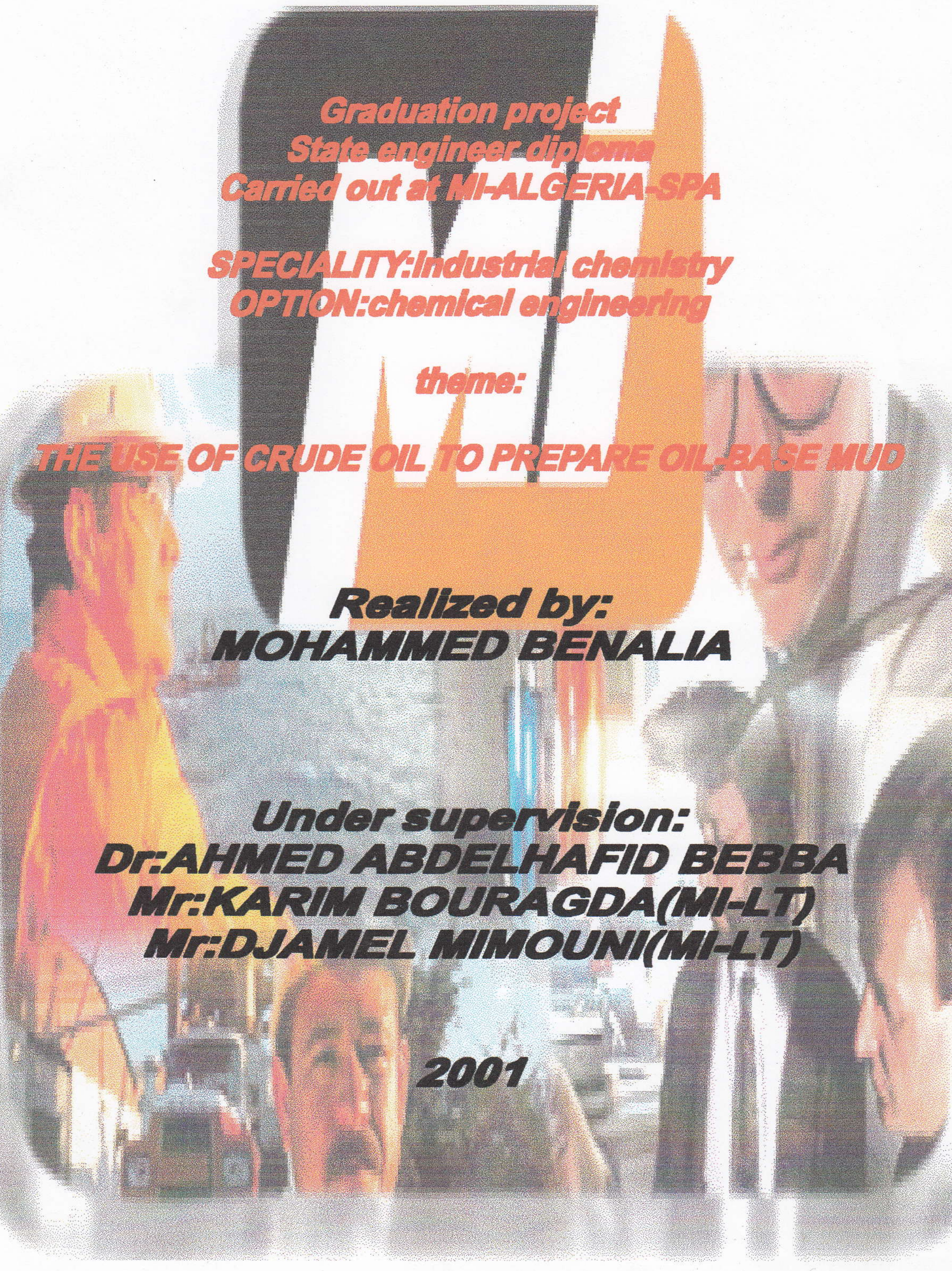
ALGERIAN DEMOCRATIC AND POPULAR REPUBLIC

MINISTRY OF HIGH EDUCATION AND SCIENTIFIC RESEARCH

UNIVERSITY OF OUARGLA
INDUSTRIAL CHEMISTRY INSTITUTE



Graduation project
State engineer diploma
Carried out at MI-ALGERIA-SPA

SPECIALITY:industrial chemistry
OPTION:chemical engineering

theme:

THE USE OF CRUDE OIL TO PREPARE OIL-BASE MUD

Realized by:
MOHAMMED BENALIA

Under supervision:
Dr:AHMED ABDELHAFID BEBBA
Mr:KARIM BOURAGDA(MI-LT)
Mr:DJAMEL MIMOUNI(MI-LT)

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DEDICATION

TO ALL THOSE WHO TRY TO MAKE SOME THING FROM ME, AND I Am sorry IF I DID NOT REALIZE THEIR OBJECTIVES.

AKNOWLEDGMENTS

The first thanks is for my ***GOD*** *for helping me to finish my study ,and to realize this subject.*

Many thanks to my parents who are sacrificed for my dreams ,and my happyness .

I like to say many thanks to many people for their precious help:

- *Starting with you RAFIK GAAFAR ; the person who opened the door to me; for your great help.*
- *To you KARIM BOURAGDA ; for your subject proposel ,patient And for your precious help.*
- *You DJAMEL MIMOUNI ;cause you are very helpful ,kind and strict in your work.*
- *You HAMED ABOU HAIF ;for your advices,help and your Kindness.*
- *To you mr:BEBBA ,for your comprehension and your smart Behavir till the end.*
- *And you ZOUBIR MESSAOUDI,for your help,and your advices.*
- *Special thanks to you ;EDMOND MERDY ;for your scientific spirit.*
- *And you MARIO ANTONACI ;for your advices.*
- *To all those who I knew in M-I ALGERIA ,during the training periode(hamza,tarek,sadek,reda,noureddine,adel,kamel, Abdessalem,rachid,ahmed,ibrahim,nadji,morad,zoubir)*
- *I D'ont forget you SAMIR CHERFOUH,the person who I respect him forever.*
- *To all my friends ,my school teachers,and university Professors.*
- *To all students of ouargla university.*

M-I PRESENTATION

THIS IS M-I [5]

M-I LLC (M-I) is a company limited liability company owned by tow members: Smith acquisition corp(60%,owner), a subsidiary of Smith International.Inc and Schlumberger MI Inc(40% owner, a subsidiary of Schlumberger Ltd.
M-I's operations are conucted in 50 countries arouned the world and include the supply of drilling fluid, drill-in fluids, completion, Work over fluids and additives as well as field engineering and technical support .M-I is also a significant worldwide producer of barite and bentonit ,which is marked both to the oil filed industry as well as to industrial markets.
SWACO, a division of M-I llc ,is the industry leader in solids control ,pressure control ,rig instrumentation ,and treatment service.

M-I Completion fluids provids specialized fluids used in completion and work over operations, as well as the technical services at the wellsite.

M-I Completion fluids olso offers a full line of filtering equipment and services to ensure that our customers' requirments for clar-ity and purity are met.

M-I Algeria S.p.A. is formed as a joint venture between M-I Drilling fluid and Sonatrach.

SUBJECT PRESENTATION AND OBJECTIVES OF STUDY

This subject originally requested from berkin group (ANADARCO) to formulate mud by using crude oil as the base fluid to meet the properties which we will discuss about it later on .

In reality gas oil (diesel) is used to formulate oil-base mud ,and through this work we will try to answer about this question :
Can diesel be replaced by crude oil one day ? .

For the following reasons we want to replace diesel by crude oil:

- Because of crude oil is cheap than diesel .
- To avoid the shortage of diesel and to reduce the costs of transportation from the source to the rig ,since several cases of rigs are far from the source of diesel .

MI –technical department has done its best to achieve the required specifications for the mud by using crude oil.
Several formulations were tested ,the best ones were chosen and would be discussed later on .

CHPTER I

AN INTRODUCTION TO DRILLING FLUID

INTRODUCTION
DRILLING FLUID FUNCTIONS
PROPERTIES OF DRILLING FLUID
DRILLIONG FLUID RHEOLOGY
THE RHEOLOGICAL FLOW MODEL
PLASTIC VISCOSITY AND YIELD POINT
DRILLING FLUID CONTAMINATION
THE EFFECT OF TEMPERATURE AND PRESSURE

I-1-INTRODUCTION :

The objectives of a drilling operations are to drill, evaluate and complete a well that will produce oil and/or gas efficiently. drilling fluids perform numerous functions that help make this possible. The responsibility for performing these functions is held jointly by the mud engineer and those who directe the drilling operation.

The cheif duty of the mud engineer is to assure that mud properties are correct for the specific drilling environment. the mud engineer should also recommended drilling practice changes that will help reach the drilling objectives.

I-2-DRILLING FLUID FUNCTIONS :[1-3]

Drilling fluid functions describe tasks wich the drilling fluid is capable of performing, although some may not be essential on every well.

Though the order of importance is determind by well conditions and current operations the most common drilling fluid functions are :

1-Removal of cuttings from the well.

2-Control formation pressures.

3-Suspension of cuttings and weighting material.

4-Isolate the fluids from the formation.

5-Cool and lubricate the bit and drill solids.

6-Support part of the weight of the drill and casing string.

7-Maximise penetration rates.

8-Control corrosion rates.

9-protect the formation.

10-Secure maximise hole information.

11-Facilitate cementing and completion.

12-Minimize impact on the environment.

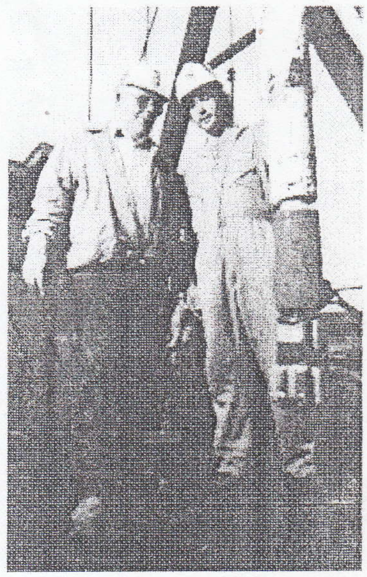


fig 01

1-REMOVE CUTTINGS FROM THE WELL :

One of the most important functions of the drilling fluid is to efficiently remove the freshly drilled cuttings from the bit and transport them in the annular space between the drill pipe and the hole to the surface. where they can be removed.

2-CONTROL FORMATION PRESSURES :

The formations are composed of solids of varying porosity. Where the pores are filled with liquids or gases. the rock and pore fluids are under pressure arising from the rocks overlying theme and from movements of the earth's crust. the columm of drilling fluid in the hole and the density of the fluid. This pressure is used to control the flow of gas, oil or water from the pores and makes an important contribution to the stability of the well bore.

The flow of the drilling fluid during circulation and movement of drill string in and out of the hole creates pressure differentials that are functions of the flow properties of the fluid and the rate of circulation or speed of drill pipe movement.

3-SUSPENSION OF CUTTINGS AND WEIGHTING MATERIAL :

The fluid should have the property to form a reversible gel structure when it is stationary. so that the cutting and weighting material remain suspended. the structuring should be reversible so that re-circulation can be easily established. The cuting should also be easily removed at the surface by the solids remove equipment.

4-ISOLATE THE FLUIDS FROM THE FORMATION :

Because of safety consideration. the hydrostatic pressure exerted by the drilling fluid in the well is usually designed to be greater than the pressures existing in the formation.

Under these conditions the drilling fluid will try to penetrate the rock as a whole Fluid. or will from filter cakes and the filtrate will penetrate. materials have to be incorporated in the drilling fluid to minimise these effects.

5-COOL AND LUBRICATE THE BIT AND DRILL SOLIDS :

During the drilling operation. a considerable amount of heat is generated by frictional forces of the rotaring bit and drill string. this heat cannot be totally absorbed by the formation and must be conducted away by drilling fluid.

Lubrication is obtained through the deposition of a slick wall cake. and through the use of various. specially formulated additives. addition of diesel or crude oil may also prove beneficial. but this practice is becoming less common due to ecological restriction.

6-SUPPORT PART OF THE WEIGHT OF THE DRILL AND CASING STRING :

The natural buoancy of a drilling fluid aids in supporting part of the weight of the drill string or the casing string. the degree of buoyancy is proportional to the fluid density.

Any increase in fluid density creates an increase in the buoyancy factor. and reduces the load on the surface equipment. the importance of this particular function becomes more apparent as depths increase.

7-MAXIMISE PENETRATION RATES :

The drilling fluid is so intimately involved in the drilling process that it is inevitable that a wide range of fluid properties will influence the rate of penetration. a part from the mechanical consideration, such as the type bit, weight on the bit and rate of rotation.

8-CONTROLE CORROSION RATES :

The fluid should be non-corrosive to the drill pipe, casing and drilling equipment. additives may be used that will specifically give protection.

9-PROTECT THE FORMATION :

The drilling fluid will come into intimate contacte with the formations being drilled. if a stable hole is to be obtaind. Then interactions between the fluid and the formations should be minimal.

10-SECURE MAXIMISE HOLE INFORMATION :

An important objective in drilling a well is to secure the maximum amount of information about the types of formations being penetrated and the fluids or gases in the pores this information is obtained by analysis of the cuttings. dissolved gases or oil, and by electric logging technology.

11-FACILITATE CEMENTING AND COMPLETION :

The drilling fluid must produce a wellbore into which casing can be run and cemented effectively and which does not impede completion operations.

Cementing is critical to effective zone isolation and successful well completion. During casing runs, the mud must remain fluid and minimize pressure surges so that facture-induced lost circulations does not occur.

12-MINIMISE IMPACT ON THE ENVIRONMENT :

Eventually, drilling fluid becomes a waste product, and must be disposed of in accordance with local environmental regulations. fluids with low environmental impact that can be disposed of near the well are the most desirable.

I-3-PROPERTIES OF DRILLING FLUIDS :[2]

The large number of functions that have to be performed has inevitably led to the formulation of complexity arising from the different environments encountred in varios geological situation .

I-3-1-DENSITY :

The correct drilling fluid density is dependent on the down hole formation pressures strong, competent formations may be drilled with air. but over-pressured shales and high pressure formations may require a fluid with a specific gravity of up to 3.0 ppg .

The density is adjusted by soluble salts or by addition of solids termed « weighting agent ».

I-3-2-VISCOUS OR FLOW PROPERTIES :

These will be dependent on the depth of the hole and the annular velocities obtainable. In the upper hole, water alone may be sufficient. but at greater depths more viscous fluids are required. deep wells, angled wells, high penetration rates and high temperature gradients all creat conditions requiring close attention to the flow properties.

I-3-3-FLUID LOSS CONTROL :

This is a fundamental property of the drilling fluid and becomes important when porous formations are being drilled. particularly when those formations may contain gas or oil . special consideration may have to be given to the high temperature and high pressure fluid loss in particular conditions.

I-3-4-FORMATION PROTECTION :

The chemistry composition of the fluid must be such there is minimal interaction with the formation. Zones of salt,anhydrite($CaSO_4$) dolomite, limestone, shale and sand may be encountered. each zone differs in its chemical and mechanical properties and each may require different and special drilling fluid properties.

I-3-5-TEMPERATURE TOLERANCE :

Temperature increase with depth quite rapidly in certain areas. the additives and properties must be chosen so that they are stable at the down-hole temperature.

I-4-COMPOSITION OF DRILLING FLUID :[2,4]

The required function and properties can be achieved by a wide range of fluids with differing composition. they are composed of various combinations of solids, liquids and gases. and are classified according to the constitution of the continous phase.

I-4-1-WATER-BASED FLUIDS :

The continuous phase is water, these constitute the most commonly used drilling fluid type and are usally referred to as drilling muds. they are classified according to the salinity of the water into fresh water and salt water fluids. the properties are controlled by the addition of clay minerals, polymers and surfactants.

I-4-2-OIL BASED FLUID :

When the continuous phase of drilling is oil , it classified as an oil-based fluids commonly, it will contain water as the discontinuous phase in any proportion up to 50% . those fluids containing over 5% water are classified as oil-base emulsion drilling fluids , or invert emulsion fluids.

I-4-3-GAS-BASED FLUIDS :

When the continuous phase of the drilling fluid is gas. it is invariably associated with different levels of water, with added surfactants or foaming agents the gas may be air or natural gas.

Gas drilling has particular application for competent rocks .such granite and for low pressure water or gas wells. Or extreme circulation zones. penetration rates can be very high.

I-5-DRILLING FLUID RHEOLOGY :

I-5-1-DEFINITION :[1]

Rheology is defined as the science of the deformation and flow of matter. when applied to drilling fluid , rheology deals with the relationship between flow rate and flow pressure and their combined influence on the flow characteristics of the fluid.

I-5-2-THE FLOW REGIMES :[1,2]

A drilling fluid is generally assumed to be in either laminar or turbulent flow depending on the flow rate, the flow pressure and the relative size of the flow channel.

I-5-2-1-LAMINAR FLOW :

Is generelly associated with low fluid velocities such as found in the annular regions of a well bore, and with fluid movement in uniform layers. in laminar flow the force required to induce flow increases or the fluid velocity and fluid viscosity increase. this effect is demonstrated graphically (see figure).

In laminar flow the fluid particals lend to move in straight lines parallel to the direction of flow . the layer nearest to the wall of the flow channel tends to move at a lower velocity than the layer immediately next to it with highest velocity existing in the centre of the flow channel.

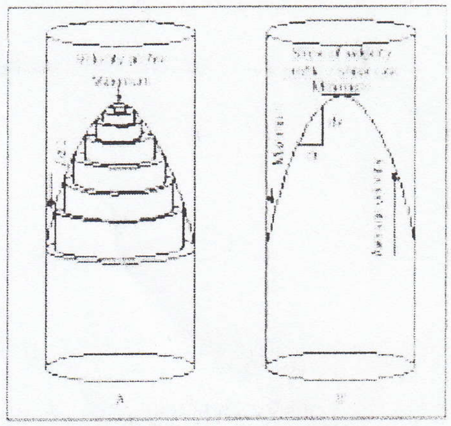


fig 02 : Newtonian velocity profile (laminar)

I-5-2-2-TURBULENT FLOW :

Occurs at high fluid velocities and is characterized movement of the drilling fluid particals. in turbulent flow the amount of force required to induce movement increases linearly with the fluid density and the square of the fluid velocity.

Although a flowing fluid is generally considered to be in either laminnar or turbulent flow ,there existe a very clear trantional period between the two regimes .

This transition therfore occurs at some critical velocity.wich is largely governed by the ratio of the fluids inertial forces to its viscous forces ,the ratio of this forces is commenly called the Reynolds number.

The reynolds number is defined by the formula :

Nre=D*V* §/µ

W here : D : Dimension of the flow channel.

V : Average flow velocity.

§ : Fluid density.

µ : Fluid viscosity.

I-5-3-VISCOSITY OF FLUID :[1,3]

All fluids exhibit a certain resistance to flow, which is loosely termed « viscosity », in general termes, a fluid is often described as being either « thick » or « thin ».a « thick » fluid, such as crude oil, has a much higher viscosity than a « thin » fluid, such as water.

Viscosity defined as the resistance of a fluid to flow, or we can defined it as the relationship between the shear stress (flow pressure) and the shear rate(flow rate) .

I-5-3-1-SHEAR STRESS :

Shear stress can be defined as the force required to over come a fluid resistance to flow. divided by the area that force is acting upon .

Shear stress(τ)=F/A

Where :

F : force applied

A : surface area subjected to stress(cm^2)

Unite of measurment : dynes/ cm^2

I-5-3-2-SHEAR RATE :

shear rate can be defined as the relative velocity of the fluid layers.or element,divided by their normal separation distance.

Shear rate(γ)=V/d

Wher :

V : velocity(cm/sec)

d : distance(cm)

Unite of measurment :1/sec

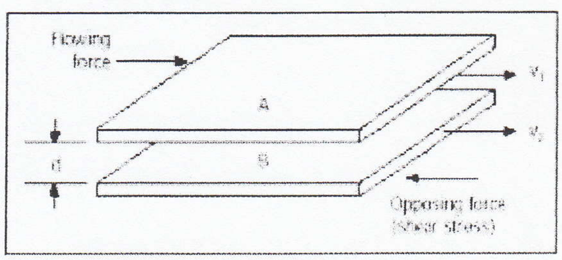


Fig 03: Shear rate and shear stress

Finally we can define viscosity like the relationship to shear stress and shear rate is illustrated in the following equation :

$\mu=\tau / \gamma$

Where :

μ : viscosity

τ : shear stress

γ : shear rate

Unite of measurment[μ]=dyne*sec/ cm^2=poise

I-5-4-TYPE OF FLUIDS :[1,2,4]

based on their flow behavior, fluids can be classified into two different types:

1-Newtonian

2-Non-newtonian

I-5-4-1-NEWTONIAN FLUID :

The simplest class of fluids is called newtonian. the base fluids (freshwater,seawater ,diesel oil,mineral oilsand synthitics) of most drilling fluids are newtonian. In these fluids the shear stress is directly proportional to the shear rate. As shown in figure(see figure). The points lie on a straight line passing through the origin(0,0) of the graph on rectangular coordinates.

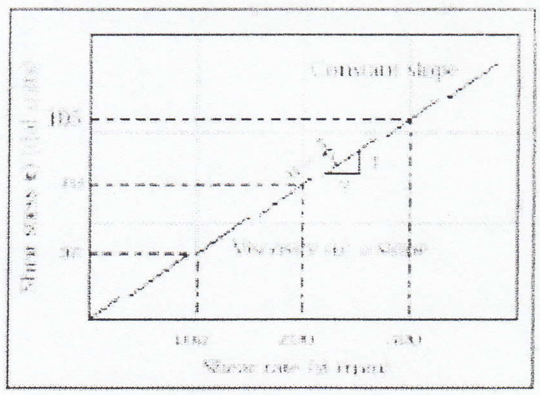


Fig 04: Newtonian fluid

Viscosity of newtonian fluid is the slop of this shear-stress/shear-rate line the yield stress(stress required to initiate flow) of newtonian fluid will always be zero.

I-5-4-2-NON-NEWTONIAN FLUID :

When a fluid contain clays or colloidal particls. these particles tend to « bump» into one another, increasing the stress or force necessary to maintain a given flow rate.if these particles are long compared to their thickness. the particale interference will be large when they are randomly oriented in the flow stream. however, as the shear rate is increased, the particles will « lime up » in the flow stream and the effect of particle interaction is decreased.this cause the velocity profile in a pipe to be different from that of water. in the center of the pipe, where the shear rate is low, the particle interferance is high and the fluid tends to flow more like solid mass.

Non –newtonian fluids exhibit a shear-stress/shear-rate relationship as shown in figure (see figure 05). the ratio of shear stress to shear rate is not constant but different at each shear rate.

NOTE :

Effective viscosity(μe) is defined as the ratio slop of shear rate at a particular shear rate. or a fluid's viscosity under specific conditions, these conditions include shear rate, pressure and temperarure.

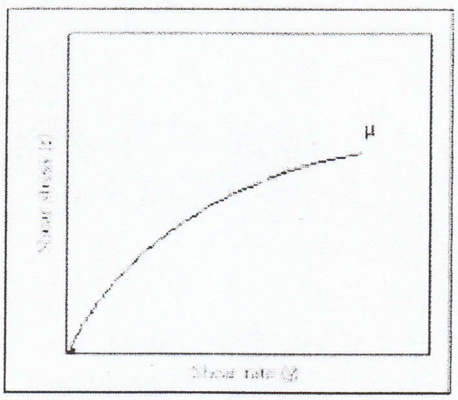


Fig 05: Non newtonian fluid

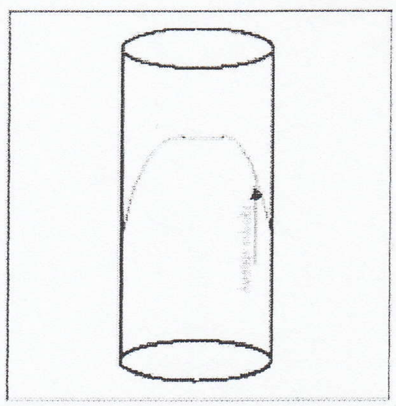


Fig06:Non newtonian velocity profile(laminar)

I-6- THE RHEOLOGICAL FLOW MODELS :[1,2]

A number of rheological flow models, based on mathimatical equations and relating shear stress and shear rate, have been developed in order to pridict fluid behaviour at shear rates other than those actually tested, those models of interest are :

1-Newtonian

2-Bingham plastic

3-Power low

1-THE NEWTONIAN MODEL :

Newtonian fluids, and the basic aspects of the newtonian model, have been previously discussed.

Newtonian fluid it will be remembered, always conform to linear equation while in laminar flow. newtonian fluids are defined by the equation :

Shear stress=viscosity*shear rate

Note that this equation predicts a constant relationship between shear stress, shear rate and viscosity.as the majority of drilling fluids do not conform to the laws governing newtonian fluids. the Newtonian model has no value in predicting the behaviour of drilling fluid.

2-BINGHAM PLASTIC MODEL :

The bingham lastic model has been used most often to describe the flow characteristics of drilling fluid. it is one the older rheological models currently in use. this model describes a fluid in which a finite force is required to initiate flow (yield point) and which then exhibits a constant viscosity with increasing shear rate (plastic viscosity). the equation of Bingham plastic model is :

$\tau = \tau 0 + \mu p \gamma$

Where : τ = Shear stress

γ =Yield point or shear stress at zero shear rate

μp = Plastic viscosity or rate of increase of sear stress with increasing shear rate(slope of the line)

γ = Shear rate

Converting the equation for application with viscosimeter reading, the equation becomes :

B=Yp + PV*300

Where :

B = Bingham plastic model

Yp=Yield point

PV=Plastic Viscosity

3-THE POWER LAW MODEL :

The power low model is cosiderably more complex than the bingham plastic model, but it provides for far greater accuracy in the determination of shear rates. the power low model assumes that all fluids are pseudoplastic in nature and may be determined by the following equation :

$\tau = k\gamma^n$

Where :

τ =shear stress

k = consistency index

γ = shear rate

n = power low index

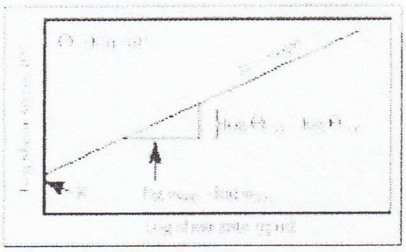


Fig 07: Log plot of power law model

The parameters « n »and « k », presented in the equation above, are constants basic to the power low model. « n » is called the power low index and indicates the fluid's degree of non-Newtonian behaviour of the fluid is considered to be Newtonian. in other words, the viscosity will decrease in shear rate. the power model actually describe three types of fluids, based on the « n » value :

n=1 : the fluid is Newtonian

n<1 : the fluid is Non-Newtonian

n>1 : the fluid is dilatent

The constant « k », the consistency index, is defind as the shear stress at a shear rate of one reciprocal second and is directly related to the fluid's viscosity at low rates of shear.

effectiveness of the fluid, « k » can be reported as dune-sec(n)/ cm^2 An increase in the value of « k » indicate an increase in the overall hole cleaning, or as $lbs/100ft^2$.

The constants « n » and « k » can be calculated from VGmeter data obtained at speeds of 300 and 600 rpm through use of the following equation :

-To caculate « n » :

$n=3.32 \log \Theta 300/\Theta 600$

-To caculate « K » :

$K=5.11*\Theta 300/511^n$(dynes-sec(n)/ cm^2)

Or :$K=\Theta 600/1022^n$ ($lbs/100ft^2$)

I-7-PLASTIC VISCOSITY AND YIELD POINT :

I-7-1-PLASTIC VISCOSITY :

Plastic viscosity is usally described as that part of resistance to flow caused by mechanical friction.

Plastic viscosity(PV) in centipoise (cp) or millipascale second (mpa.sec) is calculated from VGmeter as :

$PV(cp)= \Theta 600 - \Theta 300$

Where :

$\Theta 600$ = Viscosity in 600 rpm

$\Theta 300$ = Viscosity in 300 rpm

- Plastic viscosity is affected by :

-Solids concentration

-size and shape of solids

-viscosity of the fluid phase

-The presence of some long-chain polymers (poly-plus,hydroxyehtylecellulose(HEC) ,polypac,carboxymethylecellulose(CMC)).

-the oil to water (o/w) or synthitic-to water (s/w) ratio in invert-emulsion fluids.

-Type of emulsifiers in invert emulsion fluids.

- Plastic viscosity increased by :

-Hydratable drill solids(clay,shales).

-Invert drill solids (sand,limestone,...etc).

-Particales breaking thus increasing surface area and more friction.

-Weight material to increase density.

- Plastic viscosity decreased by :

-Removal of solids.

-shale shaker .

-desanders, desilters, clay jectors, centrifuges.

-lawering of gel strenght allows largrer particles to settle out.

-dilution of solids with water.

I-7-2-YIELD POINT :

Yield point, the second component of resistance to flow in a drilling fluid ,is a measurment of the electrochemical or attractive forces in a fluid, these forces are a result of negative and positive charges located on or near the partical surface.

Yield point is a measure of these forces under flow conditions and is depend upon :

-Types of solids and associated charges

-Concentration of these solids

-Dissolved salts, or electrical environment of these solids(concentration and types of ions in the fluid phase of the fluid).

Yield point (YP) in pounds per 100 square feet($lbs/100ft^2$) is calculated from fann VGmeter data as :

YP(lb/100ft2)=$\Theta 300$ - PV

Where :

$\Theta 300$:Viscosity in 300rpm

PV : plastic viscosity

Or in pascale :YP= 0.4788*($\Theta 300$ – PV)

- Yield point increased by :

-contaminants

-salts,cement,gyp,...etc.neutralizes charges of clay particles causing flocculation.

-clay particles fracturing causing residual forces to be left on particle edges resulting in flocculation.

-Hydratable drilled clay and shale increasing active solids

-Insufficient or overtreatment of chemicals

-Additional solids causing attractive forces to increase due to closeness of solids

- Yield point decreased by :

-Neutralization of broken bond valences by adsorption of negative ions on edges of particles (tanins ,lignin ,phosphates ,lignosulfonates)

-contamination by calcium or magnesium removed by precipetation of the ion causing flocculation-soda ash ,sodiumcarbonat,phosphates.

-Water can be used ,but it lowers mud weight(expensive).

I-8-DRILLING FLUID CONTAMINATION :

I-8-1-INTRODUTION :

A contaminant is defined as any undesirable component that causes a determinal effect when incorporated indrilling fluid. virtually any substance that is both undesirable and detrimental may be classified as a contaminant.

Contaminants are encontred at every phase of the drilling operation ; they exist in the drilled formation ,the water supplay and in the materials used to formulate and maintain the drilling fluid properties .contaminants can rapidly alter the physical and chemical characteristics of a drilling fluid, often in one circulation. In many cases, however, they may be tolerated for extanded periods with no apparent adverseffects .the severity of the problems experienced depends on the type of contaminant, the degree of contamination and the type of drilling fluid in use.

I-8-2-TYPE OF CONTAMINANTS :

As previously indicated ,potontial cotaminants exist in great numbers and depend on a number of related factors. for the purpose of simplification this discussion will centre on the more common contaminants that can effect drilling fluids. as shown as :

-some common contaminants :

1-drilled and re-cycled drilled solids

2-chimically treatable contaminants (sodium chloride ,calcium ,magnesium ,soluble carbonates ,hydrogen sulphide ,bacteria)

I-8-3-THE EFFECTS OF CONTAMINATION :

The primary indication of contamination is generall instability of the drilling fluids properties, this instability may manifest it self in deffeculty in controlling the fluid loss, alcalinity or rheology. in general terms some form of contamination should be suspected when there is no apparent a reason for a defficultly in controlling drilling fluid properties .

Contamination can be both specific and general. due to the complexity of some chimical interactions and the defficulty experienced in the correct evaluation of results from many field level analitical procedures, situation can arise where more than one contaminant are simultaneously responsible for the problem. in other words, contaminants can have « masking » effect on each other, creating situation where accurate determination of the contaminants most responsible for the problem is made difficult, are even impossible, by the presence and the effect of another.

The most relible methode for determining the presence of contaminants is regular accurate analysis of both the physical and chimical properties of the drilling fluid, in this way, trends can established that will assist in early detection of the contaminant and application of the correct treatment.

I-9-THE EFFECT OF TEMPERATURE AND PRESSURE :

Temperature and pressure effects can alter rheological properties drastically,the downhole temperature and pressure conditions generally bear no resemblance to those obtained temperature and pressure test at the surfase.

These effects are largely unpredictable and may cause rheological properties to decrease or increase.

While there are no accurate methods for determining the extent of these effects, certain assumptions can be made.

It is known, for exemple,that elevated temperatures and pressures can effect fluids in any of the ways shown next, and these effects and rheological changes should be concidered when high temperatures and pressures are expected or encountered.

I-9-1-PHYSICAL EFFECTS :

- Increasing in the temperature will decrease the viscosity of the liquid phase.
- Increasing in the pressure will increase the viscosity. through an increase in density.

I-9-2-CHEMICAL EFFECTS :

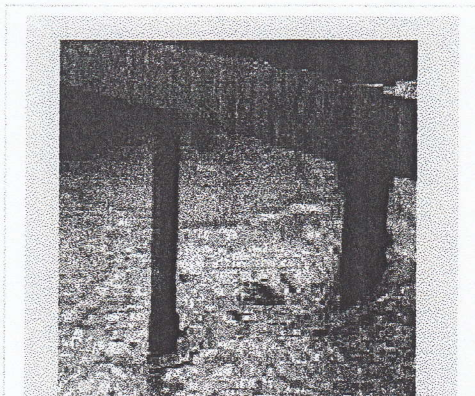
- Certain polymeric product, such as CMC's are not stable at elevated temperatures .
- Hydroxide react with clay minerals temperatures above 200°F (94°C).
- Lime –treated drilling fluids of high solids content can solidify above 300°F(150°C).
- Certain thinners and dispersants lose their effectivness at higher temperatures.

I-8-3-ELECROCHEMICAL EFFECTS :

- Higher temperatures increase the solubility of certain salts.
- Temperatures increase ionic activity of all electrolytes.

CHAPTER I I
OIL BASE SYSTEMS

RELAXED-FILTRATE VERSA SYSTEM
CONVENTIONAL VERSA SYSTEM



CHPTER I I	OIL -BASE SYSTEMS

I I-1-INTRODUCTION :

This chapter covers the specifics of the versa oil-base systems.the oil in these systems functions as the continuous external phase of a water -in-oil-emulsion (invert)mud.
The versa systems are named according to the base oil used and according to special application (function).The primery systems are :

SYSTEM NAME	BASE OIL
VERSA DRILL	DIESEL
VERSACLEAN	MINERAL OIL
VERSAVERT	ULTRA-TOX MINERAL OIL

Other versa names are used from time to time for new or unique base oils.regardless of the base oil, these systems can often use the same additives and similar formulations .
regardless of the system name, there are two general categories that can be applied to all versa systems :

1-RELAXED-FILTRATE VERSA SYSTEMS
2-CONVENTIONAL VERSA SYSTEMS
In this chapter I will base on conventional versa systems, because it 's the system using in this work.

I I-1-1-RELAXED-FILTRATE VERSA SYSTEMS :

Relaxed versa systems are less tightly emulsified fluids resulting in higher fluid loss that helps to maximise penetration rates.

These economical systems combine the inhibutive properties inherent in oil base drilling fluids with high penetration rates.

Relaxed-filtrate versa systems use Versacoat as the primary emulsifier Versawet as the wetting agent AND VG-69 versa-HRP as viscosifiers and gelling agents .calcuim chloride ($CaCl_2$) brine at 25% by weight normally comprises the internal phase, but any desired percent by weight up to 38% may be used. fluid loss additives are generally not used in relaxed systems.

When mixing a relaxed system, the following order of addition is recommended :

- **PROCEDURE OF MIXING:**

1-Oil

2-Organophilic clay(VG-69).

3-Versa-HRP OR VersaMOD

4-Versa COAT.

5-Versa WET

6-Lime .

7-$CaCl_2$ brine (add slowly)

8-Weight material.

I I-1-2-CONVENTIONAL VERSA SYSTEM :

Conventional versa systems normally use Versamul emulsifier and Versacoat wetting agent in the formulation,have low filtration rates,and utilize lime to form calcuim –base soaps. They usally have high electrical stability and a controlled high temperature ,high pressure (HTHP)fluid loss of less than 10ml at 500psi and 220°F .

With no water in the filtrate Conventional systems can be formulated for any oil mud application, Versa- mul soap to act as an emulsifire.the system must be kept alkaline at all times function properly.
Versacoat is the primary wetting agent for convetional versa systems and provides secondary emulsification.

V.G69 organophilic clay is used to viscosify the fluid to support weight material and provide gel strenghs ,a number of other organophilic clays are available, in cluding VG-PLUS ,VG-HT ,and othersdepending to the formulation and requirements. If additional viscosity is required, Versamod Versa-HRP can be used.

Calcuim chloride brine($CaCL_2$) is normally is used as the internal phase of the invert emulsion .the amount of brine ,or oil/water ratio ,will affect properties and formulation .any concentration of calcuim chloride up to 38% by weight can be used.

When mixing a conventional system the following order of addition is recommended

- **PROCEDURE OF MIXING :**

1-oil.

2-VG69.

3-Versa-HRP or Versa-MOD.

4-lime.

5-Versamul.

6-Versacoat.

7-CaCL2 brine (add slowly).

8-Weight material.

9-Versatrol

CHAPTER :III

ADDITIVES

1-CALCIUM CHLORIDE.

2-VG69.

3-LIME.

4-VERSACOAT.

5-VERSAMUL.

6-M-I-BARITE.

7-VERSATROL.

8-VERSATHIN.

9-CALCIUM CARBONATE.

III-1-CALCIUM CHLORIDE (DRY)

Calcium Chloride brine systems are used in clear brine completion or workover operations that require densities between 8.4 and 11.8 1b/gal.
This system provides inhibition preventing the hydration and migration of swelling clays and can be used for packer fluids.
Fluids can be formulated with various crystallization points and are available for special applications and winter use. Use blending tables to obtain the desired density and crystallization temperature. Use gentle agitation for thorough dispersion.

III-1-1- TYPICAL AND PHYSICAL PROPERTIES:

Physival appearance .... White powder
Specific gravity .... 2.295 @ 68 F (20 C)
Solubility in water 60%

III-1-2-ADVANTAGES:

- Mixes readily with all other calcium- and zinc- based brines.

III-1-3-PACKAGING AND STORAGE:

Calcium Chloride (DRY) is packaged in 80-Ib(36kg) bags Keep closed and firmly sealed. It is a concentrated hygroscopic salt will absorb water from the air.

III-2- VG-69:

VG-69 organophilic clay is a viscosifier and gelling agent used in VERSA oil-base and NOVA synthetic-base systems.
This amine-treated bentonite is used to increase carrying capacity and sus-pension properties, providing support for weight materials and improved cuttings removal.

VG-69 also aids in filter-cake formation and filtration control.

III-2-1- TYPICAL AND PHYSICAL PROPERTIES:

Physical appearance .... Off-white to tan powder
Specific gravity 1.57
Bulk density .... 33 lb/ft3(528 kg/m3)

III-2-2- ADVANTAGES:

- Provides gel structure and viscosity for the suspension of weight materials.
- Increases viscosity for improved hole-cleaning capacity.
- Improves filter-cake quality and filtration characteristics.
- Effective gelling agent in casing packs and packer fluids.

III-2-3-PACKAGING AND STORAGE:

VG-69 is packaged in 50-lb (22.7-kg), multi-wall, paper sacks.
Store in a dry location away from sources of heat or ignition, and minimize dust.

III-3-LIME:

Lime ,hydrated lime and slaked lime are all common names for calcium hydroxide($Ca(OH2)$) .it is used as asource of calcium and alkalinity in both water –and oil base drilling fluids. Lime , awidely available commercial chemical , is an economical source of calcium (Ca^{2+})and hydroxyl ionsOH^-

Drilling fluid applications for lime include : increasing Ph ; providing exess lime as an alkalinity buffer ; floculating bentonite muds ;removing soluble carbonate CO_3^{2-} Controlling corrosion .

CAUTION:lime is strong base and will form high pH (alkaline) solution .

III-3-1-TYPICAL AND PHYSICAL PROPERTIES:

Physical appearance..................White powder
Specific gravity.........................2.2
Ph (1% solution)........................12.4
Solubility @ 68° F(20°C).............0.165g/100ml water
Bulk density.............................138lb/ft^3

III-3-2-ADVANTAGES:

- Widely available economical source of calcium and alkanility .

III-3-3-PACKAGING AND STORAGE:

Lime is usually packaged in 50-lb(22.7-Kg) and 55-lb (25-Kg) ,multiwall ,paper sacks;numerous other sack size are used .

Store in dry area away from water and acids .

NOTE: Lime ,being a commercial chemical , is available from numerous sources with various degrees of purity.

III-4-VERSACOAT:

VERSACOAT organic surfactant is a multi-functional additive which serves as an emulsifier and wetting agent in the VERSA oil mud systems.

Secondary benefits include improved thermal stabilityand High-Temperature, High-Pressure (HTHP) filtration control.
The product is effective over a wide temperature range and in the presence of contaminants, and for reducing the adverse effects of water contamination.

III-4-1-TYPICAL AND PHYSICAL PROPERTIES:

Physical appearance .... Dark amber, viscous liquid
Specific gravity .... 0.90 – 0.97
Flash point .... 83°F (28°C) (PMCC)
Pour point .... -20°F (-28.9°C)

III-4-2-ADVANTAGES:

- Wide application, including higher-lime,conventional and lower-lime, relaxed VERSA systems.
- Improves emulsion stability
- Improves oil-wetting and prevents water-wet solids.
- Maintains stable oil-in-water emulsion and helps prevent water in HTHP filtrate.
- Improves thermal stability, rheo-logical stability, filtration control and contamination-resistance of oil-base muds
- Effective at counteracting the adverse effects of water contamination such as high viscosity, low-emulsion stability and water-wet solids.

III-4-3-PACKAGING AND STORAGE:

VERSACOAT is packaged in 55-gal (208.2-l) drums and 5-gal (18.9-l) cans. Store in a cool, well-ventilated area away from heat, sparks and flame. Keep containers closed and tightly sealed.

III-5-VERSAMUL :

VERSAMUL multi-purpose emulsifier is a liquid blend of selected emulsifiers, wetting agents, gelling agents and fluid stabilizers in a mineral oil base. VERSAMUL is used as the basic emulsifier for the VERSADRIL, T VERSACLEAN,T and VERSAPORT E oil mud systems.
VERSAMUL provides excellent emulsion stability, secondary wetting, viscosity, filtration control and temperature stability.

III-5-1- TYPICAL AND PHYSICAL PROPERTIES:

Physical appearance .... Dark amber, viscous liquid
Specific gravity .... 0.84 – 0.96
Flash point .... 197°F (91.7°C) .

III-5-2- ADVANTAGES:

- Multi-purpose product which may be used in a wide variety of oil mud systems, including VERSADRIL, VERSACLEAN and VERSAPORT systems.
- Improves emulsion stability.
- Functions as a secondarywetting agent.
- Provides viscosity.
- Provides filtration control.
- Helps maintain high-temperature, high-pressure filtrate in a water-free state.
- Improves the thermal stability and contamination-resistance of an oil mud.

III-5-3- PACKAGING AND STORAGE:

VERSAMUL is packaged in 55-gal (208.2-l) drums. Store in a location away from sources of heat or ignition. Keep containers closed and tightly sealed.

III-6-M-I-BARITE:

M-I BAR weight material is a high-quality, drilling-grade barite (barium sulfate) used to increase the density of drilling fluids. This high-specific-gravity mineral is the most widely used weight material, has application in all drilling fluid systems and meets all API specifications for barite.

III-6-1- TYPICAL AND PHYSICAL PROPERTIES:

Physical appearance .... Powder, various light colors; gray, pink, tan
Bulk density .... 107 – 135 lb/ft3 (1,714 – 2,162 kg/m3)
API Specifications
Specific gravity .... 4.20 g/cm3, min.Soluble hardness
(as calcium) .... 250 mg/kg, max.Particles >75 micron
(wet screen) .... 3% wt, max.Particles <6 micron
(sedimentation) .... 30% wt, max.

III-6-2- ADVANTAGES:

- Essentially chemically inert and insoluble — functions only in a physical manner.
- Does not react with other drilling fluid additives or interfere with their function.
- Minimally abrasive.

III-6-3- PACKAGING AND STORAGE:

M-I BAR is packaged in 100-lb (45.4-kg), multi-wall, paper sacks; 40-kg sacks; big bags and is available in bulk.
M-I BAR should be kept as dry as possible.

III-7-VERSATROL :

VERSATROL gilsonite is a natural occurring asphalt used for HTHP filtration control in all VERSA oil-base systems. It is often used to seal low-pressure and depleted formations.
It is compatible with all VERSA systems and can be used in the initial formulation or added later.

III-7-1- TYPICAL AND PHYSICAL PROPERTIES:

Physical appearance .... Black powder
Specific gravity .... 0.95 – 1.14
Bulk density .... ~34 lb/ft3 (540 kg/m3)
Flash point .... 600°F (316°C)
Melting point .... >400°F (204°C)
Ash content .... <3%.

III-7-2- ADVANTAGES:

- Reduces API and HTHP fluid loss in all VERSA oil mud systems
- Enhances emulsion and thermal stability
- Effective at all temperatures

III-7-3- PACKAGING AND STORAGE:

VERSATROL I is packaged in 50-lb(22.7-kg) and 25-kg (55-lb), multi-wall, paper sacks.
Store in a dry area and minimize dust. Slip hazard when wet.

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- Effective at all temperatures

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VERSATROL I is packaged in 50-lb(22.7-kg) and 25-kg (55-lb), multi-wall, paper sacks.
Store in a dry area and minimize dust. Slip hazard when wet.

III-8-VERSATHIN :

VERSATHIN deflocculant is used as a thinner and conditioner for oil-base muds and has application in all VERSA systems.

It reduces viscosity and gel strengths through the action of macro-molecules which deflocculate solids in the mud without the need for dilution or changing the oil-to-water ratio.

III-8-1- TYPICAL AND PHYSICAL PROPERTIES:

Physical appearance .... Dark black, viscous liquid
Specific gravity .... 0.80 – 0.85
Flash point .... ~111°F (44°C)
Pour point .... 15°F (-9.4°C)

III-8-2- ADVANTAGES:

- Easy-to-mix, fast-acting liquid thinner
- Wide application in all oil-base VERSA systems.
- Compatible with all VERSA oil-base additives

III-8-3- PACKAGING AND STORAGE:

VERSATHIN is packaged in 55-gal (208.2-l) drums and 5-gal (18.9-l) cans.
Store in a cool, well-ventilated area away from heat, sparks and flame.
Keep containers closed and tightly sealed.

III-9-CALCIUM CARBONATE :

Calcium Carbonate ($CaCO_3$) An insoluble calcium salt sometimes used as a weighting material (limestone, oyster shell, etc.) in specialized drilling fluids. It is also used as a unit and/or standard to report hardness.

III-9-1- TYPICAL AND PHYSICAL PROPERTIES:

Physical appearance .... White powder
Specific gravity .... 2.368 @ 68 F (20 C)

III-9-2- ADVANTAGES:

- Support M-I-Barite.
- It is good unit and /or report hardness.

III-9-3- PACKAGING AND STORAGE:

LIME stone or calcium carbonate is packaged in 100-lb (45.4-kg), multi-wall, paper sacks; 40-kg sacks; big bags and is available in bulk.
LIME stone should be kept as dry as possible.

CHAPTER IV

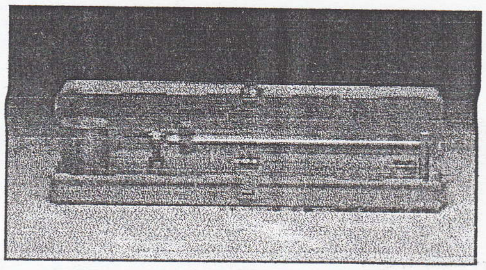
TESTING AND MESURMENT

CHAPTER IV TESTING AND MEASURMENT

IV-1-DENSITY OF FLUID :

IV-1-1-INSTRUMENTS:

the density (commonly referred to as mud weigh)is measured with a mud balance .The weigh of mud may be expressed as a hydrostatic pressure gradient in lb/in2. per 1000ft of vertical depth (psi/1000ft) as a density in lb/gal ,lb/ft^3 *or specific gravity* (SG) see the table:



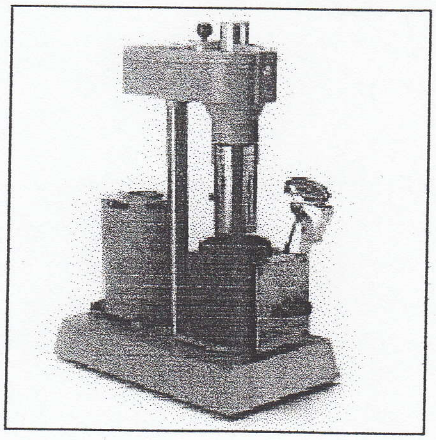
$$SG=\frac{lb/gal}{8.333}=\frac{lb/ft^3}{62.3} \text{ or } g/cm3$$

IV-1-2-MUD BALANCE PROCEDURE :

1- Remove the lid from the cup ,and completely fill the cup with the mud to be tested.
2- Replace the lid and rotate until firmly seated , making sure some mud is expelled through the hole in the lid.
3- Wash the mud from the outside of the cup ,and dry it.
4- Place the balance arm on the base ,with the knife edge resting on the fulcrum
5- Move the rider until the graduated arm is level vial on the beam.
6- At the edge of the rider closet to the cup ,read the density or weigh of the mud.
7- Report the result to the nearest scale division ,eitgher in lb/gal, Lb/ft^3 .

IV-2-VISCOSITY:

IV-2-1-ROTATIONAL VISCOSIMETER DESCRIPTION:



Direct –indicating viscosimeters are rotational types of instruments powred by an electric motor or a hand crank .
Drilling fluid is contained in the annular space between two concentric cylinders .the outer cylinder or rotor sleeve is driven at a constant RPM (rotational velocity). The rotation of the rotor sleeve in the fluid produces a torque on the bob ,and a dial attached to the bob indicates displacement of the bob .
Instrument constants have been adjusted so that plastic viscosity and yield point are obtained by using reading from rotort sleeve speeds of 600and300 RPM.

IV-2-2-PROCEDURE FOR PLASTIC VISCOSITY AND YIELD POINT DETERMINATION:

1-Place recently agitated sample in a thermocup and adjast surface of mud to scribed line on the rotort sleeve .

2-heat or cool the sample to 150°F .stir slowly while adjasting the temperature.
3-Start the motor by placing the switch in the high speed position with the gear shift all the way down .Wait for a steady indicator dial value and record the 600RPM reading ,change gears only when the motor is runing.
4-Change switch to the 300RPM speed .wait for a steady value and record 300 RPM reading.
5-Plastic viscosity in centipoise =600 reading mins 300 reading.
6-Yield point in lb/100ft2=300 rerading minus plastic viscosity.

IV-2-3-PROCEDURE FOR GEL STRENTH DETERMINATION:

1-Stir sample at 600 RPM for approximately 15sec and slowly lift the gear assembly to the neutral position.

2-Shut motor off and wait 10sec.

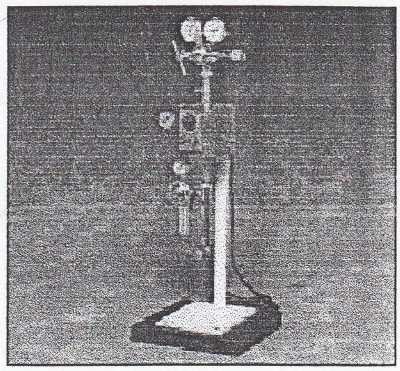
3-Flip swich to the low –speed position and record maximum deflection units in lb/100ft2 as initial gel .if the dial indicator does not return to zero with motor off, do not reposition.

4-Repeat 1 and 2, but allow 10min then place switch in the low -speed positioin and read maximum deflection units as the 10min gel .Report measured temperature.

IV-3-FILTRATION:

IV-3-1-HIGH –TEMPERATURE,HIGH –PRESSURE (HTHP) FILTER PREESS DISCRIPTION:

The instrument (see figure) consists of a heating jacket with thermostate, cell plate assembly ,primary pressure assembly and back pressure receiver .
A routine test can be conducted at 300°F and 500psi.
High temperature fluid loss is recorded as double the Number of milliliters lost in 30 min.



IV-3-2-PROCEDURE:

1- plug heating jacket cord into proper power source and allow instrument to preheat .place place thermometer in well in heating jacket and adjust thermostatto obtain 10°F above desired test temperature .
2- Close the intel valve on the cell and invert the cell .
3- Take the mud from the flow line and fill to within ½ in .of the O-ring groove to allow for expansion .
4- place one circle of filter paper in groove and place the O-ring on top of paper .use Whatman No. 50 paper or equivalent.
5- Place the cell plate assembly over the filter paper and align the safety locking lugs .
6- Evenly tighten cap screws finger tight and close the discharge valve .
7- With cell plate assembly down ,place cell in heating jacket with all valves closed .transfer the thermometer to the cell' s thermometer well .
8- Place CO2 cartridge in primary pressure assembly and tighten cartridge holder until cartridge is punctured.
The regulator and bleed –off valve should be closed.
9- While lock ring is lifted ,slide primary pressure assembly onto the top " slide coupling" and realise the lock ring.

10- place 100psi pressure on top valve ,then open it to pressurize unit .this pressure will minimize boiling while sample is heating.

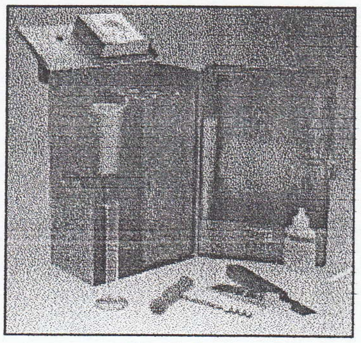
11- always use the back –pressure receiver to prevent vaporisation of the filtrate at test temperatures near boiling or higher .place and activate a CO2 cartridge into the back -pressure receiver assembly.

12- Slide back pressure assembly into place with slotted lock ring.
13- apply 100psi pressure to the bottom pressure unit with valve still closed .
14- after the temperature has reached the desired range (300°F) ,as noted by the cell thermometer ,increase pressure on top cell regulator Open bottom cell valve one turn ,and start timing test.

15-Maintain 100 psi on the receiver during the test .if it rises ,drain a little filtrate to maitain the 500psi differential .maintain temperature +/-5°F
16-After 30min filtration ,close bottom cell value and then close top cell valve.
17-Back of both regulator T-screws and bleed pressure from both regulators.
18-Drain filtrate into graduated cylinder and read volume .double the reading to report.remove receiver .
19-Disconnect primary pressure assembly by lifting lock ring and slip assembly off .
CAUTION: Cell still contains pressure.
20-Maintain cell in upright position and cool to room temperature ,then bleed off cell pressure ;do not blow mud through valve.
21-Invert cell ,loosen cap screw(use allen-head wrench if necessery) and disassemble throughly clean and dry all parts.

IV-4-LIQUID AND SOLID CONTANT:

IV-4-1-DESCRIPTION:



A mud retort with " oven" heating capability is used To determine the quantity of liquids and solids in a drilling fluid .
Internal –prob heater retorts are not recommended.
A sample of mud (either 10,20 or 50 ml retorts are available) is placed in the cup and the lid added to expel some fluid.this ensure a correct volume.it is heated until the liquid components have been vaporised .
The vapors are passed through a condenser and collected in graduated in percent .the volume of liquid ,oil and water ,is measured directly in percent .
The solids ,suspended and dissolved ,are determined by subtracting from 100% or by reading the void space at the top.

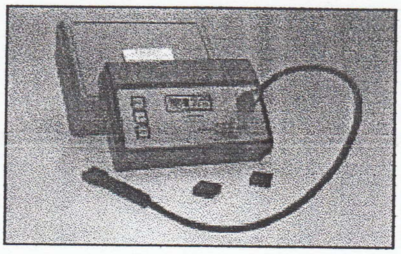
IV-4-2-PROCEDURE:

1-Allow the mud sample to cool to room temperature.
2-Disassemble retort assembly and lubricate sample cup threads with high-temperature grease .fill sample cup almost level full of the fluid to be tested. Put sample cup cover in place by rotating firmly . squeezing out excess fluid to obtain the exact volume –10,20 or 50ml required .clean spills from cover and threads.
3-Pack fine steel wool into the upper expansion chamber ,then screw sample cup into expansion chamber . the steel wool should trap the solids boiled out. keep assembly upright so that mud does not flow into the drain tube.
4-Insert or screw the drain tube into hole at end of condencer .seating firmly. the graduated cylinder which is calibrated to read in percent should be clipped in place on the condencer.

5-Plug power cord into the correct voltage and keep power on untily distillation stops. which may require 25 min depending on the characteristics of oil.water and solids content.
6-Allow the distillate to cool to room temperature.
7-Read the percentage of water ,oil and solids directly from the graduate .a drop or two of aerosol solustion will help define the oil-water interface . after reading the percent solids.
8-At end of the test ,cool completely ,then clean and dry retort assembly.
9-Run a pipe cleaner through condencer hole and retort drain tube to clean and maintain full opening.
NOTE:Do not allow drain tube to become restricted.

IV-5-ELECTRICAL STABILITY:

IV-5-1-PROCEDURE:



1-Place a sample which has been passed through a 12 mesh screen (marsh funnel screen) in container assuring that the fluid has been stirred well.

2-Heat or cool the sample to 120 -/+5°F (50-/+2°C) . record the temperature at which the electrical stability reading was taken .

3-After inspecting cleanlines of the electrod ,immerse the electrode into the mud .hand stir the sample with the electrode for approximately 10 sec.hold the electrode to touch the sides or bottom of container when taking a reading.

4-Depress and hold down red botton while starting from a zero reading .increase the voltage by moving the dial in a clock –wise direction at a rate of 100 to 200 volts per second .continue increasing the voltage until the indicator light illuminate,the voltage ramp has ended .

5-Clean electrical prob and repeat test the tow reading should not differ by more than 5%. if the reading differ by more than 5%, check meter and electrical prob for mal- function .

6-Rcord the average of the two measurments as the electrical stability.

IV-6-ALKALINITY(Pom) :

- **PROCEDURE:**

1. Put 100 ml of Xylene/IPA blend or 75 ml of propyle propasol in glass jar .fill a syring with whole mud to past the 3 ml mark.
2. disperse 2ml of oil mud into the solvant and add 200 ml of distilled water .
3. add 15 drops of phenolphtaleine .
4. stir rapidly with a magnetic stirrer .hamilton beach stirrer or equivalent .

5.While stirring .slowly titrate with 0.1N H_2SO_4 until the pink color just disappears. Continue stirring and if no pink color reappears within one min. stop stirring .it may be necessary to stop stirring and allow the mixture to separate into two phases to more clearly see the color in the aqueouse phase.

6.Let the sample stand for 5 min .if no pink color reapears .the end piont has been reached .if the pink color returns titrate a second time with sulfiric acid .if pink color returns a third time titrait again. Do not after the third time.

7. Pom = ml of 0.1N H_2SO_4 per ml mud.

CHAPTER V

SENSITIVITY STUDY AND INTERPRETATION

❖ PREPARATON OF FORMULATIONS :

The formulations are prepared as ,conventional versa system mixing procedure:

➢ PROCEDURE OF MIXING :

1-oil.

2-VG69.

3-Versa-HRP or Versa-MOD.

4-lime.

5-Versamul.

6-Versacoat.

7-CaCL2 brine (add slowly).

8-Weight material.

9-Versatrol

➢ ORDER AND TIME OF MIXTURE FOR OIL-BASE MUD:

PRODUCT	TIME
OIL	
CLAY	**5min**
LIME	**10min**
EMULSIFIER 01 **EMULSIFIER 02**	**10min**
BRINE	**15min**
SOLIDS	**10min**
REDUCTOR OF FILTRATE	**10 min**

TOTAL.. 60min

V-1-MUD WEIGHT(9.2):

V-1-1-DRILLING FLUID FORMULATIONS AND TEST RESULTS :

SAMPLE DETAILS

FLUID SYSTEM	OBM VERSADIL (crude oil)
DESCRIPTION	9.2 ppg.use crude oil
TEST DATE	7/7/2001
TESTED BY	MOHAMMED BEN ALIA
SAMPLE VOLUME	350 ml

SAMPLE COMPOSITION

PRODUCT	UNITS	1	2	3		1	2	3
CRUDE OIL	ml	245.54	247.6	248				248
CaCI2	PPB	21.09	21.27	21.31				61.36
WATER	ml	60.75	61.26	61.36				21.31
VG69	PPB	4	3	2				2
LIME	PPB	8	8	8				8
VERSA-MUL	PPB	6	5	5				5
VERSA-COTHF	PPB	4	3	3				3
BARTE	PPB	77.21	77.83	78.37				78.37
VERSA-TROL	PPB	4	4	4				4

TEST RESULTS

PHYSICAL PROPERTIES					
PERIOD AGED	HOURS		16	16	16
TEMPERATURE	DEG F		200	200	200
DYNAMIC/STATIC	D/S		D	D	D

RHEOLOGY

RHEOLOGY TEMP	DEG F	150	150	150		150	150	150
600RPM		67	66	65		57	59	59
300RPM		43	42	41		37	37	36
200RPM		34	23	30		29	28	27
100RPM		25	23	20		21	20	19
6RPM		14	13	8		12	11	10
3RPM		13	12	7		10	9	8
GELS10s/10Mn	Ibs/100ft2	11/15	10/14	9/12		10/14	11/14	9/12
PLASTIC VISCOSITY	Cp	24	24	24		20	22	23
YIELD POIT	Ibs/100ft2	19	18	17		17	15	13

FILTRATION

POM	ml							1.55
ELECTRIC SABILITY	VOLTS	1183	732	760		1087	715	720
HPHT TEMP	Deg f					220	220	220
DELTA PRESSURE	Psi					500	500	500
HPHT FLUID LOSS	ml/30min							5.6

DISTILLATION

MUD WEIGHT	ppg	9.2	9.2	9.2				9.2
OIL/WATER RATIO	OWR	80/20	80/20	80/20				80/20

V-1-2-CONTAMINATION WITH 35 g DRILL SOLIDS (hymod prima clay):

RHEOLOGY

600RPM			70
300RPM			42
200RPM			32
100RPM			21
6RPM			10
3RPM			9
GELS10s/10Mn	Ibs/100ft2		13/17
PLASTIC VISCOSITY	Cp		27
YIELD POINT	Ins/100ft2		24

FILTRATION

POM	Mi		1.7
HPHT TEMP	Deg f		220
ELECTRIC STABILITY	Volts		639
DELTA PRESSURE	Psi		500
HPHT FLUID LOSS	MI/30mn		7

DISTILLATION

MUD WEIGHT	PPG		9.4
OIL/WATER RATIO	OWR		80/20

V-1-3-CONTAMINATION WITH 10% OF WATER:

RHEOLOGY

600RPM			79
300RPM			53
200RPM			45
100RPM			32
6RPM			15
3RPM			13
GELS10s/10Mn	Ibs/100ft2		16/18
PLASTIC VISCOSITY	Cp		26
YIELD POIT	Ins/100ft2		27

FILTRATION

POM	Mi		1.8
HPHT TEMP	Deg f		220
ELECTRIC STABILITY	Volts		610
DELTA PRESSURE	Psi		500
HPHT FLUID LOSS	MI/30mn		6

DISTILLATION

MUD WEIGHT	PPG		8.9
%OIL	O%		56
% WATER	W%		24
% SOLIDS	S%		30
OIL/WATER RATIO	OWR		70/30

In the purpous of reduce the vqlue of Yp ,we prepared the third formulation,in this case ,the amount of VG69 becomes 2grs ,before hot rolling ,we obtain these results:

- Pv remains 24 Cp.
- Yp decreases to 17 lbs/100ft2.

After hot rolling the values Pv and Yp reduce ,Pv becomes 23 Cp and Yp becomes 13.

The third formulation selected as the best formulation , because generally ,the results are acceptable despite the Pv value is not included in the requested interval . as we can choose the second formulation as the best formulation but the third one is preferred because Yp value is less than 15(the max value obtained in the second formulation) .

<u>NOTE01</u> :We discussed about this with members from ANADARCO ,and they have accepted these results .

<u>NOTE02</u>:The electrical stability results are acceptable in all my tests ,for this reason ,I would not speak about it in my interpretation.

Finally we have calculated the alkalinity Pom and HPHT fluid loss :

- Pom =1.55 ml .
- HPHT = 5.6 ml.

B)-CONTAMINATION:

- **CONTAMINATION WITH 35 g OF (hymod prima clay):**

We observe that rheology values generally increase ,because this drill solids (hymod prima clay) increases the resistance of fluid to flow, so it increase the viscosity.the new values are (PV=27,Yp=24) ,which is generally acceptable. The mud weight becomes 9.4ppg (hpc is clay so increase the specific gravity) *NOTE:yield point increase by contaminants(see page 16).*

- **CONTAMINATION WITH 10 % OF WATER:**

We observe generally that the rheology values increase because the water increase the resistance of fluid to flow ,the new values are: (PV=26Cp,Yp=27),we observe that the difference in Yp is concederable;so we need a special treatment to decrease Yp value .we observe too that the new mud weight becomes 8.9 ppg.After distillation the OWR becomes 70/30.

V-2-MUD WEIGH(10.5ppg):

V-2-1-DRILLING FLUID FORMULATIONS AND TEST RESULTS:

SAMPLE DETAILS

FLUID SYSTEM	OBM VERSADIL (crude oil)
DESCRIPTION	10.5pp.use curds oil
TEST DATE	20/7/2001
TESTED BY	MOHAMMED BEN ALIA
SAMPLE VOLUME	350 ml

SAMPLE COMPOSITION

PRODUCT	UNITS	1	2	3		1	2	3
CRUDE OIL	ml	230.32	230.72	244.54				244.54
CaCI2	PPB	19.79	19.82	14.83				14.83
WATER	ml	56.99	57.08	42.71				42.71
VG69	PPB	2	1	1				1
LIME	PPB	8	8	8				8
VERSA-MUL	PPB	5	5	5				5
VERSA-COTHF	PPB	3	3	3				3
BARTE	PPB	121.37	121.91	129.93				129.93
VERSA-TROL	PPB	6	6	6				6
CaCO3	PPB	30	30	30				30

TEST RESULTS

PHYSICAL PROPERTIES					
PERIOD AGED	HOURS		16	16	16
TEMPERATURE	DEG F		200	200	200
DYNAMIC/STATIC	D/S		D	D	D

RHEOLOGY

RHEOLOGY TEMP	DEG F	150	150	150		150	150	150
600RPM		89	86	72		84	83	62
300RPM		61	58	43		56	55	38
200RPM		48	47	32		44	43	28
100RPM		35	32	21		32	30	17
6RPM		18	12	9		14	11	8
3RPM		15	11	8		13	10	6
GELS10s/10Mn	Ibs/100ft2	16/20	12/17	9/11		13/10	12/16	7/11
PLASTIC VISCOSITY	Cp	28	28	29		28	28	24
YIELD POIT	Ins/100ft2	33	30	14		28	27	14

FILTRATION

POM	ml							1.55
ELECTRIC STABILITY	volts	822	756	1537		792	720	1457
HPHT TEMP	Deg F	220	220	220		220	220	220
DELTA PRESSURE	Psi					500	500	500
HPHT FLUID LOSS	ml/30mn							4.8

DISTILLATION

MUD WEIGHT	ppg	10.5	10.5	10.5		10.5	10.5	10.5
OIL/WATER RATIO	OWR	80/20	80/20	85/15		80/20	80/20	85/15

V-2-2-CONTAMINATION WITH 35g DRILL SOLIDS (hymod prima clay):

RHEOLOGY

600RPM		70
300RPM		44
200RPM		30
100RPM		19
6RPM		8
3RPM		7
GELS10s/10Mn	Lbs/100ft2	9/12
PLASTIC VISCOSITY	Cp	26
YIELD POIT	Lbs/100ft2	18

FILTRATION

POM	ml	1.2
HPHT TEMP	Deg f	220
ELECTRIC STABILITY	Volts	1401
DELTA PRESSURE	Psi	500
HPHT FLUID LOSS	ml	2.2

DISTILLATION

MUD WEIGHT	ppg	10.6
OIL/WATER RATIO	OWR	85/15

V-2-3-CONTAMINATION WITH 10% OF WATER:

RHEOLOGY

600RPM		74
300RPM		50
200RPM		40
100RPM		28
6RPM		11
3RPM		9
GELS10s/10Mn	Lbs/100ft2	11/12
PLASTIC VISCOSITY	Cp	24
YIELD POINT	Lbs/100ft2	26

FILTRATION

POM	ml	1
HPHT TEMP	Deg f	220
ELECTRIC STABILITY	volts	500
DELTA PRESSURE	Psi	500
HPHT FLUID LOSS	ml/30mn	5.6

DISTILLATION

MUD WEIGHT	ppg	10
%OIL	O%	52
% WATER	W%	23
% SOLIDS	S%	25
OIL/WATER RATIO	OWR	69/31

V-2-4-CONDITIONS OF WORK:

PHYSICALAND CHEMICAL PROPERTIES

	MIN	MAX
MUD WEIGHT	10.5	11.0
GELS 10sec/10min	8/10	10/18
Pv	16	20
YP	12	14
HPHT FLUID LOSS		6
ELECTRIC STABILITY	600	
OIL-WATER RATIO	80/20	85/15
Pom	1.5	

Heat aging required	200°F

Static/Dynamic	Dynamic

V-2-5-COMMENTS AND INTERPRETATION OF RESULTS :

A)-RHEOLOGY :

In the first formululation we choose OWR 80/20.before hot rolling ,these results are obtained:

- Pv =28Cp.
- Yp = 33 lbs/100ft^2
- Gels 10sec/10min =16/20. lbs/100ft^2

In this case we use CaCO3 (weightning agent) in our formulations to support the barite.before hot rolling the rheology values decrease but always d'ont verify the condition of work .

In the second formulation we reduce the amount of VG69 ,always to decrease the rheology values ,but Pv ,Yp ,and gels remain conciderable.

In the third formulation we change (OWR).in this case we work with 85/15. we observe that the rheology values decrease with important difference.the following results are obtained after hot rolling.

- Pv = 24 Cp
- Yp = 14 lbs/100ft^2
- Gels10sec/10min = 7/11 lbs/100ft^2

NOTE: We observe that the values of pv are conciderable,because of the use of crude oil which contains many solids ,and Pv as we have discussed in the first chapter affect by solids.

The third formulation(after hot rolling) selected as the best formulation ,despite Pv value is more than 20 Cp(see the conditions of work).

B)-CONTAMINATION:

- **CONTAMINATION WITH 35 g OF (hymod prima clay):**

Like with (MW=9.2ppg) , we observe that the rheology values increase ,the new values are(PV=26 Cp,Yp=18) , Pv increase with 5 Cp ,while Yp increase with 4.these results are generally acceptable.
Mud weight becomes 10.6ppg ,we observe too that OWR remaines constant Because of the influence of hpc is not not concederable.

- **CONTAMINATION WITH 10 % OF WATER:**

Rheology values generally increase ,the new values are (Pv=24 Cp,Yp=26), We observe that the value of Yp is very concederable.in this case we need some special treatments to decrease the difference ,OWR becomes 69/31.

V-3-MUD WEIGH(16.5ppg):

V-3-1-DRILLING FLUID FORMULATIONS AND TEST RESULTS:

SAMPLE DETAILS

FLUID SYSTEM	OBM VERSADIL (crude oil)
DESCRIPTION	10.5ppg.use curds oil
TEST DATE	20/7/2001
TESTED BY	MOHAMMED BEN ALIA
SAMPLE VOLUME	350 ml

SAMPLE COMPOSITION

PRODUCT	UNITS	1	2	3	4		1	2	3	4
CRUDE OIL	ml	184.89	194.79	175	155.8					
DISEL	ml	0	0	19.5	39					
CaCI2	PPB	11.19	7.44	7.44	7.44					
WATER	ml	32.22	21.43	21.43	21.43					
VG69	PPB	0	0	0	0					
LIME	PPB	8	8	8	8					
VERSA-MUL	PPB	4	4	4	4					
VERSA-COAT HF	PPB	5	6	6	6					
BARITE	PPB	476.31	482.34	482.34	482.34					
VERSA-TROL	PPB	4	4	4	4					
CR/DIESEL RATIO	C/D	100/0	100/0	90/10	80/20					

TEST RESULTS

PHYSICAL PROPERTIES						
PERIOD AGED	HOURS		16	16	16	16
TEMPERATURE	DEG F		200	200	200	200
DYNAMIC/STATIC	D/S		D	D	D	D

RHEOLOGY

RHEOLOGY TEMP	DEG F	150	150	150	150		150	150	150	150
600RPM		147	149	142	127		145	138	115	125
300RPM		91	86	83	71		97	80	65	70
200RPM		72	70	60	53		75	59	46	45
100RPM		48	45	37	33		52	36	38	27
6RPM		16	13	11	10		19	10	7	7
3RPM		13	11	9	9		16	9	6	6
GELS10s/10min	Ibs/100ft2	15/14	12/13	11/12	10/11		17/17	10/9	8/7	8/7
PLASTIC VISCOSITY	Cp	56	63	59	56		48	58	50	55
YIELD POIT	Ins/100ft2	35	23	24	15		49	22	15	15

FILTRATION

POM	ml									
ELECTRIC STABILITY	volts	1405	1987	>2000	1978		909	1310	1316	1053
HPHT TEMP	Deg f									220
DELTA PRESSURE	Psi									500
HPHT FLUID LOSS	ml									

DISTILLATION

MUD WEIGHT	ppg	16.5	16.5	16.5	16.5		16.5	16.5	16.5	16.5
OIL/WATER RATIO	O/ W	85/15	90/10	90/10	90/10		16.5	90/10	90/10	90/10

SAMPLE COMPOSITION

PRODUCT	UNITS	5	6	7		5	6	7
CRUDE OIL	ml	136.4	116.88	97.39				97.39
DIESEL	ml	58.5	77.92	97.39				97.39
$CaCl_2$	PPB	7.44	7.44	7.44				7.44
WATER	ml	21.43	21.43	21.43				21.43
VG69	PPB	0	0	3				3
LIME	PPB	8	8	8				8
VERSA-MUL	PPB	4	4	4				4
VERSA-COAT HF	PPB	6	6	6				6
BARTE	PPB	482.34	482.34	482.34				482.34
VERSA-TROL	PPB	4	4	4				4
CR/oil RATIO	C/D	70/30	60/40	50/50				50/50

TEST RESULTS

PHYSICAL PROPERTIES								
PERIOD AGED	HOURS					16	16	16
TEMPERATURE	DEG F					200	200	200
DYNAMIC/STATIC	D/S					D	D	D

RHEOLOGY

RHEOLOGY TEMP	DEG F	150	150	150		150	150	150
600RPM		116	100	112		110	80	96
300RPM		75	61	69		60	44	55
200RPM		59	44	36		43	31	41
100RPM		38	27	41		27	18	27
6RPM		13	8	20		8	5	10
3RPM		11	7	19		6	4	9
GELS10s/10Mn	Ibs/100ft	12/13	9/8	21/18		7/8	5/6	12/17
PLASTIC VISCOSITY	Cp	41	39	43		50	36	41
YIELD POIT	Ins/100ft2	34	22	26		10	8	14

FILTRATION

POM	ml							1.7
ELECTRIC STABILITY	volts	1870	925	1255		1097	898	1006
HPHT TEMP	Deg f							220
DELTA PRESSURE	Psi							500
HPHT FLUID LOSS	ml							5.7

DISTILLATION

MUD WEIGHT	ppg	16.5	16.5	16.5		16.5	16.5	16.5
OIL/WATER RATIO	O/ W	85/15	90/10	90/10		90/10	90/10	90/10

V-3-2-CONTAMINATION WITH 35 g DRILL SOLIDS (hymod prima clay):

RHEOLOGY

600RPM			189
300RPM			129
200RPM			105
100RPM			73
6RPM			39
3RPM			38
GELS10s/10Mn	Lbs/100ft2		33/46
PLASTIC VISCOSITY	Cp		60
YIELD POINT	Lbs/100ft2		69

FILTRATION

POM	ml		1.6
HPHT TEMP	Deg f		220
ELECTRIC STABILIT	Volts		>2000
DELTA PRESSURE	Psi		500
HPHT FLUID LOSS	ml		1.6

DISTILLATION

MUD WEIGHT	ppg		16.9
OIL/WATER RATIO	OWR		90/10

V-3-3-CONTAMINATION WITH 10% OF WATER

RHEOLOGY

600RPM			155
300RPM			106
200RPM			88
100RPM			66
6RPM			34
3RPM			32
GELS10s/10Mn	Lbs/100ft2		30/33
PLASTIC VISCOSITY	Cp		49
YIELD POINT	Lbs/100ft2		57

FILTRATION

POM	ml		
HPHT TEMP	Deg f		220
ELECTRIC STABILITY	Volts		1509
DELTA PRESSURE	Psi		500
HPHT FLUID LOSS	ml		7.6

DISTILLATION

MUD WEIGHT	ppg		16.1
% OIL	% O		64
% WATER	% W		16
% SOLIDS	% S		20
OIL/ WATER RATIO	O/W		80/20

V-3-4-CONDITIONS OF WORK:

PHYSICAL AND CHEMICAL PROPERTIES	MIN	MAX
MUD WEIGHT	16.5	17.0
GELS 10sec/10min	8/12	12/20
Pv	34	45
YP	10	15
HPHT FLUID LOSS		6
ELECTRIC STABILITY	600	
OIL-WATER RATIO	80/20	85/15
Pom	1.5	

Heat aging required	200°F

Static/Dynamic	Dynamic

V-3-5-COMMENTS AND INTERPRETATION OF RESULTS :

A)-RHEOLOGY :

In this third case (MW=16.5) , many problems cofronted us in our tests,we start with the first formulation ,we start with OWR 85/15 , before hot rolling we observe that the rheology values are very concederable ,(PV=56 ,Yp=35). After hot rolling ,the rheology reduce generally,but the values remaine always concederable.
In the second formulation we change OWR ,in this case we use 90/10,but the rheology values remain concederable .
From the third formulation ,other paramether are added . we use a percentage of diesel mixed with crude oil in the formulations ,so the new paramether is crude-oil/Diesel ratio(C/D) ,the other paramethers are kept (OWR(90/10) , additives amounts).
We start with C/D=90/10 ,rheology values genarally reduce ,the obtained results are:

- PV=59 Cp
- Yp=24 lbs/100ft2.

We observe that the values remain concederable .every time we reduce C/D ratio ,and we observe that the rheology values decrease ,until we arrive to the 7^{th} formulation ,in this formulation ,we use C/D=50/50 ,also we change the amount of VG69 , in this case we use 3 PPB of VG69 .the following results are obtained befor hot rolling:

- PV=43Cp
- YP=26 lbs/100ft2.
- Gels=21/18 lbs/100ft2.

We observe that YP value is out of the interval of conditions of work(see the table above).
After hot rolling ,the following results are obtained:

- PV=41Cp
- YP=14 lbs/100ft2.
- Gels=12/17 lbs/100ft2.

Which is acceptable and verify the conditions of work ,after that we calculate alkalinity Pom ,HPHT fluid loss and electrical stability , the following results are obtained:

- Pom=1.7ml
- HPHTfluid loss=5.7ml
- Electrical stability=1006 volts

Which are acceptable and verify the conditions of work(see the table above)
NOTE:from the 2nd to the 7th formulation ,OWR used is out of the requested interval ,because when we use all the probabilities in this interval ,we observe that the rheology values remain concederable(I based on some tests results,prepared by M-I technicien -lab members).

B)-CONTAMINATION:

- **CONTAMINATION WITH 35 g OF (hymod prima clay):**

After contamination with hymod prima clay ,we observe that the rheology values generally increase ,with an important difference ,the following results are obtained after contamination :

- PV=60 Cp
- YP=69 lbs/100ft2
- Gels=33/46

In this case we need some special treaments ,to reduce the difference between these results and the obtained results before contamination.

- **CONTAMINATION WITH 10 % OF WATER:**

After contamination with 10% of water ,we observe that the rheology values generally increase ,the following results are obtained after contamination:

- PV=49Cp
- YP=57lbs/100ft^2
- Gels=30/33 lbs/100ft^2

In this case say that our mud ,need some special treatments especially to reduce the YP value.

CONCLUSION

I think that it is the first attempt,to do such awork,which is using of crude oil to prepare oil-base mud .despite the problems that confronted us in our study ,I think that it is the first step in this field.

From our results study , I can conclude the following :

- With mud weight(MW)=9.2ppg and 10.5 ,I can say that the results are generally accepted .
- With mud weight(MW)=16.5ppg ,we need to use always diesel in our formulation.

Finally I can say that the time is early to replace completely diesel by crude oil .it is only step ,I wish in the future there will be followed steps.

REFERENCES

[1]............M-I-DRILLING FLUIDS ENGINEERING MANUAL.

[2]............TECHNICAL MANUAL FOR DRILLING ,COMPLETION AND WORKOVER FLUIDS.

[3]............M-I-DRILLING FLUID HAND BOOK.

[4]............FLUID DE FORAGE, COFERENCIER: S MEGDOUD(IAP HMD).

[5]................www.midf.com.

[6]................BULTIN PRODUCT (M-I HAND BOOK)

APPENDIX

MATERIAL SAFETY DATA SHEET(MSDS):

- Crude oil:

Section 01-Description and application:

Crude oil is a naturally occuring mixture of paraffins ;naphthenes ;aromatic hydrocarbons and small amounts of sulphur benzene ,and nitrogen compounds. The composition and priperties will vary significantly according to the source of crude .crude oil with a sulphur content greater than 0.5 weight percent is considered sour and sweet if below this value .

Section 02-regulatory classification:

WHMIS: Class B, Division 2 : Flammable liquids
Class D, Division 2 ,subdivision B :toxic material

Section 03-Typical physical and chemical properties:

Physical state: liquid
Specific gravity: 0.7 to 0.95
Vapor pressure : > 0.36 Kpa @ 20 C°
Vapor density :3 to 5 (approx)
Freezing / Melting point:-60 to –20 C°
Viscosity: <15 centistokes @ 20 C°
Solubility: insoluble
Water /OIL distribution:<1
Percent volatile: varies

Section 04-Health hazard information :

High vapour concentrations are irritating to the eyes,nose,throat and lungs;may cause headaches and dizziness; may be anesthetic and may cause other central nervous system effects .

- DIESEL:

Section 01-physical and chemical properties :

Physical state: liquid
Color: colorless to brown
Odor: petroleum odor
Boiling point:340-680 F° (171-360 C°)
Freezing point:0F° (-18C°)
Vapor pressure:1mmHg @ 20C°
Vapor density (air = 1) :>1
Specific gravity (water=1): 0.87-0.90
Water solubility: insoluble

appendix

Section 02- Hazards identification :

Major health hazard : respiratory tract irritation ,skin irritation ,central nervous system depression .
Physical hazard: flash back hazard. Combustible liquid and vapor .

Section 03-Handling and storage:

Storage : store and handle in accordance with all current regulations and standards.keep separated from incompatible substances.

CONVERTION FACTORS

U.S to metric

TO Convert	To	Multiply by
Atmosphere	Kg/cm^3	1.033
Bbl	M^3	0.159
Bbl/ft	M^3/m	0.5211
ft	M	0.3048
Ft^2	M^2	0.0929
Ft^3	M^3	0.0283
Ft^3	liter	28.32
gal	M^3	0.00379
gal	liter	3.785
in	cm	2.54
lb	kg	0.4535
$Lb/100ft^2$	pa	0.4788
Lb/bbl	G/l (kg/cm^3)	2.853
Lb/ft	Kg/m	1.49
Lb/ft-sec	Cp	1.488
Lb/ft^3	G/l(kg/m^3)	16.02
Lb/gal	Kg/cm^3	119.83
Lb/gal	SG	0.12
Lb/gal	Kg/l	0.1198
miles	km	1.609
F°	C°	(F°-32)/1.8
psi	Atmosphere	0.068
psi	Kg/cm^2	0.07
psi	kpa	1.895
Psi/ft	Kpa/m	22.61
qt	Cm^3	946.4

Metric to U.S

TO Convert	To	Multiply by
Atmosphere	Psi	14.7
bar	psi	14.5
Cp	Lb/ft-sec	0.00067
cm	in	0.3937
G/l	Lb/bbl	0.3505
G/l	Lb/ft^3	0.0624
Kg	lp	2.205
Kg/cm^2	atmosphere	0.9178
Kg/cm^2	psi	14.29
Kg/l	Lp/gal	8.347
Kg/m	Lb/ft	0.6711
Kg/m^3	Lb/bbl	0.3505
Kg/cm^3	Lb/ft^3	0.06242
Kg/m^3	Lb/gal	0.00835
km	miles	0.6215
kpa	psi	0.145
Kpa/m	Psi/ft	0.04423
litre	Ft^3	0.03531
litre	gal	0.2642
m	ft	3.28
M^2	Ft^3	10.76
M^3	bbl	6.289
M^3	Ft^3	35/31
M^3	gal	264.2
M^3	qt	3.448
M^3/m	Bbl/ft	1.917
C°	F°	(C°*1.8)+32
pa	$Lb/100ft^2$	2.089
SG	Lb/gal	8.333

1bbl = 42 U.S gal
1bbl = 5.61 m^3
1 m^3 = 7.48 U.S gal

APPENDIX

Rig Components

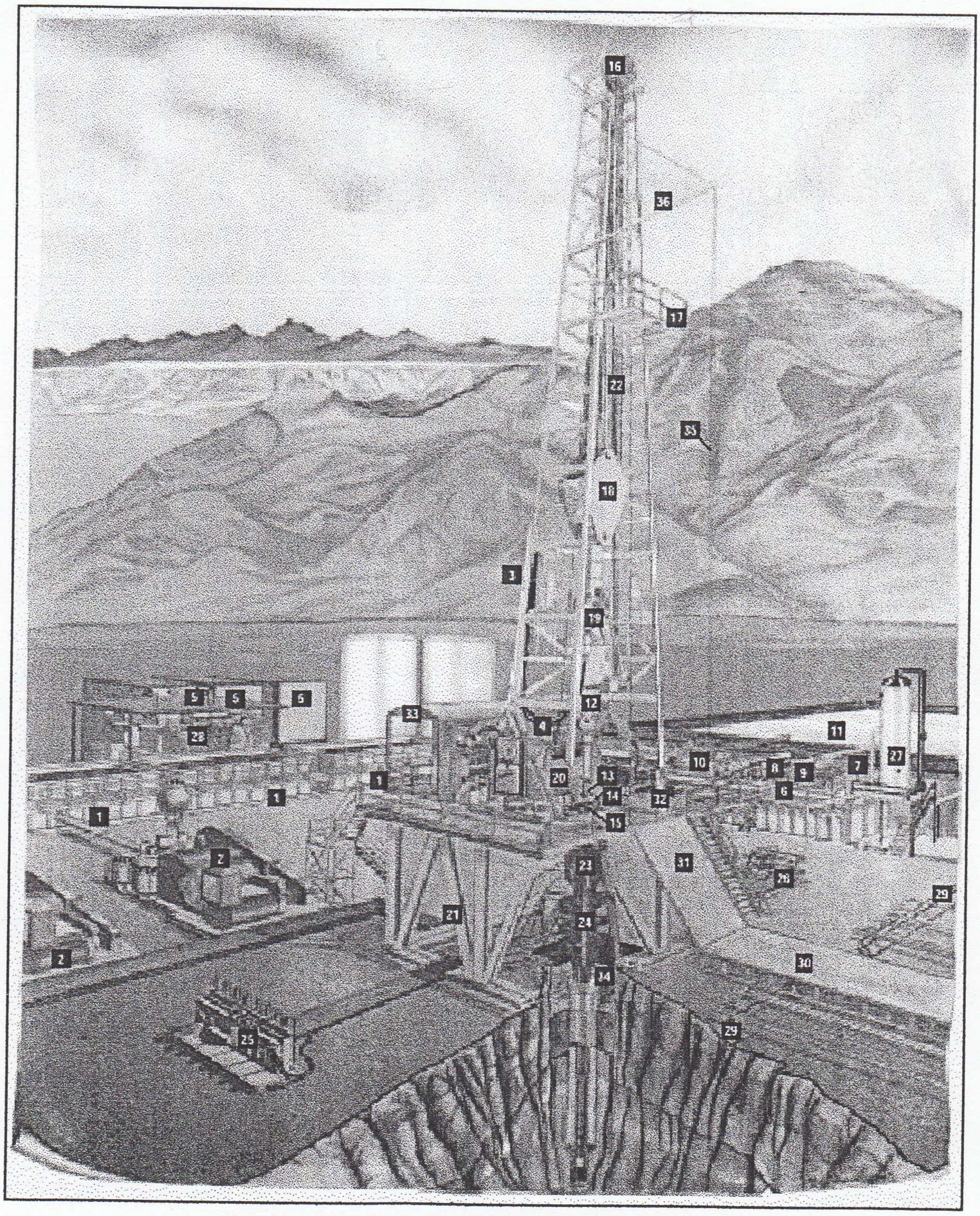


Figure 3: Diagrammatic view of rotary drilling rig (after Petex).

Circulating System
1. Mud pits
2. Mud pumps
3. Standpipe
4. Rotary hose
5. Bulk mud storage
6. Mud return line
7. Shale shaker
8. Desilter
9. Desander
10. Degasser
11. Reserve pits

Rotating Equipment
12. Swivel
13. Kelly
14. Kelly bushing
15. Rotary table

Hoisting System
16. Crown block
17. Monkeyboard
18. Traveling block
19. Hook
20. Drawworks
21. Substructure
22. Drilling line

Well-Control Equipment
23. Annular blowout preventer
24. Ram blowout preventers
25. Accumulator unit
26. Choke manifold
27. Mud-gas separator

Power System
28. Generators

Pipe and Pipe-Handling Equipment
29. Pipe racks
30. Catwalk
31. V-door
32. Rathole

Miscellaneous
33. Doghouse
34. Cellar
35. Hoisting line
36. Gin pole

APPENDIX

Types of Bits

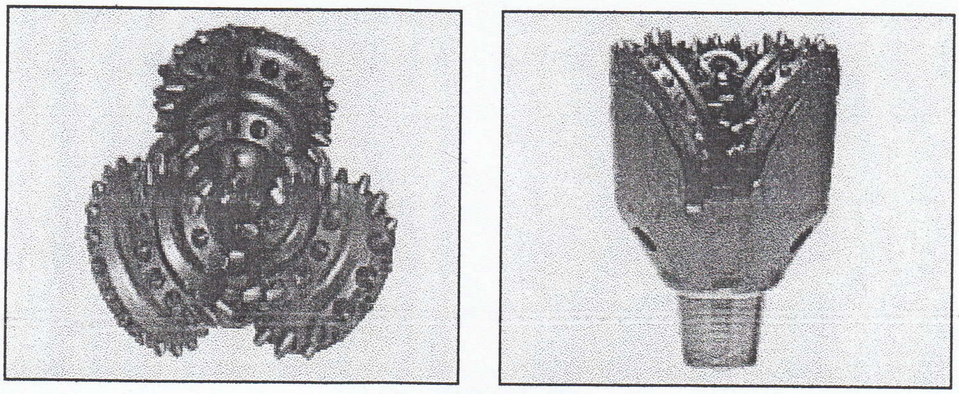


Figure 4a: Rock bit (TCI type).

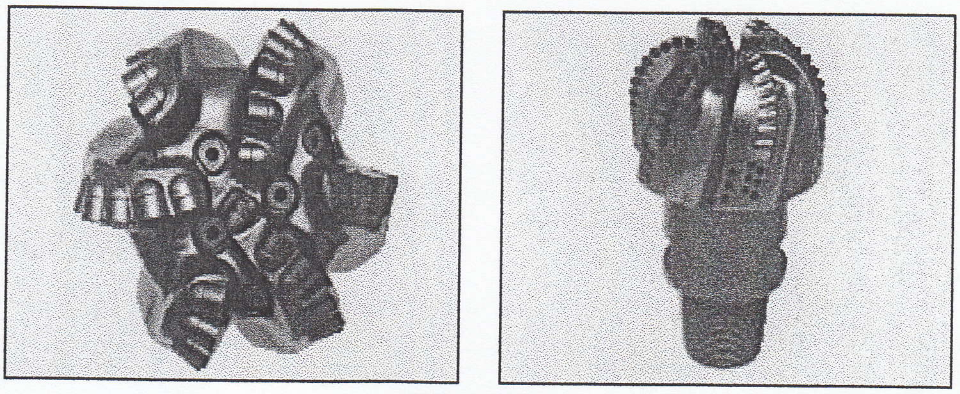


Figure 4b: PDC bit.

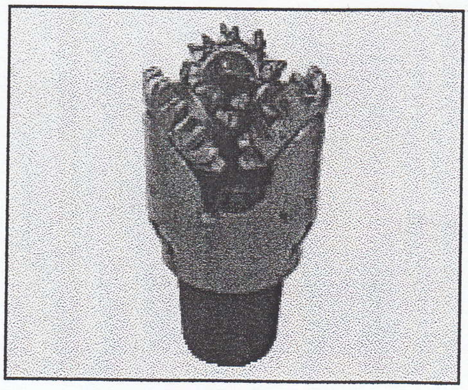


Figure 4c: Milled tooth rock bit.

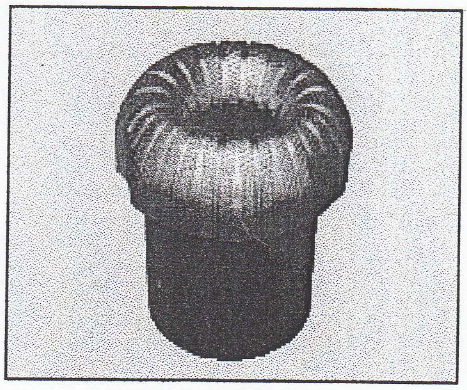


Figure 4d: Natural diamond core bit.

APPENDIX

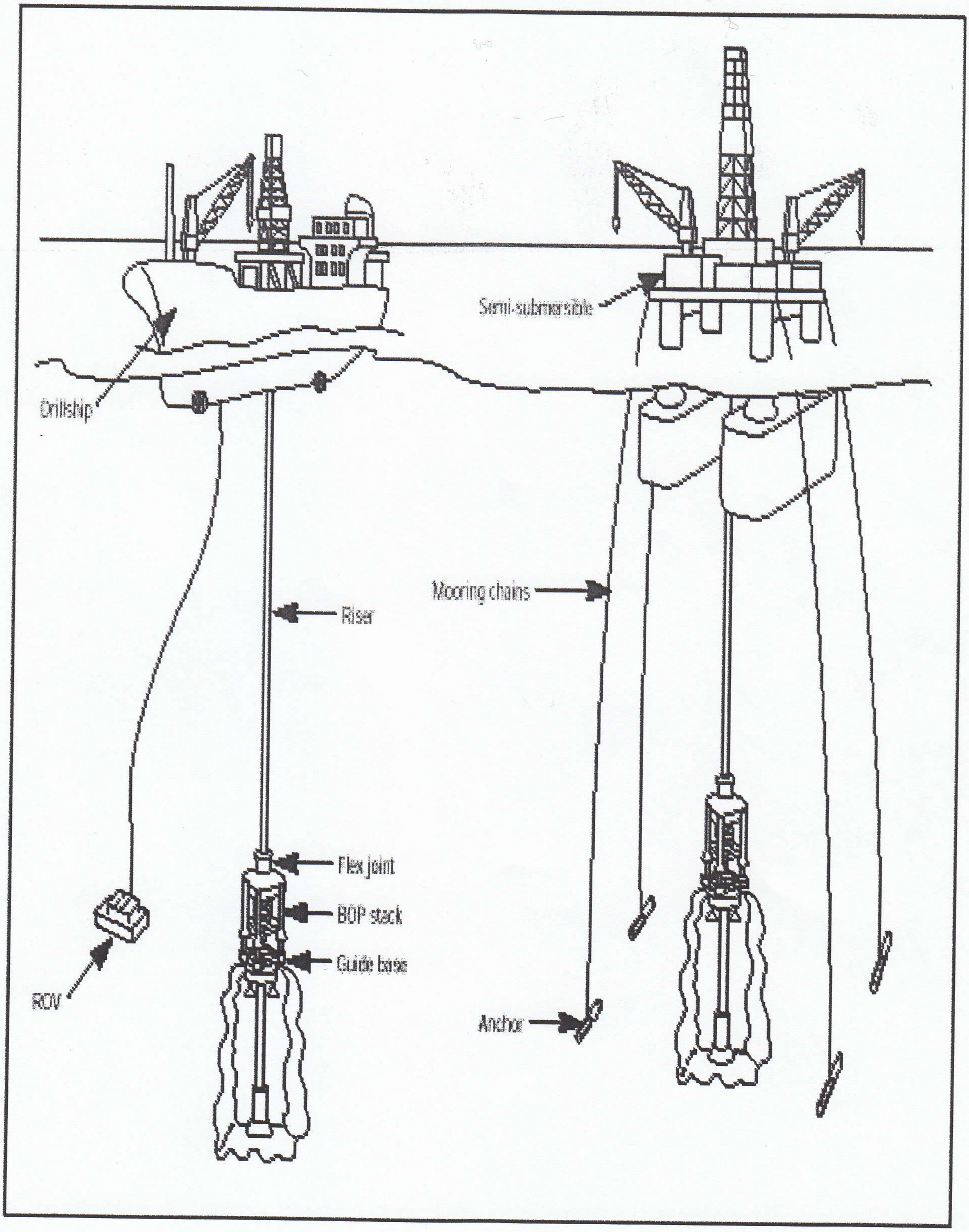


Illustration of deepwater rigs

MI Ownership

M-I *L.L.C.* (M-I) is a limited liability company owned by two members: Smith International Acquisition Corp (60% owner), a subsidiary of Smith International, Inc. and Schlumberger MI Inc. (40% owner), a subsidiary of Schlumberger Ltd.

M-I's operations are conducted in 50 countries around the world, and include the supply of drilling fluids, drill-in fluids and completion and workover fluids and additives as well as field engineering and technical support. M-I is also a significant worldwide producer of barite and bentonite, which is marketed both to the oilfield industry as well as to industrial markets.

Swaco, a division of M-I *L.L.C.*, is the industry leader in solids control, pressure control, rig instrumentation, and treatment services. Its technologies are critical to the effective management of fluids at the wellsite - not only ensuring the performance of the fluid but also minimizing the volumes required, hence, reducing the overall cost of using and disposing of the fluids once drilling operations have ceased.

M-I Completion Fluids provides specialized fluids used in completion and workover operations, as well as the technical services at the wellsite. M-I Completion Fluids also offers a full line of filtering equipment and services to ensure that our customers' requirements for clarity and purity are met.

GLOSSARY

GLOSSARY

A :

Alkali : Alkali Any compound having marked basic properties yielding a pH value above 7.See Base.

Alkalinity: Alkalinity The combining power of a base measured by the maximum number of equivalents of an acid with which it can react to form a salt. In water analysis, it represents the carbonates; bicarbonates; hydroxides and occasionally the borates,silicates and phosphates in the water. It is deter-
mined by titration with standard acid to certain datum points. See API RP 13B* for specific directions for determination of phe-nolphthalein (P f) and
methyl orange (M f) alka-linities of the filtrate in drilling fluids and the alkalinity of the mud itself (P m). Also see P f , M f and P m.

Annular Velocity: The velocity of a fluid moving in the annulus.

Annulus or Annular Space: The space between the drillstring and the wall of the hole or casing.

API Gravity The gravity (weight per unit volume) of crude oil or other related fluids as measured by a system recommended by the American Petroleum Institute. It is related to Specific Gravity (SG) by the following formula:

Degrees API = 141.5 – 131.5 SG 60°F

Apparent Viscosity: The viscosity a fluid appears to have on a given instrument at a stated rate of shear. It is a function of the plastic viscosity and the yield point. The apparent viscosity in centipoises, as determined by the direct-indicating viscometer, is equal to ½ the 600-RPM reading. In a Newtonian fluid, the apparent viscosity is numerically equal to the plastic viscosity. See also Viscosity, Plastic Viscosity and Yield Point.

B:

Balance, Mud: A beam-type balance used in determining mud density. It consists pri-marily of a base, graduated beam with con-stant-volume cup, lid, rider, knife edge and counter-weight.

Barrel: A volumetric unit of measure used in the petroleum industry consisting of 42 U.S. gallons.

Bridge: An obstruction in a well formed by intrusion of subsurface formations.

Brine: Water saturated with or containing a high concentration of common salt (sodium chloride); hence, any strong saline solution containing such other salts as calcium chloride, zinc chloride,calcium nitrate, etc.

Buffer: Any substance or combination of substances which, when dissolved in water produces a solution which resists a change in its hydrogen ion concentration upon the addition of acid or base.

GLOSSARY

C:

Cake Consistency: According to API RP 13B*, such notations as "hard," "soft," "tough," "rubbery," "firm," etc., may be used to convey some idea of filter-cake consistency.

Centipoise (cP): A unit of viscosity equal to 0.01 poise. A poise equals 1 g per meter-second, and a centipoise is 1 g per centimeter-second. The viscosity of water at 20°C is 1.005 cP (1cP = 0.000672 lb/ft-sec).

Clay: A plastic, soft, variously colored earth,commonly a hydrous silicate of alumina, formed by the decomposition of feldspar and other aluminum silicates. Clay minerals are essentially insoluble in water but dis-perse under hydration, shearing forces such as grinding, velocity effects, etc., into the extremely small particles varying from submicron to 100-micron sizes. See also Attapulgite Clay, Bentonite, High-Yield Drilling Clay, Low-Yield Clays and Natural Clays.

CMC: Carboxymethylcellulose.

Colloid: A state of subdivision of matter which consists either of single large molecules or of aggregations of smaller molecules dispersed to such a degree that the surface forces become an important factor in determining its properties. The size and electrical charge of the particles determine the different phenomena observed with colloids, e.g., Brownian movement. The sizes of colloids range from 1×10^{-7} to 5×10^{-5}cm (0.001 to 0.5 microns) in diameter, although the particle size of certain emulsoids can be in the micron range.

Contamination: The presence in a drilling fluid of any foreign material that may tend to produce detrimental properties of the drilling fluid.

D:

Deflocculation: Breakup of flocs of gel structures by use of a thinner.

Density: Matter measured as mass per unit volume expressed in pounds per gallon(lb/gal), kilograms per liter (kg/l) and pounds per cubic ft (lb/ft^3). Density is commonly referred to as "weight."

Desander, Desilter: Hydrocyclone-based, solids-removal device to separate sand or silt from the mud.

Dilatant Fluid: A dilatant or inverted plastic fluid is usually made up of a high concentration of well-dispersed solids which exhibits a non-linear consistency curve passing through the origin. The apparent viscosity increases instantaneously with increasing rate of shear. The yield point, as determined by conventional calculations from the direct-indicating viscometer read-ings,is negative; however, the true yield point is zero.

E:

Electrolyte: A substance which dissociates into charged positive and negative ions when in solution or a fused state and which will then conduct an electric current. Acids, bases and salts are common electrolytes.

Emulsifier or Emulsifying Agent :A substance used to produce an emulsion of two liquids which do not mix. Emulsifiers may be divided, according to their behavior,into ionic and non-ionic agents. The ionic types may be further divided into anionic,cationic and amphoteric, depending upon the nature of the ion-active groups.

GLOSSARY

F:

Filter: A device which uses a coating of some type to separate solids from a liquid. Solids plate out on the surface and near the surface of the device's coating. The coating can be diatomaceous earth, cloth, paper or a number of other substances.
Filter Cake: The suspended solids that are deposited on a porous medium during the process of filtration.

Filter Paper: Porous unsized paper for filtering liquids. API filtration test specifies one thickness of 9-cm filter paper Whatman No. 50, S & S No. 576 or equivalent.
Filter Press: A device for determining fluid loss of a drilling fluid having specifications in accordance with API RP 13B.

Flocculation: Loose association of particles in lightly bonded groups, non-parallel association of clay platelets. In concentrated sus-pensions,such as drilling fluids, flocculation results in gelation. In some drilling fluids,flocculation may be followed by irreversible precipitation of colloids and certain other substances from the fluid, e.g., red beds.

G:

Gel Strength: The ability or the measure of the ability of a colloid to form gels. Gel strength is a pressure unit usually reported in lb/100 ft^2. It is a measure of the same interparticle forces of a fluid as determined by the yield point except that gel strength is measured under static conditions, yield point under dynamic conditions. The common gel-strength measurements are initial and the 10-min gels. See also Shear (Shearing Stress) and Thixotropy.

Granule or Granular: A small, rough piece of substance. The word is usually used to describe the physical appearance of the small pieces of rock in a matrix (q.v.).

H:

Hydroxide A designation that is given for basic compounds containing the OH^-radical. When these substances are dissolved in water, they increase the pH of the solution.

I:

Indicator: Substances in acid-base titrations which, in solution, change color or become colorless as the hydrogen ion concentration reaches a definite value; these values vary with the indicator. In other titrations such as chloride, hardness and other determina-tions, these substances change color at the end of the reaction. Common indicators are phenolphthalein, potassium chromate, etc.

Invert: Oil-Emulsion Mud An invert emulsion is a water-in-oil emulsion where freshwater or saltwater is the dispersed phase and diesel, crude or some other oil is the con-tinuous phase. Water increases the viscosity and oil reduces the viscosity.

Ion Acids, bases and salts (electrolytes) when dissolved in certain solvents, especially water, are more or less dissociated into electrically charged ions or parts of the molecules, due to loss or gain of one or more electrons. Loss of electrons results in positive charges producing a cation. A gain of electrons results in the formation of an anion with negative charges. The valence of an ion is equal to the number of charges borne by it.

GLOSSARY

L:

Laminar: Flow Fluid elements flowing along fixed streamlines which are parallel to the walls of the channel of flow. In laminar flow, the fluid moves in plates or sections with a differential velocity across the front which varies from zero at the wall to a max-imum toward the center of flow.
Laminar flow is the first stage of flow in a Newtonian fluid; it is the second stage in a Bingham plastic fluid. This type of motion is also called parallel, streamline or viscous flow.

Lime: Commercial form of calcium hydroxide.

M:

Molecule: When atoms combine they form a molecule. In the case of an element or a compound,a molecule is the smallest unit that chemically still retains the properties of the substance in mass.

Mud A water- or oil-base drilling fluid whose properties have been altered by solids — commercial and/or native, dissolved and/or suspended. Used for circulating out cuttings and many other functions while drilling a well. Mud is the term most commonly given to drilling fluids.

Mud Additive: Any material added to a drilling fluid to achieve a particular purpose.

N:

Newtonian Fluid: The basic and simplest fluids from the standpoint of viscosity consid-eration in which the shear force is directly proportional to the shear rate. These fluids will immediately begin to move when a pressure or force in excess of zero is applied.Examples of Newtonian fluids are water, diesel oil and glycerine. The yield point as determined by direct-indicating viscometer is zero.

O:

Oil Content: The oil content of any drilling fluid is the amount of oil in volume-percent.

Oil-Emulsion Water: A drilling fluid in which the oil content is usually kept between 3 to 7% and seldom over 10% (it can be consid-erably higher). The oil is emulsified into freshwater or saltwater with a chemical emulsifier. Sometimes CMC, starch or gum may be added to the freshwater and saltwater systems.

P:

Particle Size: The diameter of a particle, which is assumed to be spherical. (While we assume particles are spherical, this is rarely the case.) Size is usually defined in microns (q.v.).

Percent: For weight-percent, see ppm. Volume-percent is the number of volumetric parts

Plastic Viscosity: The plastic viscosity is a measure of the internal resistance to fluid flow attributable to the amount, type and size of solids present in a given fluid. It is expressed as the number of dynes per cm^2 of tangential shearing force in excess of the Bingham yield value that will induce a unit rate of shear. This value, expressed in centipoises, is proportional to the slope of the consistency curve determined in the region of laminar flow for materials obeying Bingham's Law of Plastic Flow.

When using the direct-indicating viscometer, the plastic viscosity is found by subtracting the 300-RPMreading from the 600-RPM reading.

Pound Equivalent: A laboratory unit used in pilot testing. One gram or pound equiva-lent, when added to 350 ml of fluid, is equivalent to 1 lb/bbl.

R:

Rate of Shear: The rate at which an action, resulting from applied forces, causes or tends to cause two adjacent parts of a body to slide relatively to each other in a direction parallel to their plane of contact. Commonly given in RPM.

Reynolds Number: A dimensionless num-ber, Re, that occurs in the theory of fluid dynamics. The number is important in fluid hydraulics calculations for determining the type of fluid flow , whether laminar or turbulent. The transitional range occurs approximately from 2,000 to 4,000; below 2,000 the flow is laminar, above 4,000 the flow is turbulent.

Rheology: The science that deals with deformation and flow of water.

S:

Sample Mud: A drilling fluid possessing properties to bring up suitable samples.

Samples: Cuttings obtained for geological information from the drilling fluid as it emerges from the hole. They are washed, dried and labeled as to the depth.

Stability (Electrical) Meter An instrument to measure the breakdown voltage of invert emulsions.

T:

Thinner: Any of various organic agents (tan-nins,lignins, lignosulfonates, etc.) and inorganic agents (pyrophosphates, tetra-phosphates,etc.) that are added to a drilling fluid to reduce the viscosity and/or thixotropic properties.

Turbulent Flow: Fluid flow in which the velocity at a given point changes con-stantly in magnitude and the direction of flow; pursues erratic and continually varying courses. Turbulent flow is the final stage of flow in a fluid. See Velocity, Critical; and Reynolds Number.

V:

Velocity: Time rate of motion in a given direction and sense. It is a measure of the fluid flow and may be expressed in terms of linear velocity, mass velocity, volumetric veloc-ity,etc. Velocity is one of the factors which contribute to the carrying capacity of adrilling fluid.

Velocity, Critical: That velocity at the transitional point between laminar and turbulent types of fluid flow. This point occurs in the transitional range of Reynolds numbers of approximately 2,000 to 3,000.

Viscosity: The internal resistance offered by a fluid to flow. This phenomenon is attributable to the attractions between molecules of a liquid, and is a measure of the combined effects of adhesion and cohesion to the effects of suspended particles, and to the liquid environment. The greater this resis-tance, the greater the viscosity. See Plastic Viscosity.

GLOSSARY

W:

Wall Cake The solid material deposited along the wall of the hole resulting from filtration of the fluid part of the mud into the formation.

Water-Base Mud: Common conventional drilling fluids. Water is the suspending medium for solids and is the continuous phase, whether or not oil is present.

Weight In mud terminology, this refers to the density of a drilling fluid. This is normally expressed in either lb/gal, lb/ft3or kg/l.

Weight Material: Any of the high specific gravity materials used to increase the density of drilling fluids. This material is most commonly barite but can be hematite,etc. In special applications limestone is also called a weight material.

Y:

Yield: A term used to define the quality of a clay by describing the number of barrels of a given centipoise slurry that can be made from a ton of the clay. Based on the yield, clays are classified as bentonite, high-yield, low-yield, etc., types of clays. Not related to yield value below.

Yield Point: In drilling fluid terminology, yield point means yield value. Of the two terms, yield point is by far the most commonly used expression.

Yield Value The yield value (commonly called"yield point") is the resistance to initial flow or represents the stress required to start fluid movement. This resistance is due to electri-cal charges located on or near the surfaces of the particles. The values of the yield point and thixotropy, respectively, are measure-ments of the same fluid properties under dynamic and static states. The Bingham yield value, reported in lb/100 ft^2, is determined by the direct indicating viscometer by subtracting the plastic viscosity from the 300-RPM reading.