwood I/100 °F, secs	Min.- Max	400-1,250	400-1,500	400 – 1,250	400 – 1,500
Viscosity at 50°C, mm^2/sec.	Max.	-	-	225	380
Pour point, °F	Max.	80	90	80	90
Calorific value gross, BTU/lb	Min.	18	18	-	-
Sulfur content, % mass	Max.	3.5	3.5	5.0	5.0
Water content, % volume	Max.	0.75	0.75	0.5	0.5
Sediment content, % mass	Max.	0.15	0.15	0.10	0.10
Neutralization value: strong acid number, mg KOH/gr	Max.	Nil	Nil	-	-
Flash point P.M.cc, °C (°F)	Min.	65.5 (150)	65.5 (150)	60	60
Carbon residue, % mass	Max.	14	14	15	18
Ash content, % mass	Max.	-	-	0.10	0.15
Vanadium content, mg/kg	Max.	-	-	200	300
Aluminum + silicon, mg/kg	Max.	-	-	80	80

1). Specification of National fuel oils, issued by Directorate General Oils and Gas on behalf of Indonesian Goverment in their SK No. 03/P/DM/MIGAS/1986 dated April 14, 1986.

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2. Proposal of a new Domestic Fuel Oil Specification.

Fuel oil specification are some requirements of physicals and chemicals property of marine fuel oils that its parameter measured with standard test method. According to Indonesian Government Regulation No. 36 /2004 Chapter X Paragraph 62 Articles 3 and Regulation of ESDM Ministry No. 0048/2005 Paragraph 4 mentions that "Specification establishment have to consider the technology development, producer ability, consumer need and ability, safety and health, and environment.

Regarding international residue fuel oil specification (ISO 8217:2005, BS MA 100:1996 and CIMAC:1996) and the above mentioned goverment regulation, domestic fuel oil specification should be reformulated with addition of several physicals and chemicals properties that presented in Table 6.

Indonesia residual fuel oil is also referred as marine fuel oil. Characteristics residual marine fuel oil (MFO) or marine residual fuel (MRF) should have lower metals content requiredment (vanadium, aluminium and silicon) due to its corrosive nature to engine components, but its sulfur content not to tight compare to onshore requirement. Proposal of the new domestic fuel oil specification tabulated in Table 6.

The main changes in domestic marine residual fuels are:

- Addition of: vanadium content, aluminium and silicon content and ash content properties;
- Reduced flash point content;
- Increased carbon residue content;
- Increase sulfur content;
- Viscosity measured at 50^{o}C instead of 100^{o}C.

V. CONCLUSION

1. With adding 6% volume LSWR into commercial fuel oils, there is possibility to get more supply of domestic fuel oils without breaking any property limit of current fuel oils specification. All properties of fuel oils modification such as specific gravity, viscosity, flash point, sulfur content, heating value, water content, sediment content, acid number, and conradson carbon residue, all comply with National Fuel Oils, standard issued by Directorate General Oils and Gas.
2. Proposal of residual marine fuel oils spesification in Indonesia shall be conform with international residual marine fuel spesification (ISO 8217:2005) and should consider the development of marine engine technology, capability of domestic refineries, environment concern.
3. Capability of domestic refineries should be investigated to produce recidual marine fuel oil in lieu with propose a new residual marine spesification. Fuel oil laboratory should be fitted up with the new test equipment releted to all characteristic of residual marine fuel oil test.
4. Fuel oil laboratory shall be provided with related equipment test that required for tested residual marine fuel.

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