Palm Oil Diesel as a Base Fluid in Formulating Oil Based Drilling Fluid

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ABSTRACT

The usage of oil especially diesel oil as the continuous phase of drilling mud is widespread when drilling through sensitive producing formation and troublesome shale zone.
Diesel oil is harmful to the environment, particularly marine environment during offshore drilling. Extensive legislation now exist in many countries to regulate this form of oil pollution. The use of palm oil derivative could be considered as an alternative based fluid which is harmless to the environment. Tests have been undertaken to evaluate the characteristics of palm oil derivative as a base fluid in the oil base mud. The test results showed that palm oil derivative is a suitable alternative to formulate oil based drilling mud with necessary rheological properties, compatible with existing mud additives and non-toxic to the marine life.

INTRODUCTION

The use of oil-based mud in drilling operation has increased significantly. Various types of low-toxicity oils had long been introduced to replace the more toxic mineral oils and diesel oil-based mud system which has proven toxic to the environment. This is solely due to the pressure from the enviromental regulations which do not allowed the discharge of any oil and oily cuttings into the sea. Thus, the introduction of vegetable oils including palm oil has been suggested as alternative fluids to overcome these problems.

The main advantage of vegetable oils is that they are generally regarded as non-toxic and contain no aromatic content and are widely used in the food industries. In addition, they are cheaper than any mineral oils.

Extensive research into such system have been carried out by various companies. In 1988, admixture of crude palm oil (CPO) with mineral oil (Shellsol-DMA) in a ratio of 15:85 has been tested for the properties as drilling fluids by Sarawak Shell Berhad and Sabah Shell Petroleum Company. The results showed that it is feasible to use palm oil to formulate an oil-in-water emulsion drilling fluid. In addition, a saving of M$24(US$9.60) per barrel of base oil can be achieved.(1)

International Drilling Fluid (IDF) had introduced Trudrill MVO System recently (2). It is an all-oil based fluid that uses 'palm oil derivative' and which does not contain an emulsified brine phase.

This paper presents the laboratory study that had been undertaken to determine whether the palm derivatives is an acceptable alternative to diesel and mineral oils. Two types of palm oil derivatives i.e methyl ester of crude palm oil (m.e of CPO) and methyl ester of Palm Fatty Acid Distilled (m.e of PFAD) were being tested in this study. The tests are conducted to measure the physical properties of the palm oil derivatives and their properties as an invert emulsion drilling fluid system. The properties measured are aniline point, pour point, flash point and kinematic viscosity of the base oils. mud tests and consistometer tests are being carried out to evaluate the resulting muds performance.

BASE OIL PROPERTIES REQUIREMENT

Guidelines of the basic requirements for base oil for drilling fluid had been discussed in detail by Johanscvik and Grieve[3] and are resummarized as follows:

a. Non-toxic and low aromatic content

   Base oil should have total aromatic hydrocarbon content of less than 5%. It should be non-acutely toxic in a standard 96 hr LC 50 toxicity test, performed using 100% water-soluble fraction of the base oil.

b. The base oil must be able to form a stable emulsion.

c. Kinematic viscosity

   It should be as low as possible. This allows the oil-based mud to be formulated at lower oil/ water ratios and gives better rheology (lower plasticviscosity), especially at low mud temperature.

d. Flash point

   It should be greater than 100°F. Higher flash point will minimize fire hazards as less hydrocarbon vapours is expected to generate above the mud.

e. Pour point

   It should be lower than the ambient temperature to allow pumpability of mud from storage tanks.

f. Aniline point

   It is the temperature at which an equivalent mixture of oil aniline soluble in each other. Generally, the less saturated hydrocarbon (usually with lower heating value) will mix more readily aniline point. To minimize the deterioration of rubber components on the rig, the base oil should have an aniline point of above 65°C.

g. Nonfluorescent

   Fluoresence of the base oil is undesirable because it inhibits the ability of the well-site geologist to detect native hydrocarbons when evaluating drilling cuttings.

RESULTS

The properties of palm oil derivatives i.e methylester of CPO and PFAD had been tested. Table 1 list their properties together with mineral oil and diesel oil (no.1) for comparison. Base oil required properties were also stated.

Fig. 1 shows the effect of temperature on the kinematic viscosity of the methyl esters, mineral oil and diesel oil. At ambient temperature, the viscosities of the methyl esters are very high (about 7 cST) when compared with disel and mineral oil. Both of the methyl esters having viscosity of around 4.6 cST at 40°C. This value seems too high to produce a low plastic viscosity mud system. The high viscosity problem may be solved by various methods that we will discuss later. However, it shows that the relative viscosity differences gradually decreased with increasing temperature and thus possess nearly similar viscosity values at higher temperature. (as determined with a consistometer.)

The emulsion stability of the oils is tested using the Herschel Emulsifier in accordance to ASTM D 1401.A40-ml of distilled water with added emulsifier are stirred and minced for 5 minutes at two separate temperature i.e 30°C and 54°C in a graduated cylinder. The stirer speed is 1500 + 15 rpm. The time required for the separation of the emulsion formed is recorded. Fig.2A and Fig.2B compare the graph of emulsion volume vs time of separation taken by the base oils at 30°C and 54°C respectively. It shows that the methyl esters have stable emulsion and the stability of emulsion decreases with increasing temperature.

The initial testing (Table 2) of the base mud systems are carried out to find a suitable formulation and then comparison tests on the mud properties using various base oils will be carried out. The mud additives from two drilling-fluid companies were used to prepare the formulations. The results are presented in Table 3. Fig. 3 through 8 shows the properties comparison. Generally, the palm diesel muds show higher gel strength and also slightly high viscosity values. Higher filtrate volumes and thicker filter mud cakes are also observed.

A study of the mud rheologic properties using the high temperature, high pressure consistometer to simulate down hole condition is undertaken. Figure 9 shows the consistometer test results of consistency at various temperatures. Two samples had been tested for comparison: the palm based mud (Test #2) and another treated based mud sample with 2 ppb of commercial oil-mud thinner. The consistency increased with temperature. The base mud tends to became gelled at higher temperature. The second treated base mud shows lower consistency over temperature and exhibit a more stable consistency pattern. The hold down pressure is maintained at 6000 psi throughout the tests.

DISCUSSION

Based on the results of laboratory testing, both of the methyl esters (palm oil derivatives) show some promise for use as oil-based-drilling fluid. Promising qualities of the methyl esters are high flash point, non-toxic, availability with low price and also good emulsion stability. However, both the methyl esters exhibit some undesired properties that needs further investigation. This include high viscosity, high pour point and low aniline point.

The high pour point of the palm oils would make the oil undesirable for use in cold climates. However, this properties is not critical in hot climates region such as South East Asia. Another undesirable properties is the low aniline point value where it indicates the possibility of deterioration of rubber products on the rig. Special care should be strictly outlined to eliminate this problem. All rubber components in the drilling system should be substituted by neoprene or similar components to avoid any possible failure due to rubber degradation.

As discussed earlier, the kinematc viscosity of the methyl esters is very high. (about 4.6 cST @ 40°C). The application of these oils might cause a high PV in the mud system especially at low-temperature drilling. The problem may be solved by the following methods:

a. dilution by mixing with thin mineral oil. (not so much recommended as the introducing of mineral oil will increase the toxicity level of the mud system.)
b. find other low-viscosity palm derivatives.
c. emulsification of a portion of the oil in water.
d. thinning with appropriate thinner.

The flash point of the palm diesel oils is higher than that of mineral oils. (Table 1) This will reduce the hazards of oil vapour (hydrocarbon fumes and mists) in the mud processing areas thus provide a safer working condition to the rig workers. (3)

From the emulsion characteristics study, the methyl esters show good emulsion stability that is comparable or better than the mineral oils. (Fig.2). This stable property can be proved by the absence of water from the HTHP filtration test although the values are not as good as diesel, when tested with the FANN ESV meter. However tests must be conducted further to ensure this property is maintained at higher temperatures and pressures.
Initial tests from the consistometer data are illustrated in Figure 9. It shows that the base mud gelled at higher temperature. To remedy this, 2 ppb of oil base mud thinner was added. This results in a reduction of consistency and thus exhibits a more stable viscosity pattern. Further steps should be taken to determine the appropriate thinner with suitable concentration.

CONCLUSION

1. From the laboratory tests and properties comparison, both palm oil derivatives were found to have acceptable base oil properties. However, further works such as contamination tests are needed to test this mud system.

2. Both the palm derivatives shows good emulsion characteristics i.e stable emulsion when tested with the Herschell Emulsifiers.

3. The flash-point of the palm oils is higher than that of mineral oils, will considerably reduces the hazard of oil and this vapour (hydrocarbon fumes and mists) in the mud processing areas thus provide a safer working conditon to the rig workers.

4. From the consistometer test results, it can be concluded that the high PV, high gel palm muds can be treated to some extend by adding appropriate concentration of thinner.

5. The search of other palm oil derivatives that would show properties improvement including lower viscosity is highly recommended, Altering the base components of the esterification reaction would also become an interesting idea.

ACKNOWLEDGEMENTS

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TABLE 1 : Base Oil Physical Properties

Property	Base oil Required Properties	m. e of CPO	m. e of PFAD	Diesel Oil	Mineral Oil	Test Method
Specific Gravity		0.873	0.873	0.8364	0.7906	ASTM D1250
Aniline Point, C	> 65 C	15	12	63	73	ASTM D611
Pour Point, C	< Ambient temp.	14 C	13.5 C	-45 C	-54 C	ASTM D 97
Flash Point, C	> 66 C	172 C	169 C	76 C	79 C	ASTM D93
Fire Point, C	> 80 C	180 C	178 C	108 C	93 C	ASTM D93
Kinematic Viscocity @ 40 deg.C, cST	2.3 - 3.5	4.6	4.7	3.4	1.6	ASTM D445
Aromatic Content, %	4 - 8	-	-	30	0.9	ASTM D1250

Figure 1:

GRAPH KINEMATIC VISCOSITY VS TEMPERATURE

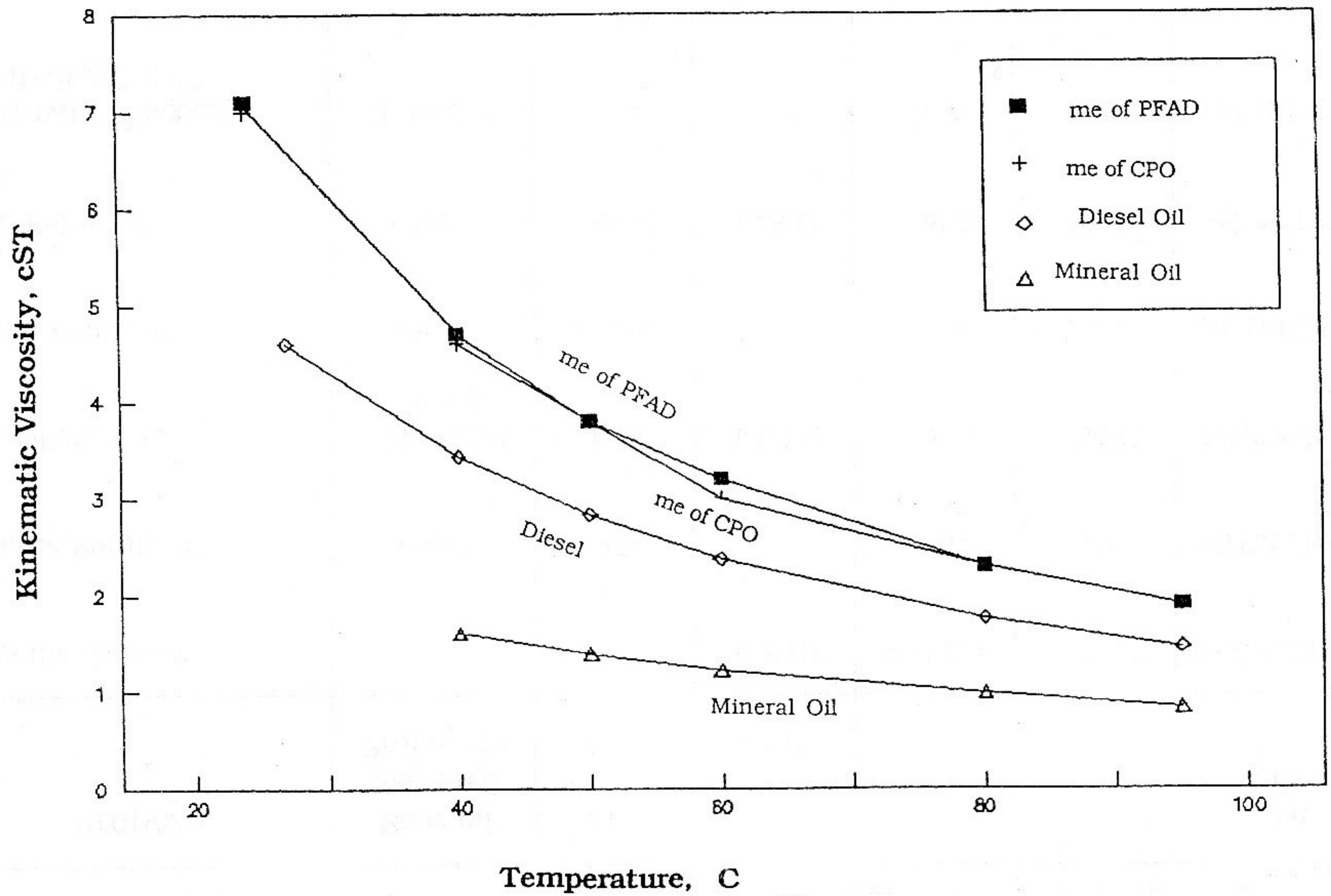

FIG. 2A:
EMULSION VOLUME VS TIME
test temp.: 30. 0 C

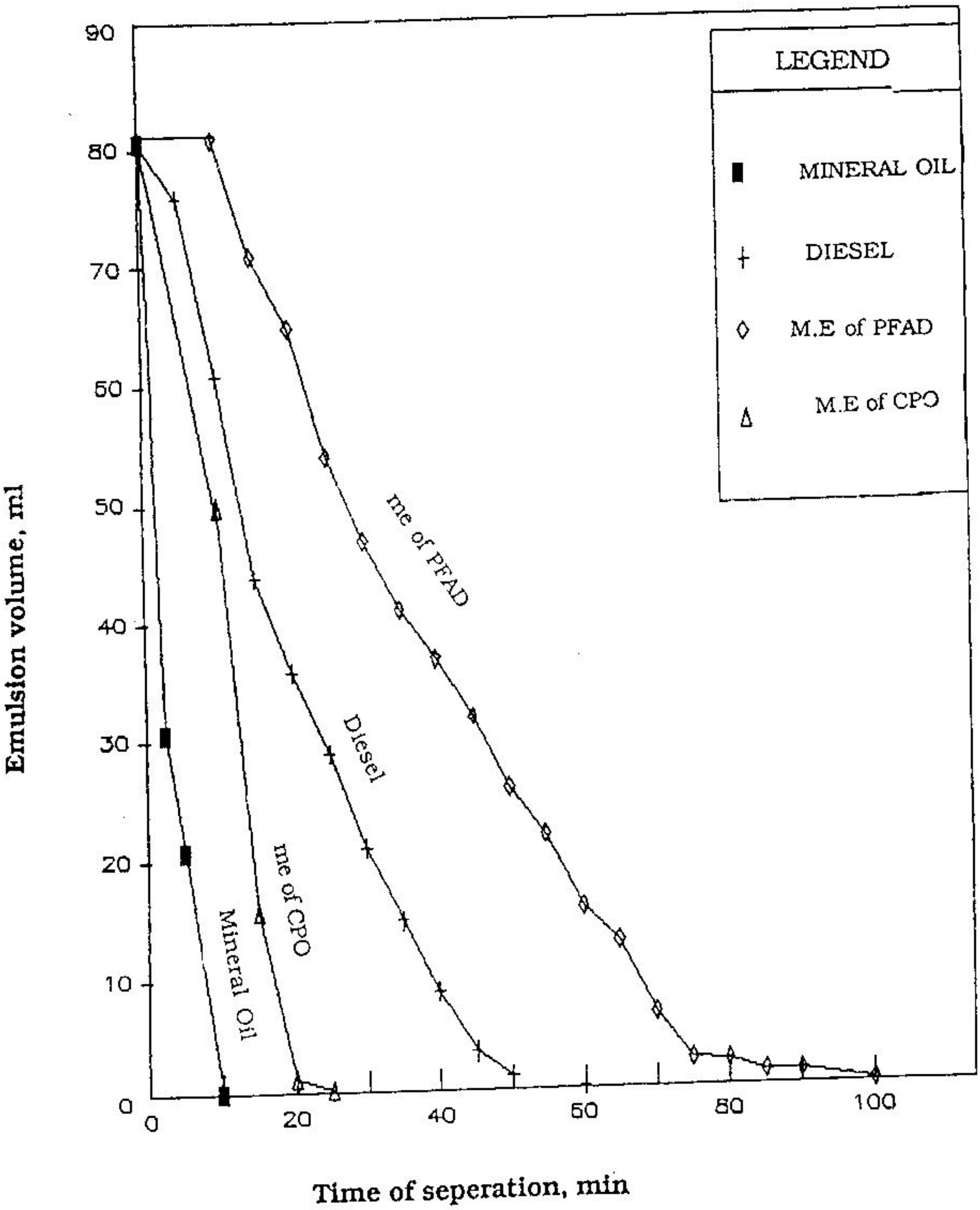

FIG. 2 B

EMULSION VOLUME VS TIME

TEST TEMP.: 54.0 C

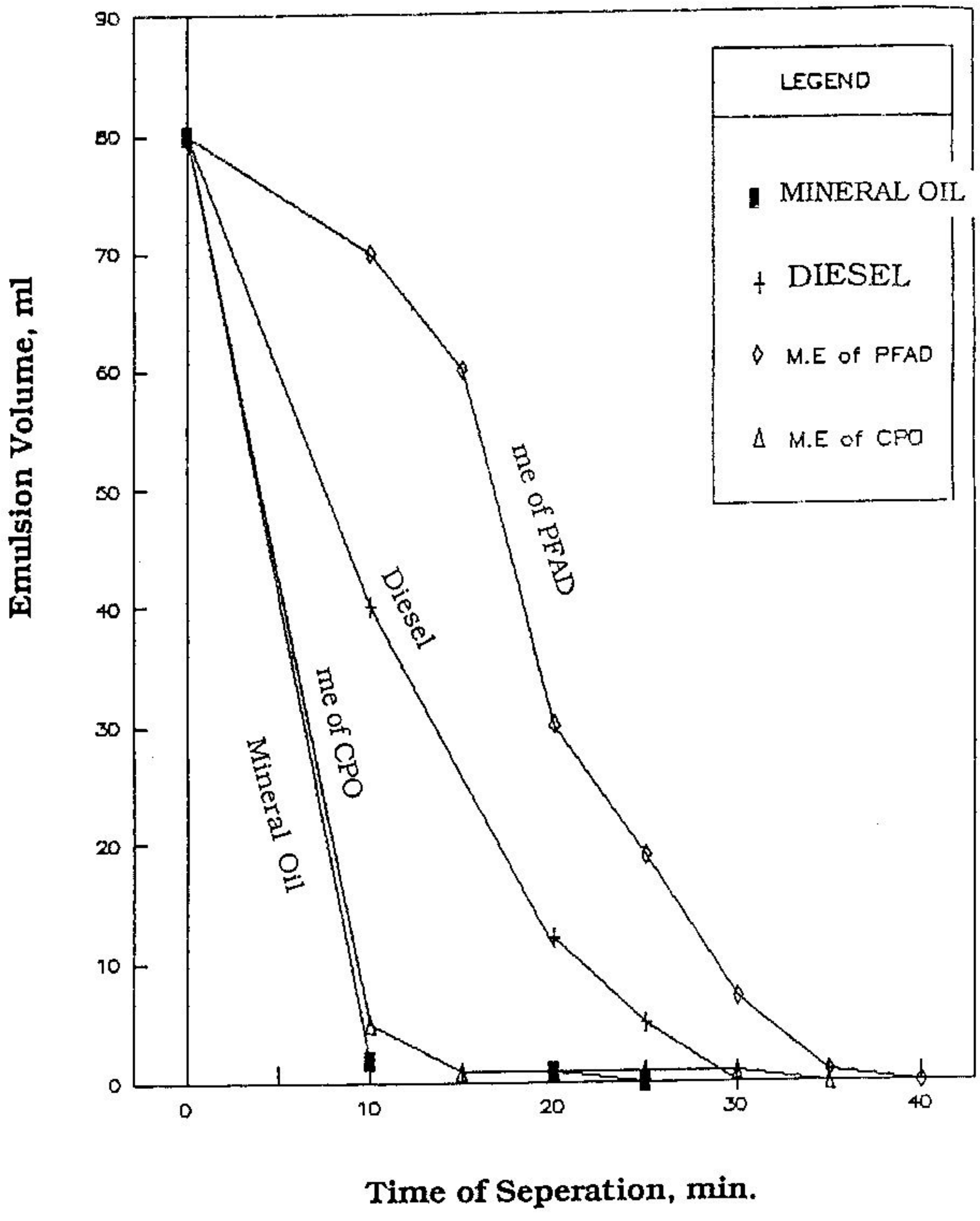

TABLE 2 : Mud Formulations (10.5 PPG, OWR : 85/15)

Compositions	Test #1	Test#2	Test#3	Test#4
Diesel	0.66 bbl	-	-	-
me of CPO	-	0.66 bbl	-	-
me of PFAD	-	-	0.66 bbl	-
Mineral Oil	-	-	-	0.66 bbl
Primaru Emulsifier, lb	10	10	10	10
Secondary Emulsifier, lb	8	8	8	8
Lime, lb	5	5	5	5
Filtration Loss Control Agent, lb	6	6	6	6
Viscosifier, lb	5	5	5	5
Oil-wetting agent, lb	2	2	2	2
Water	0.14 bbl	0.14 bbl	0.14 bbl	0.14 bbl
Calcium Chloride, lb	15	15	15	15
Barite, lb	192	192	192	192

Table 3 : Mud Properties Comparison

	Test #1		Test#2		Test#3		Test#4	
	BHR	AHR	BHR	AHR	BHR	AHR	BHR	AHR
PV. pphsf	22	25	29	35	28	42	19	26
YP. pphsf	4	10	10	35	8	39	2	4
Gel (10s/10m)	4/6	7/14	8/6	21/28	5/7	25/30	4/3	4/11
ESV. volts	1140	940	1060	770	960	880	910	860
MW. ppb	10.5	10.5	10.5	11.6	10.5	10.5	10.5	10.5
Excess lime	2.2		1.4		1.5		2.1	
Filtrate ml oil		2.0		11.6		10.2		1.0
(250F. 500 psf) ml water		-		-		-		-
Mud cake tickness (per 32 in.)		2.25		5.45		6.25		1.50

BHR = Before Hot Rolling AHR = After Hot Rolling

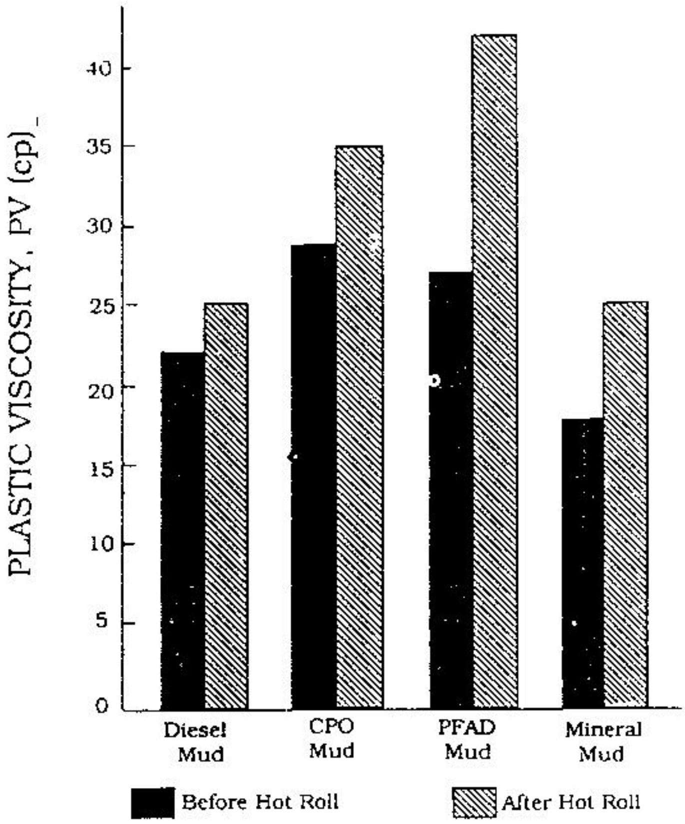

FIG.3: PLASTIC VISCOSIT

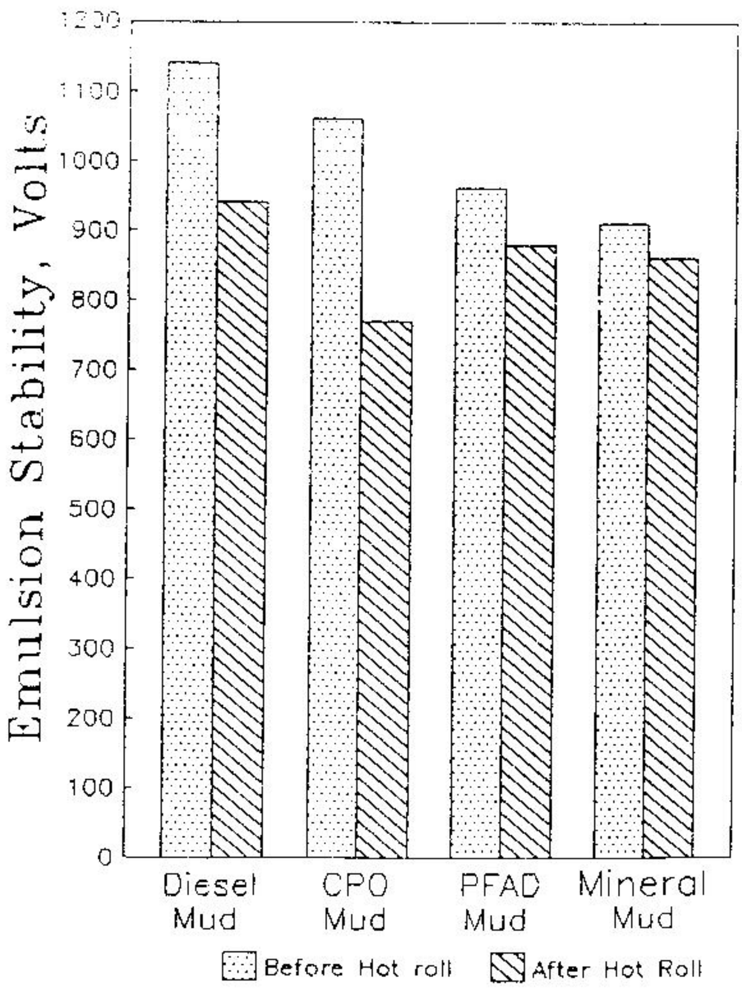

FIG. 4: Emulsion Stability

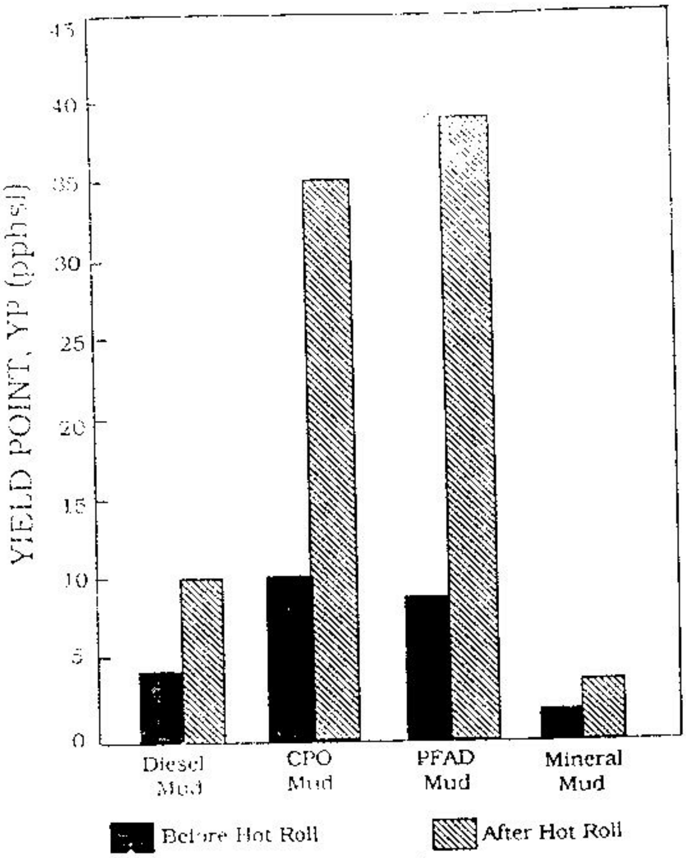

FIG.5: Yield Point

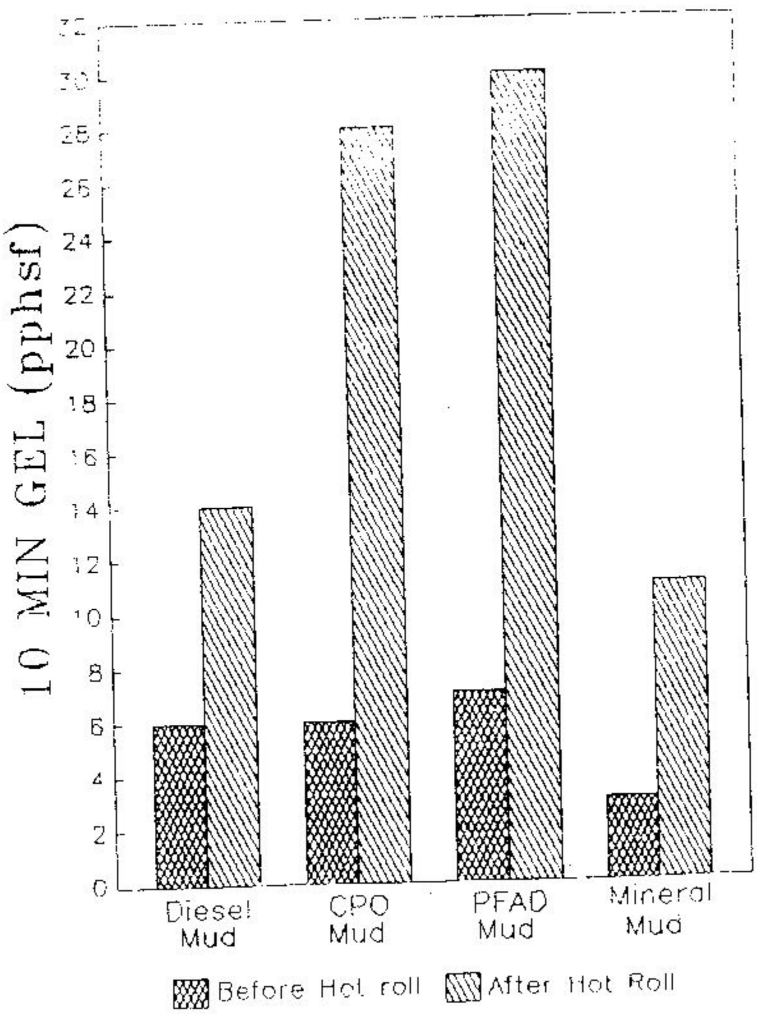

FIG.6 : 10 Minutes Gel

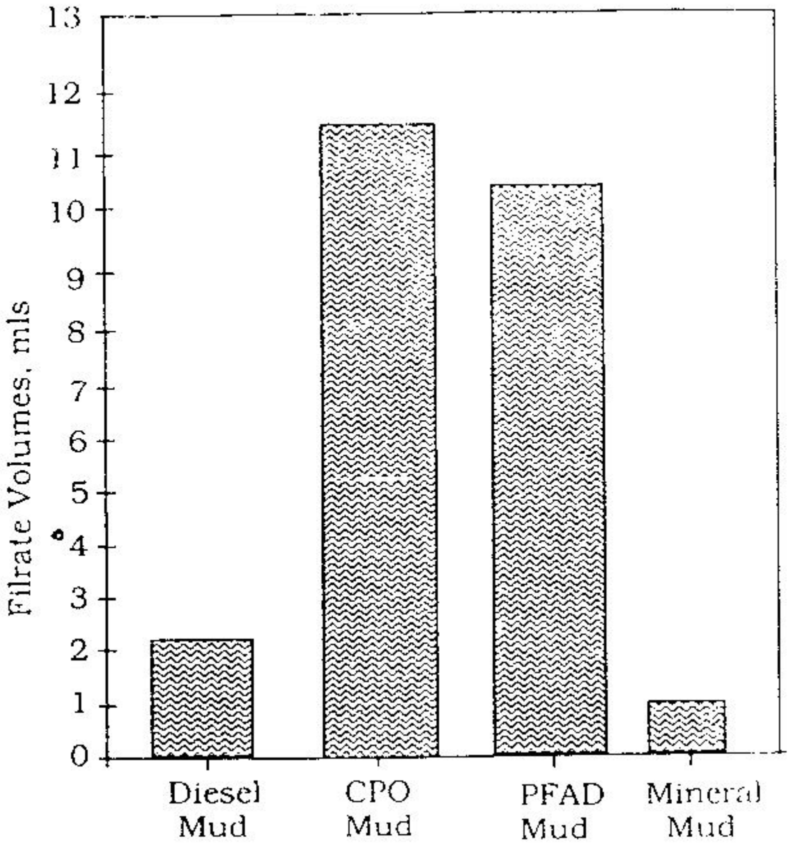

FIG 7: Filtrate Volumes

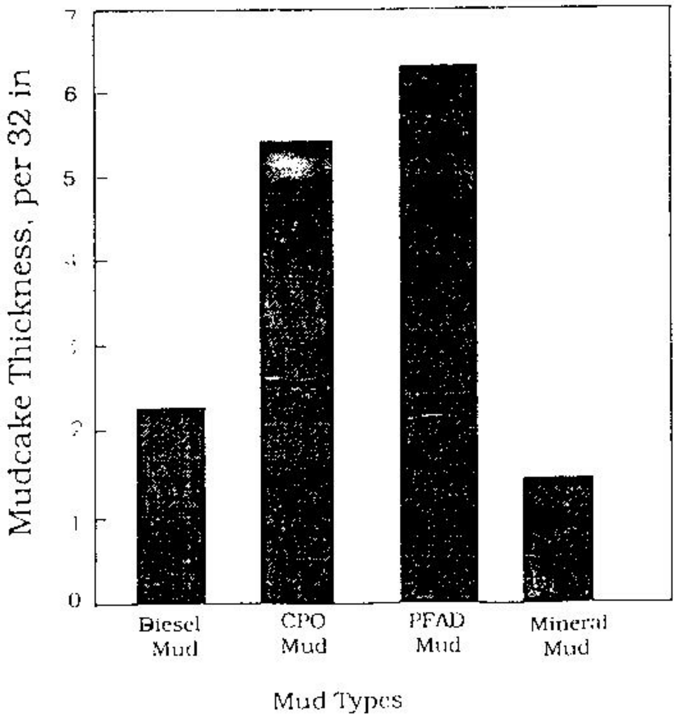

FIG.8: Mudcake thickness

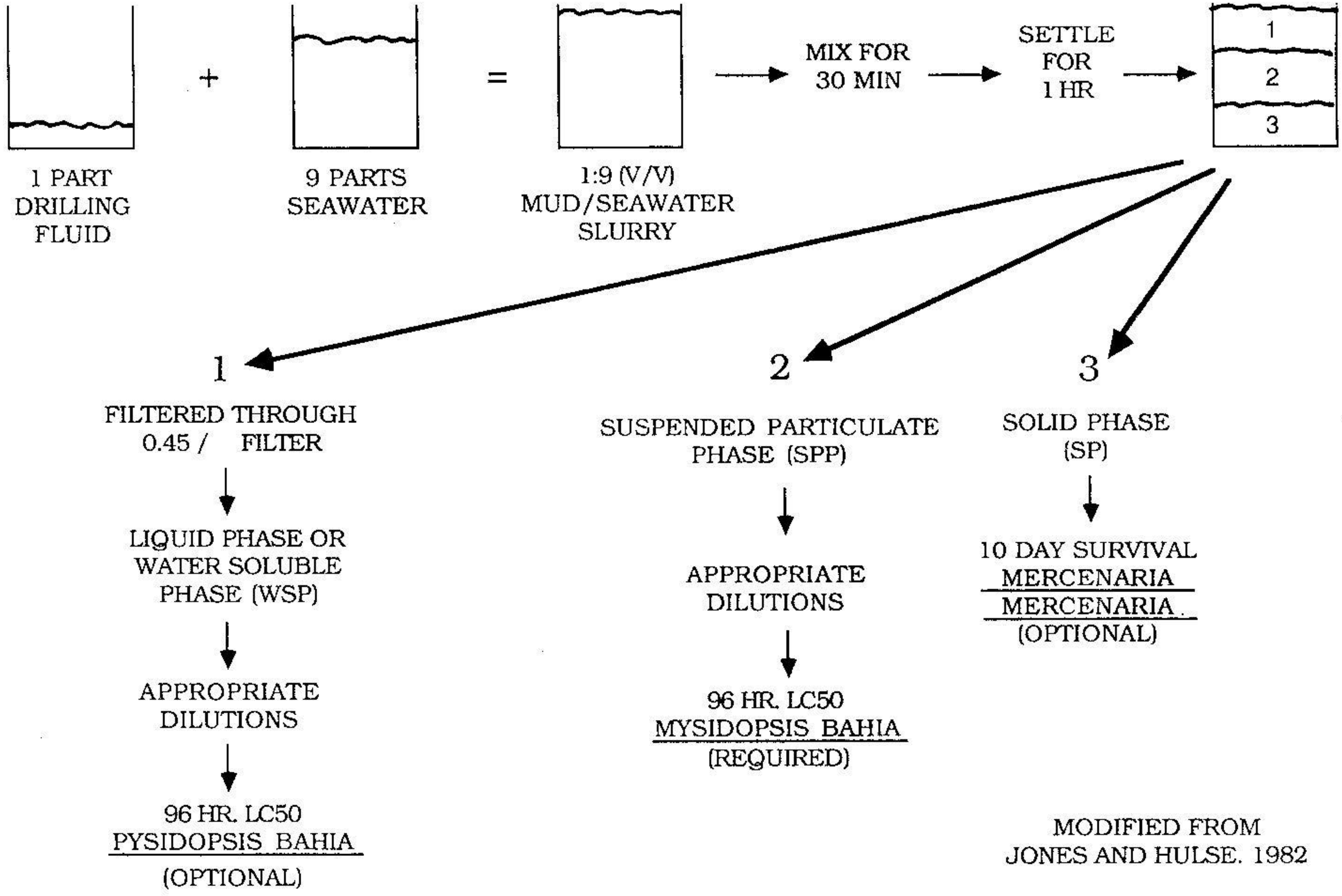

FIGURE
SCHEMATIC OF THREE PHASE BIOASSAY FOR DRILLING FLUIDS

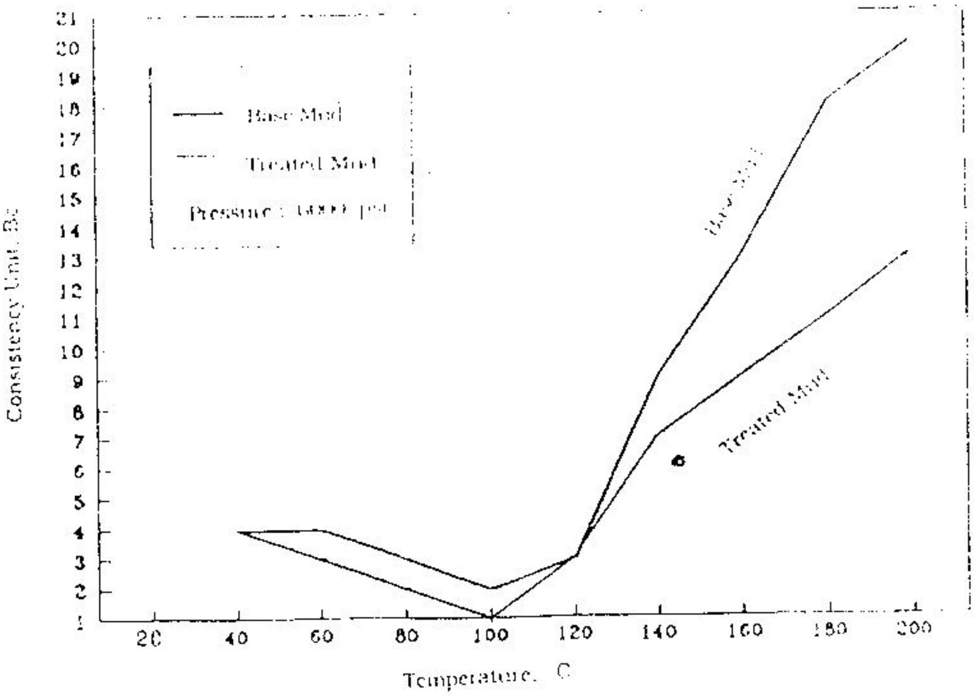

FIG.9 : Consistometer Data

Parameter	Chemical Properties
salinity	29 ppt
Ph	8.5
turbidity	0.06 NTU
temp.	24 C
dissolved oxygen suspended solids total alkalinity	6.5 mg/1

Table 10: Chemical Properties of the Artificial Sea Water Used in the SP 10-d Toxicity test.

FIG. 1 : Survival Percentage of _Anadara granosa L_ After 10-days of Ecposure