THE EFFECT OF CONTAMINANTS ON THE RHEOLOGICAL PROPERTIES OF A WATER-BASE LIGNOSULFONATE DRILLING MUD

BY

UMOH KINGSLEY SYLVANUS

2003 /15103EH

A PROJECT SUBMITTED TO THE DEPARTMENT OF CHEMICAL ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR DEGREE IN CHEMICAL ENGINEERING (B.ENG)

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DECLARATION

I, Umoh Kingsley Sylvanus with Reg. number 2003/15103EH declare that this project report is my original work and has not been presented else where to the best or my knowledge.

Umoh K.S.	10th November 2008 **Date**

CERTIFICATION

This research project by Umoh Kingsley S. has been examined and certified under the supervision of Engineer (Mrs.) A. Farouk to be adequate in scope and quality for the partial fulfillment of the requirement for the award of bachelor of Engineering (B.Eng) in Chemical Engineering.

____________________	4/11/08
Engr. (Mrs.) A. Farouk **(Project Supervisor)**	**Date**
____________________	____________________
Dr. M. O. Edoga **(Head of Department)**	**Date**
____________________	____________________
External Examiner	**Date**

DEDICATION

This project is dedicated to the most-high God for his protection and guidance throughout the duration of achieving my firs degree certificate. Also, to my lovely parent Elder and Deaconess S.S Umoh and the entire Umoh's family whose contribution of my educational pursuit cannot be quantified.

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My profound gratitude goes to my beloved parent Elder and Deaconess S.S Umoh for their love and care, from the inner most part of my heart, I am glad to thank my uncle, Engr. Innocent Etotok for his support.

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My thanks also go to my good friends who lived through my idiosyncrasy, I could not have asked for better friends in life Picanto de desperado, Profet, Momoh, Sadiq, Toyosi, Johnny. May God bless you all and further strengthen our friendship.

ABSTRACT

The effect of contaminants on the rheological properties of a water base lignosulfonate drilling mud was analyzed; a field test was carried out to determine how contaminants such as salt, cement, and carbonate affect the rheological properties such as viscosity, gel strength, yield point, weight and pH of a water based lignosulfonate drilling mud. A prepared mud was mixed with varying quantities of the contaminants, different equipments such as viscometer, mud balance, and phydrion dispenser were used. The result showed that the properties have steady and progressive increase as the mud contaminants were increased. Also, the mud can not resist contaminate effect on the properties of drilling mud above salt concentration of 124,000 ppm, 104,000 ppm concentration of cement and 8.8 % per volume of carbonate. It was observed that water based lignosulfonate mud cannot function well at high pounds per million (ppm) e.g. above 180,000ppm at high mud contaminant.

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CHAPTER ONE

1.0 INTRODUCTION

The first reported use of drilling mud was noted in France in 1845, when water was pumped down a hallow bearing rod while drilling water wells to bring cuttings form the bit to the surface (Dermott, 1993).Through the 1920's iron oxide and barium sulphate (barite) were use to increase the density of mud thus preventing entry of the formation fluid into the bore hole. The use of bentonite days in the 1930's to suspend barite formed the basis of today's large commercial drilling industry. Generally spreading, a "drilling mud" describes a broad range of fluid both liquids and gases, use in drilling operations to achieve specific purposes which ranges from lubricating to carrying capacities. (Adam, 1989).

A mud is a mixture of fine clay particles and water, prepared such that the clay particles are suspended in water. The success of any drilling operation in the oil industry depends largely on the quality of the drilling mud and in order to drill deeper and consequently more hazardous wells and to exploit productive formation more fully, the drilling mud must have physical and chemical properties. These properties are related to the fundamental characteristics of density which indicates the weight per unit volume of the drilling mud that may be used to determine the hydrostatic pressure exacted by the mud, the viscosity which has to do with the flow and relation properties such as apparent viscosity, plastic viscosity, gel strength and yield point of the drilling mud, also the pH properties that deals with the acidity or alkalinity of the drilling mud and filtration which involves the ability of drilling solid compound of the mud to form a thin, and other important properties like solid content, and specific gravity. The physical and chemical properties of the drilling mud are affected by contaminants such as cement, sodium chloride, sand, anhydrite, carbonate, carbon dioxide, salt water and hydrocarbon, some of which are encountered in the mud system during drilling operation.

These contaminants exist in the drilled formation and are often experience during period of circulation of mud from the pit down the hole and back to the surface through the annulus. These contaminants alters the drilling properties in an undesirable manner even as it is one of the contributing factors to unstable mud properties, which may be due to difficulty is controlling the fluid loss, alkalinity or rheology and they are commonly experienced in water base and oil base mud. This is usually why a mud once used should be subjected to test, for various properties to determine its ability to function again. A drilling mud is therefore under continuous monitoring to correct or remove these contaminants. (Walter, 1981).

1.1 AIM AND OBJECTIVES

The research project is carried at studying and analyzing the effect of contaminants on the rheological properties of a water base drilling mud.

The aim can be achieved through the following objectives;

1) Study the various drilling mud.
2) Study of contaminants on drilling mud properties and treatment to eliminate their effects.
3) The behavior of drilling rheological properties of drilling mud in the drilling process.

1.2 JUSTIFICATION

The research project is to prevent the effects of contaminant on drilling mud, because the mud is pumped back down and is cautiously re-circulated. After testing, the mud is treated periodically in the mud pit to give it properties that optimize and improve drilling efficiency.

1.3 SCOPE OF WORK

The research work covers the effect of contaminants (salt, cement and carbonate) on drilling fluid properties on a water based lignosulfonate mud.

CHAPTER TWO

2.0 LITERATURE REVIEW

Most oil and gas well are drilled by pushing a drill bit against the rock and rotating it until the rock wears away. A drilling rig and system is designed to control how the drill bit pushes against the rock, how the cuttings are removed from the well by drilling mud and how the cutting are then removed from drilling mud so that the mud can be reused. During drilling, mud is injected down the drill string through small holes in the drill bit designed with holes to allow the mud clean the cutting away from the bit.

The mud mostly used in the drilling process is water followed by oil, air, natural gas and foam. When water or oil is used as the base mud, it is called "Mud". Water base drilling mud is used in about 85% of the wells drilled world wide, while oil-based mud is used for virtually all of the remaining wells (George, 1980). During drilling process, some mud can be lost to the permeable underground formations, to ensure that mud is always available to keep the well full, extra mud is always mixed at the surface and kept is reserves or mud pits for immediate use.

2.1 DRILLING MUD

Drilling mud may be defined as a suspension of solids in a liquid phase. Drilling mud consists of solid liquid for fractions, solid fractions and chemical additives (Lummus, 1987).

2.2 MUD ENGINEER

The name given to an oil field service company individual who is charged with maintaining a drilling fluid or completion fluid system on an oil and (or gas drilling rig). The cost of the drilling fluid is typical about 10% (may vary greatly) of the total cost of well construction, and demands competent mud engineers. Large cost saving result when the mud engineer performs adequately. The mud engineer is not to be confused with mud loggers, service personnel who monitor gas from the mud and collect well-bore samples.

2.3 CLASSIFICATION OF DRILLING MUD

2.3.1 WATER-BASE DRILLING MUD

In many areas most readily obtainable and cheap natural liquid is fresh or mineralized water. Being the lightest, water exerts lesser pressure on the bottom hole face. It penetrates freely the voids and micro fracture in the rock, preventing closure of the latter and thus facilitates breaking up the face with the bit. Thus, it is expedient that water in its capacity of a drilling fluid is to be used in drilling of stable and sufficiently from rocks of un-producing horizons whose mechanical properties remain visually unchanged on their humidification, whereas an aqueous solution of sodium chloride should be employed in drilling out halite deposits in the presence of abundant sources of water supply.

2.3.1.1 TYPES OF WATER-BASE DRILLING MUD'S.

1) low-solids system
2) fresh-water bentonite
3) chrome lignosulfonate fresh water mud
4) calcium-treated mud
5) gypsum-treated mud
6) salt water mud
7) non dispersed weighed mud
8) potassium-treated mud

2.3.2 OIL-BASE DRILLING MUD

Drilling fluids that contain oil as the continuous liquid phase are called oil-base or oil mud's, such mud's always contain some water, and if the water is emulsified as a useful constituent, the mud is called an invest-emulsion mud. These oil base muds are made up to 60 to 98 % of oil. Diesel fuel is commonly used, although some crude oils are satisfactory. Some principal application of oil mud's prevent damage to the productive formation by the drilling fluid; drill or core evaporates, release stuck pipe; drill under extreme time conditions and drill formation containing corrosive fluids, such as hydrogen sulfide.

2.3.3 GAS (AIR) DRILLING MUD

These types of drilling fluids had been called reduced pressure because their circulating medium and density are less than those of water. The principle benefit desired from air and aerated drilling fluids is the gain in penetration rate resulting from the lowered differential pressure. Problems arise with dry-air drilling when water is penetrated because cuttings stick to the wet borehole and may plug the annulus. After a water producing formation has been entered, the amount of water coming into the hole will control drilling rate.

2.4 DETAILS OF USE

On a drilling rig, mud is pumped from the mud puts through the drill string where it sprays out of nozzles on the drill bit, clearing and cooling the drill bit in the process. The mud then carries the crushed rock ("cuttings") up the annular space ("annulus") between the drill string and the sides of the hole being drilled, up through the surface casing, and emerges back at the surface. Cuttings are then filtered out at the shale shakers and the mud returns to the mud pits. The returning mud can contain natural gases or other flammable materials. These can collect in and around the shale shakers area or in other work areas. There is a potential risk of a fire, an explosion or a detonation occurring if they ignite. In order to prevent this safety measures have to be taken. Safety procedures, special monitoring sensors and explosion-proof certified equipment has to be installed. The mud is then pumped back down and is periodically in the mud pits to give it properties that optimize and improve drilling efficiency.

2.5 PROPERTIES OF WATER – BASE MUDS.

Drilling mud have four basic properties that determine the behaviors of the mud as a drilling fluid; viscosity, density, gel strength, and filtration. Several other properties, although of lesser important are sand content and pH.

2.5.1 VISCOSITY

Viscosity is defined as the resistance offered by a fluid (liquid or gas) to flow. The thicker a particular fluid is the higher its viscosity. Accurate measurement of the viscosity of drilling mud is dependent on a number of factors and requires special equipment. The basic factor which affect the viscosity of a mud are the viscosity of the base fluid (water); the size, shape and number of suspended particles, and the forces existing between particles as well as between particle and the fluid.

2.5.2 DENSITY

Density in defined as the weight per unit volumes of drilling fluid. It is commonly reported as kilograms per cubic meter (kg/m^3) as well as pounds per gallon (Ib/gal) or pound per cubic foot (Pcf). The desired density, which is frequently incorrectly called weight for most drilling situations is usually less than 1,080kg/m^3 (9.0Ib/gal) and can be easily determine by a mud balance.

2.5.3 GEL STRENGTH

The measure of the capability of a drilling fluid to hold particles in suspension after flow ceases is referred to as gel strength (thixotropy). Gel strength results from the electrical charges in the individual clay platelets. The positively charged edges of a platelet are attracted to the negatively charge flat surface of adjacent platelets. For a bentonite mud in which the particles are completely dispersed, essentially all the bond between particles is broken while the mud is flowing.

2.5.4 FILTRATION

Filtration refers to the ability of the drilling fluid to limit fluid loss to the formation by deposition of mud solids on the walls of the hole. During drilling operations, the drilling fluid tends to move from the borehole into the formation as a result of hydrostatic pressure which is greater in the hole than in the formation. As the flow of drilling fluid (water) occurs, the drilling fluid solids are deposited on the walls of the borehole and thereby significantly reduce additional fluid loss. The solids deposit is referred to as a filter cake. The ideal filter cake is thin with minimal intrusion into the formation. The thickness of the filter cake for a particular mud is generally a function of the permeability of the formation. For example, the filler cake in a clay interval of the borehole would be thinner than in a sand interval.

2.5.5 SAND CONTENT

Sand in any solid greater than 75 microns in size and its determination in necessary because excessive sand results in the deposition of thick filter cake on the wall of the hole which may settle in the hole around the tools when circulation is in progress, thus interfering with successful operation of drilling tools or the setting of casing also non-reactive low gravity solids creates an erosive environment which is detrimental to circulating equipment and high sand contents also cases excessive abrasion of pumps and pipe connection. (Lummus, 1987).

2.5.6 PH OF MUD

pH is one of the most important measurable characteristics of mud and is defined as the degree of acidity or alkalinity of drilling mud indicated by the hydrogen ion concentration which is commonly expressed in terms of pH. A perfectly neutral solution has a pH of 7.0. Alkaline solution has pH reading ranging above 7.0 for slight alkalinity to 14.0 for strongest alkalinity while acidity solution has pH below 7. The pH measurement is used in determining the need for chemical control of mud as well as indicating the presence of contaminants such as cement, gypsum. The drilling pH for any drilling mud is dependent upon the type of mud being use. (Walter, 1981).

Water for bentonite mud should have a pH of 7 to 9.5 and for lignosulfonate mud the pH is between 5 to 7 (Arnold, 1990).

Table 2.1 Properties of Drilling Mud.

Property	Influences	Desirable limit	Control
Density	Drilling rate. Hole stability	Less than about 1.080kg/m (9.0Ib/gal) mud balance.	Dilute with water or remove solids to decrease. Add barium to increase
Viscosity	Cutting transport, cuttings settlement, circulation pressure.	34-40 sec/dm (32.38 sec/qt) Marsh funnel and measuring cup.	Add water, phosphates or lignite's to thin. Add bentonite or polymers to thicken.
Filtration	Wall cake thickness	very thin {less than 0.2m (1/16 m)}	control density and viscosity of mud polymers
Sand content	Mud density abrasion to equipment Drilling rate	less than 2 percent by volume	Add water to lower viscosity good mud pit design use descanter.
pH	Mud properties filtration control hole stability, corrosion of equipment	8.5 to 9.5 (Neutral 7.0)	Increase with sodium carbonate.
Calcium content (Hard water)	Mud properties filtration control	less than 100 parts per million (ppm) calcium	Pretreated mixing water with sodium bicarbonate

(Baroid, 1987)

2.6 FUNCTION OF DRILLING MUD.

Drilling mud serve many purposes. The major functions include the following;

Control Formation Pressure: Drilling interval that have abnormally high pressure require that the mud system be able to provide sufficient pressure to equal or exceed the formation pressure the hydrostatic pressure of the mud system achieves this purpose.

Carrying cuttings out of the hole and to the surface which will be separated from the mud and to be re-circulated. The carrying capacity of mud depends on several factors, including viscosity and dimension of cuttings or chips

Provide logging information and interpretation of the well which depend in mud resistivity for filtrate loss/mud cake around hole bore.

Remove cuttings from well; Drilling fluid carries the rock excavated by the drill bit up to the surface. Its ability to do so depends on cutting size, shape, and density, and speed of fluid traveling up the well (annular velocity).

Cooling and lubricating the bit and drill pipe. Considerable frictional resistance is encountered by the bit in drilling the formation and by the drill pipe in coating against the side of the hole. If no fluid were present the bit would soon be burned and severely abraded. The presence of a liquid mud reduces the friction factor of the pipe and bit, for the hole and dissipates any heat so generated.

Clearing of the hole bottom; the removal of cutting from below the bit is one of the most important functions of a drilling mud. Cuttings removal is controlled by factors such as the chip hold down effect of the mud, fluid viscosity, density and size of cuttings and density of the fluid.

2.7 COMPOSITION OF DRILLING MUD

Water-based drilling mud may consist of bentonite clay (gel) with additives such as barium sulfate (barte), calcium carbonate (chalk) or hematite. Various thickness are used to influence the viscosity of the fluid, e.g. Xan thus Gum, quar gum, glycol, carbonxymethyle cellulose, polyamine cellulose (PAC), or starch. In turn, deflocculates are used to reduce viscosity of clay-based mud; anionic polyelectrolyte (e.g. acrylates, polyphosphates, lignosulfonates (lig) or tarmac acid derivates such as quebracho) are frequently used. Red mud was the name for a quebracho-based mixture, named after the colour of the real tannic acid salts; it was commonly used in 1940s to 1950s, and then was made obsolete when lignosulfonates became available.

2.8 WATER BASE MUD CONTAMINANTS.

A mud contaminant is any material incorporate into a drilling mud that has an adverse effect on the rheological characteristics of a drilling mud. They can either be physical and chemical properties of drilling mud only in one circulation. (Adam, 1989).

In many cases, however they maybe tolerated for extended periods with no apparent adverse effect. The severity of the problem experienced depends on the type and degree of contamination and the type of mud in use. The instability of mud properties caused by contaminants may be due to the form of difficulty in controlling the fluid loss, alkalinity or rheology. (Walter, 1981).

There are a number of sources of contamination. One of these is the accumulation of drilled cuttings. Other sources of contamination are:

- Cement
- Sodium Chloride (Salt)
- Gypsum/Anhydrite
- Carbonates
- Sand/Solid

2.8.1 CONTAMINATION DUE TO SOLIDS.

These are contaminant that occurs in all mud types. They may be drilled solids or over-treatment with commercial clay. Their effect on drilling mud includes high viscosity, high gel strength, and high fluid loss. A relatively low percentage of solids may develop viscosities and gel strength of such high value as to convert the mixture into a plastic mass. Grinding of clay and shale cuttings into colloidal particles in water clay mud is particularly responsible for high mud viscosities and it becomes extremely troublesome at times to keep this viscosity to a reasonable value.

2.8.2 CONTAMINATION DUE TO CARBONATE.

Carbonate accumulates in alkaline drilling mud due to the presence of carbon dioxide ($C0_2$), which reacts with hydroxyl ions (OH^{2-}) to from carbonate ion (CO_3^{2-})

Carbonate contamination is recognized with increased in high flow line viscosity, progressive gel strength, yield point and increase in pH.

A laboratory investigation of the effect of carbonate contaminant in the rheological properties of drilling mud was carried out. The yield point, plastic viscosity, initial gel strength and 10 minute gel strength were investigated.

Sight samples of the same mud were used in the investigation, the result showed that carbonate contaminant in drilling mud diversely increases the yield point and gel strength, marginal increase in the plastic viscosity of the mud was also observed. (Warren, 2005).

2.8.3 SALT CONTAMINATION (NaCl)

Sodium chloride is encountered in make-up water, sea water, from drilling massive salt sections, salt stringers and high pressure salt water flow.

In bentonite base fluids, the presence of sodium chloride above 10,000ppm will result in severe flocculation. This is recognized by an increase in viscosity, gel strength, high fluid loss and chlorides. The most extensive contamination of mud with salt comes from the drilling of salt beds and domes. In these cases, depth up to several thousands feet of salt maybe penetrated and the mud fluid soon becomes saturated. Contamination may also occur from the entrance of salt water bearing fluid from drilled permeable horizons such fluids normally contain dissolved salt concentrations up to 15 percent. The mechanism of contamination in the case of salt is based on cat ion exchange reactions with the clays, mass action by the predominant cat ion and sometimes pH.

2.8.4 CONTAMINATION DUE TO CEMENT

Cement contaminations exist in all wells. The contamination is man-made through the use of cement for casing, squeezing pipe, plugging back operation e.t.c, that is, the drilling mud suffers cement contamination from close contact it maintains with cement either in the slurry or hardened stage. The hardened cement is drilled out with the mud and in the cause of performing this operation, cement particles can be introduced into the mud. The mud gets thicker and highly alkaline. The visible sign of cement contamination is high viscosity and pH.

On further mud check, there is high filtrate alkalinity and high fluid loss, usually when circulating out cement; phenolphthalein is dropped on mud from the flow line to detect the presence of cement in the mud. (Walter, 1981).

2.8.5 CONTAMINATION DUE TO GYPSUM OR ANHYDRITE

Gypsum contamination results form the drilling of beds. Contaminations range in thickness from that of stringers of several inches to beds of soft thick. Gypsum and Anhydrite are names for the chemical compound calcium sulphate (CaSo4). In the drilling of wells the material is usually found in the anhydrous condition and is referred to as gypsum. Anhydrite contamination is similar to ions that flocculate sodium bentonite as calcium bentonite. The flocculation of bentonite results in an increase in the mud water loss. The water loss value of the drilling fluid may 8cc at the time of entering a massive anhydrite section and 24 hours anywhere from 25 to 27cc.

In order to determine the drilling fluid's behavior, multiple fluid samples were exposed to four common drilling contaminants

- Gypsum ($CaSO_48H_2O$ simulating anhydrite contamination)
- Lime $(CaCOH)_2$ simulating cement contamination)
- Salt (NaCl) simulating evaporates contamination)
- Low gravity solids (Tar sand core simulating an over loading the system with excess solids and heavy oil).

The table 2.2 below shows the effect of contaminants as expected with a polymer based fluid which contains no bentonite. The effect of lime, elevated pH and salt are minimal on the basic rheological properties. Gypsum addition resulted in a decrease of plastic viscosity and yield point increasing the solid contents give and expected increase in plastic viscosity while the yield point and gel strength remain stable.

TABLE 2.2 EFFECTS OF DRILLING CONTAMINANTS ON FLUID PROPERTIERS

System W. Visc. A &									PV	YP	G.S 10"	G.S 10'	API.FL
5% tar sand	600	300	200	100	60	30	6	3	(mPa.s)	(Pa)	(Pa)	(Pa)	(ml)
+5kg/m3 gypsum	48	35	29	20	16	12	5	4	13	11	2.5	2.5	9.5
+1kg/m3 lime	64	47	39	28	23	16	8	6	17	15	3	3.5	10
+20kg/m3 salt	49	35	29	21	16	11	5	4	14	10.5	2	2.5	8
+60% Tar Sand (LGS)	72	52	42	31	24	18	9	6	20	16.0	3.0	3.5	6.0

(SPE / IADC 92462)

2.9 TREATMENTS FOR WATER-BASE CONTAMINANTS.

Solid control: Control of solids in the mud maybe accomplished by the following methods.

1) Settling Method
2) Dilution Method
3) Mechanical Separation Method

1. Settling Method: The reduction or removal of drilled solids by this means is achieved by detaining the drilling fluid in an undisturbed state, long enough to allow the solids which are heavier than water to settle out.
2. Dilution Method: Dilution occurs at all times during the drilling of a well, it takes place in the form of water, added in chemical treatment, for washing and cleaning the solids.
3. Mechanical Separation Method: Mechanical separation devices are available in two basic types, vibrating screening devices and system based on an increased settling rate through the use of centrifugal force.

The various types of devices include shale shakers, descanter, and mud clearer and centrifuge. (Bariod, 1987)

TABLE 2.3 TREATMENTS OF MUD CONTAMINANTS

Contaminants	Treatment
Cement	Add soda ash or sodium bicarbonate. Optimize solid control equipment. Treat with thinner. Convert to a system that tolerates high cement levels when treatments are not sufficient to counter indicator.
Salt (NaCl)	Displace oil based mud system or synthetic system, when treatment is not sufficient to counter indications or convert to a saturated salt water system.
H_2S	Treat with hydrogen sulphate scavenger Adjust the pH with caustic soda.
CO2	Treat with chrome free, lignosulfonate for thickening, caustic soda to increase the pH and dilution of the mud with fresh water.
Carbonates	Treat the mud with lime or gypsum
Gypsum/Anhydrate	Treat with soda ash to maintain acceptable calcium levels. Convert to a system that tolerates high calcium level when treatment is not sufficient to counter indications

(Bariod, 1987)

TABLE 2.4 API SPECIFICATIONS ON FLUID PROPERTIES FOR GENERAL CORE DRILLING

FLUID PROPERTIES	VALUES
Mud weight	< 8.9 Ib/gal
Funnel viscosity	40-50 seconds per Us quart
Gel strength	4-8 Ibf/100ft2
Sand content	< 2%
Total solids	< 4%
pH	7-9

(Bariod, 1986)

CHAPTER THREE

3.0 MATERIALS AND EXPERIMENTAL METHOD

3.1 MATERIAL

The mud sample (water-base lignosulfonate drilling mud) was derived from Addax Petroleum Company Victoria Island, Lagos state.

TABLE 3.1 LISTS OF EQUIPMENTS

SN	EQUIPMENTS
1	Marsh funnel
2	Mud balance
3	Mud can
4	Measuring cylinder
5	Multi mixer (Electric type)
6	Weighing balance
7	Stop watch
8	Spatula
9	200 mesh screen
10	Viscometer (rotational type)
11	Graduated cup
12	Measuring glass tube
13	Phydrion dispensers
14	pH meter
15	Oven (electric)
16	Cold water bath

EXPERIMENTAL METHOD.

3.2.1 SAMPLE PREPARATION OF LIGNOSULFONATE MUD

350ml of distilled water was measured and poured into a mud cup, the water was stirred for 5 minutes, additives were measured in order of 14.0g of aguagel, 3.5g of broxin, 2.0g of k-lig, 2.0g of dextrid, 92-0g of barite. Each was added to the water and stirred for another 5 minutes using electric multi-mixer. The mud mixture was then left to age for 24 hours.

3.2.2 FIELD TESTING OF DRILLING FLUIDS

MARSH FUNNELS VISCOSITY-CUP AND FUNNEL PROCEDURE

1. Hold one finger over tip of funnel pour the mud through funnel screen until the funnel is filled to the bottom of the screen.
2. Begin the flow of mud into the mud cup by removing the finger. Start a stop watch at exactly the same time.
3. Stop the watch when the mud level reaches the one quart mark.
4. Note the number of seconds recorded by the stop watch and enter as "Funnel Viscosity (see/qt) API"

MUD DENSITY-MUD BALANCE PROCEDURE

1. Using the same sample of mud, completely fill the mud balance cup.
2. Place lid on cup with a rotating motion, expelling some mud through the hole in the lid, and wash mud from outside of cup. Wipe the excess water from mud balance with towel.
3. Place balance arm on the base with knife edge in the fulcrum and move the rider along the balance arm until balance indicates the aim is level
4. Note the density (weight of the mud at the left hand edge of the rider and enter mud report. (Ib/g, 1b/ft^3).

PLASTIC VISCOSITY, YIELD POINT, APPARENT VISCOSITY.

1. Start the viscometer test.
2. Fill viscometer cup with mud to approximately two inches from the top. Inverse the rotor sleeve to the scribed line.
3. Place the thermometer in the mud, bud do not lay it against the rotor sleeve.
4. Run rotary speed at 600rpm until dial stabilizes. Record the reading
5. Change speed to 300rpm, also record the reading

a. Plastic viscosity (PV) recorded in centipoises (cp)

PV = 600rpm reading – 300rpm reading

b. Yield point (YP) in Ibs/100ft = 300rpm reading – PV

c. Apparent viscosity (AV) in centipoises (cp)

$$AV = \frac{600\text{rpm reading}}{2}$$

GEL STRENGTHS

1. After running the plastic viscosity and yield point, stir mud at 600 rpm for 10seconds
2. Put viscometer in the 3 rpm position.
3. Wait 10seconds, and then manually turn the hand wheel (on top of viscometer) very slowly to produce a positive reading. The highest reading will be the initial gel strength and this is the reading that should be recorded.
4. Again stir sample at 600rpm for 10seconds, go to the 3rpm setting, and turn of viscometer.
5. set timer and keep mud in static state for 10minutes
6. Repeat procedure in step 3, record the highest reading as the 10-minute gel strength

pH TEST

1. Place on inch strip of indicator paper on surface of mud or place into filtrate. Allow it to remain until liquid gas wetted the surface of the paper and the color has stabilized (usually about 30seconds).
2. Compare the color of the paper with the color standards provided with the paper dispenser and estimate pH.

SAND CONTENT TESTS

1. Fill glass measuring tube to indicated mark with mud. Add water to next mark, close mouth of bulb, and shake vigorously

2. Pour mixture into a clean, wet 200 mesh screen. Add wash water to the tube and pour this on screen. Repeat washing until tube is clean.
3. Fit funnel on top of sieve, insert tip of funnel into glass bulb and wash sand back into bulb with water.
4. Allow sand to settle and read sand content present in graduation of bulb.
5. Record sand to settle and read sand content percent in graduating of bulb.

3.3 DETERMINATION OF THE EFFECT OF SALT (NaCl) CONTAMINATION ON MUD PROPERTY

The prepared mud was measured out in five potions in a mud cup, each containing 250ml. The salt was also measured out in varying of 31g, 32g, 33g, 34g and 35g and was added to each of the five portion of the mud cup and the mixture was stirred for 5 minutes, using the oven, the mixture was heated to 150^0C temperature. It was later cooled and stirred for 5 minutes; the sample was tested for various rheological properties. The procedure was repeated after each stage of 1g increment and the values recorded in parts per million (ppm) after converting from grams.

3.4 DETERMINATION OF THE EFFECT OF CEMENT CONTAMINATION ON MUD PROPERTIES

The cement (contaminant) was measured out in varying weight of 26g, 27g, 28g, 29g and 30g also the mud sample was measured out into five mud cups each containing 250ml.The samples were introduced into the multi-mixer and stirred for 5 minutes, the mixture was heated to 150^0C temperature using the oven .It was cooled and stirred for 5 minutes and tested for the various rheological properties. The procedure was repeated at the end of each stage with increment of 1g and the various values obtained and recorded.

3.5 DETERMINATION OF THE EFFECT OF CALCIUM CARBONATE CONTAMINATION ON THE MUD PROPERTY.

250ml of the mud sample was measured out into a mud cup and varying weight of $CaCO_3$ contamination in five portions of 22ml, 24ml, 26ml, 28ml and 30ml, each added into the mud cup and placed in the multi mixer where stirring took place for 5 minutes. After which the mixture was tested for various rheological properties, the procedure was repeated at the end of each stage with increment of 2ml and the reading recorded.

CHAPTER FOUR

4.0 RESULT AND DISCUSSION

4.1 RESULTS

TABLE 4.1 RHEOLOGICAL TEST RESULT OF LIGNOSULFONATE MUD.

LIGNOSULFONATE MUD AND 350ML OF WATER	THEOLOGICAL READING		MUD WEIGHT (Ib/gal)	pH	PV (cp)	AV (cp)	YP Ibf/100ft^2	GEL STRENGTH Ibf/100ft^2	SAND CONTENT %	MARSH FUNNEL VISCOSITY sec/qt
	600rpm	300rpm						10sec		
	48	30	8.7	6.6	18	24	12	3.0	0.025	70

TABLE 4.2 SALT CONTAMINANTED RESULTS (LIGNOSULFONATE – 250ml).

CONCENTRATION OF SALT	THEOLOGICAL READING		MUD WEIGHT (Ib/gal)	pH	PV (cp)	AV (cp)	YP Ibf/100ft^2	GEL STRENGTH Ibf/100ft^2	
	600rpm	300rpm						10 sec	10 min
124,000pm	71	45	10.5	11.5	26	35.5	19	10	12
128,000pm	72	45	11	12	27	36	18	10.5	14
132,000pm	78	49	11	12	29	39	20	10.5	15
136,000pm	81	51.5	11	12	29.5	40.5	22	11	16
140,000pm	83	53.0	11	12	30	41.5	23	11.5	18

TABLE 4.3 CEMENT CONTAMINANT RESULTS (LIGNOSULFONATE – 250ml.)

CEMENT CONCENTRATION	THEOLOGICAL READING		MUD WEIGHT (Ib/gal)	pH	PV (cp)	AV (cp)	YP Ibf/100ft^2	GEL STRENGTH Ibf/100FT^2	
	600rpm	300rpm						10 sec	10 min
104,000pm	62	35	10.8	7	27	31	8	10	12
108,000pm	64	36	10.85	7	28	32	8	12	12
112,000pm	70	40	10.9	7	30	35	10	13	14
116,000pm	76	44	11	8	32	38	12	13	14
120,000pm	84	48	11.15	8	36	42	12	15	14

TABLE 4.4 CARBONATE CONTAMINANT RESULT (LIGNOSULFONATE-250ml)

$CaCO_3$ CONCENTRATION	THEOLOGICAL READING		MUD WEIGHT (Ib/gal)	pH	PV (cp)	AV (cp)	YP Ibf/100ft^2	GEL STRENGTH Ibf/100ft^2	
	600rpm	300rpm						10 sec	10 min
8.8%	72.5	44.0	9	11.5	28.5	36.3	15.5	11	14.5
9.6%	74.0	45.0	9.5	11.5	29	37	16	11	11.5
10.40%	76.3	46.5	9.5	12	29.8	38.2	16.7	11.5	15
11.20%	82.5	50.5	9.6	12	32	41.3	18.5	12	16
12%	84.5	51.5	9.6	12.5	33	42.3	18.5	13	17

DISCUSSION OF RESULT

Table 4.1 is the experimental analysis of lignosolfonate mud comparing with table 2.4 which is that of API (America Petroleum Institute) specification on fluid properties for general are drilling. In table 4.1 the mud weight was 8.7 Ib/gal which agrees with that of API specification in table 2.4 which is less than <8.9 Ib/gal. The pH had a value of 6.6 in table 4.1 and was cited in chapter two that for lignosolfonate mud the pH ranges from 5 to 7 (Arnold, 1990),which falls within the range. The gel strength was 3.0 Ibf/100ft^2 in table 4.1 compared to that of API specification which ranges from 4-8 Ibf/100ft^2; this is due to the thixotropy character of the mud. Thixotropy is the ability of the mud to form a gel structure when at rest and collapse of gel structure leads to reduction to the gel strength (Knell, 2000).The sand content was 0.25% in table 4.1 compared to the API specification has a sand content less than 2% which falls into the range. The funnel viscosity was 70 seconds per Us quart which is above the API specification range of 40-50 seconds per Us quart, due to high mud weight and the fluid velocity was low (Knell, 2000).

Table 4.2 shows the experimental analysis of rheological behavior in mud contaminated with salt. There was a steady increase in plastic viscosity and apparent viscosity of the mud, from 26cp to 30cp and 35.50 to 41.50cp respectively as the salt contamination was increased. This was also observed in the gel strength rheological property, as the time increases from 10 seconds to 10 minutes. There was a small increase in weight of the mud from 10.5Ib/gal to 11.0Ib/gal with increase in concentration of the salt from 124,000ppm to 128,000ppm, before being unaffected as the contamination increases from 128,000ppm to 140,000ppm. A slight decline in the yield point was noticed from 124,000ppm to 128,000ppm, but there was a gradual and steady increase from 238,000ppm as the contaminant increases. Salt is a powerful flocculants that increases viscosity, gel strength and water loss. Once the gel structures completely collapse, the viscosity and gel strength are minimized. Also increase in gel strength and viscosity lead to difficulty in mud pumping sate.

The increase in yield point reduces drilling efficiency by cutting penetration rate, increases circulation pressure.

Table 4.3 shows the rheological behavior observed in mud contaminated with cement. From the values observed, there was a rapid increase in both plastic viscosity and apparent viscosity from 27cp to 36cp and 31cp to 42cp respectively from 104,000ppm concentration to 120,000ppm of cement concentration. There was increase in the weight while it was observed that the pH remain unchanged at 7.0 from 104,000ppm to 112,000ppm, elevated a little to 8.0 from 116,000ppm to 120,000ppm. There was a stable condition in the yield point at 8 Ibf/100ft^2 between 104,000ppm and 108,000ppm after which it increases to 12 Ibf/100ft^2 as the contamination lasted. Also the gel strength increases as the time was increased from 10 seconds to 10 minutes during the contamination process. Increase in the plastic and apparent viscosity of lignosolfonate mud due to cement contamination alters smooth operation of the drilling process by increasing pressure drop in the mud circulating system. The yield point of the mud is influenced by the concentration of the solid content in cement; it causes reduction in drilling efficiency by altering pipe penetration salts. The pH values may lead to increase in corrosion of drilling equipment. The increase in weight of the mud causes formation fracture, the increase in the gel strength causes the pipe to stick in the hole and also well bore fracture is feasible.

From table 4.4 the experimental analysis shows the rheological behavior observed in mud contaminated with carbonate. From the table, it was observed that there was a steady increase in the plastic viscosity from 28.5cp to 33.0cp and apparent viscosity from 36.3cp to 42.3cp as the carbonate concentration increases from 8.8% to 12%. Also these was a gradual increase in the yield pint from 15.5 Ibf/100ft^2 to 16.7 Ibf/100ft^2 , before it become stable between 11.2% and 12% at 18.5 Ibf/100ft^2. There was a visible increase in the gel strength as the time of contamination increases from 10 seconds to 10 minutes while carbonate concentration increases.

Increase in the viscosity due to carbonate contamination causes reduction in mud cutting carrying capacity and reduction in mud pumping rate. Due to high pH value, some thinner effectiveness in the mud is hindered such as lignosulfonate mud that operates at pH below 10.The small increase of the mud weight might affect the drilling rate.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

In conclusion, this research project deals with the effect of contaminants in the rheological properties of water based lignosolfonate drilling mud. Water-based lignosulfonate mud can not resist contaminate effect on the properties of drilling mud above salt concentration of 124,000ppm, 104.000ppm concentration of cement and 8.8% per volume of carbonate contamination as above these, drilling mud functions are affected by leading to severe well problems such as pipe sticking, well kick, blowout, formation damaged, flocculation and lost circulation.

5.2 RECOMMENDATION

The mud engineer should develop pretreatment of mud so as to prevent effects of contaminant in time and therefore negate the requirement for post-corrective measure, which is time and cost intensive. The mud engineer should adjust any of the drilling mud properties at any point in time to achieve the most suitable hole stability requirement and the set objectives high pH concentrations is desirable in drilling mud. To enhance hole safety, stability requiring and against contaminants effect.

Special mud should be generally introduced during drilling to combat specific holes problems to reduce the cost of drilling and help formation evaluation.

Good solid control equipment and proper additives of water-based mud and chemicals should be provided to a high mud weight system to eliminate solid build up problems in the hole since the water dilution used as a corrective measure of solid problem is very expensive since water-based mud suffers thermal degradation and break down at high temperature, to prevent down hole gel strength the operating temperature range of the mud should not be exceeded unless temperature – extending chemical are added in proper proportion.

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APPENDIX I

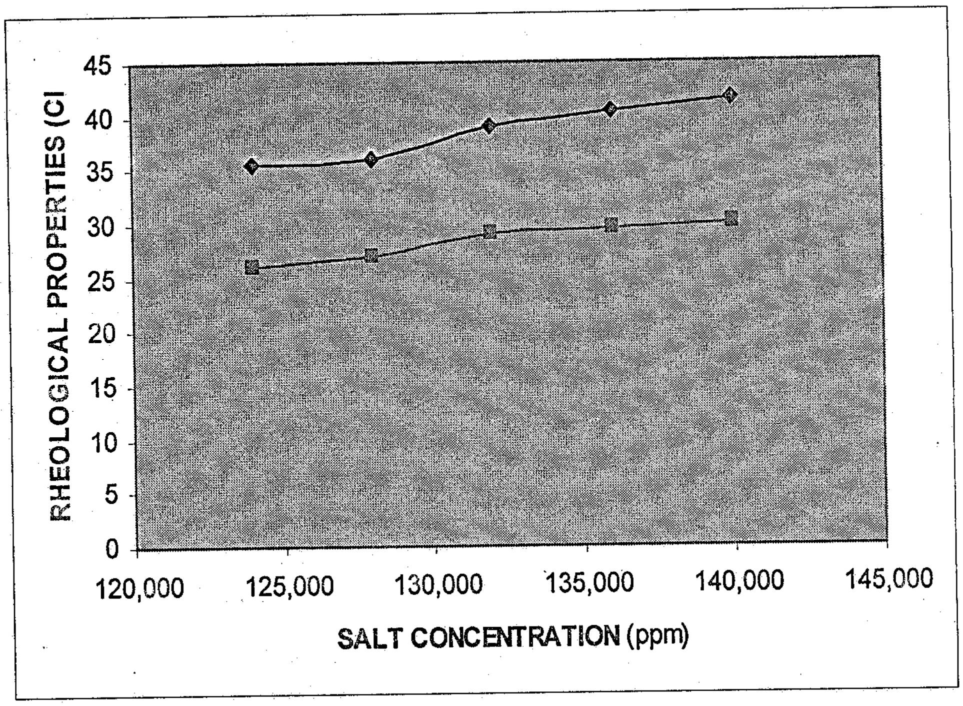

FIGURE 4.1 Graph of Viscosity versus Salt Concentration

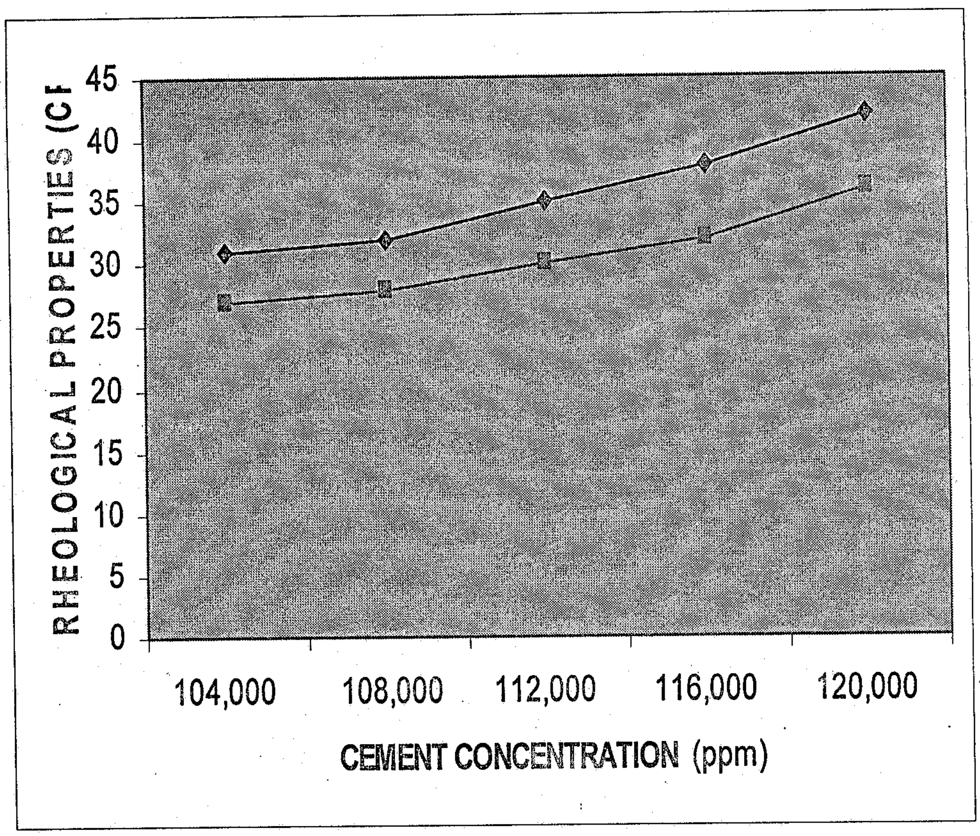

FIGURE 4.2 Graph of Viscosity versus Cement Concentration

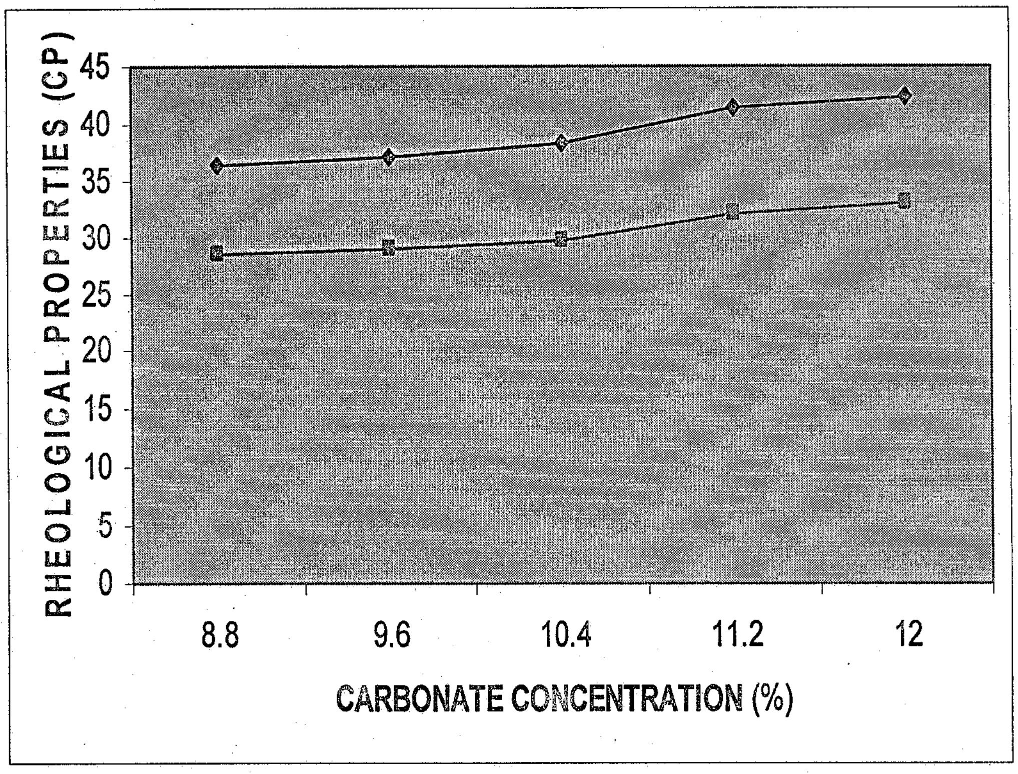

FIGURE 4.3 Graph of Viscosity versus Carbonate Volume

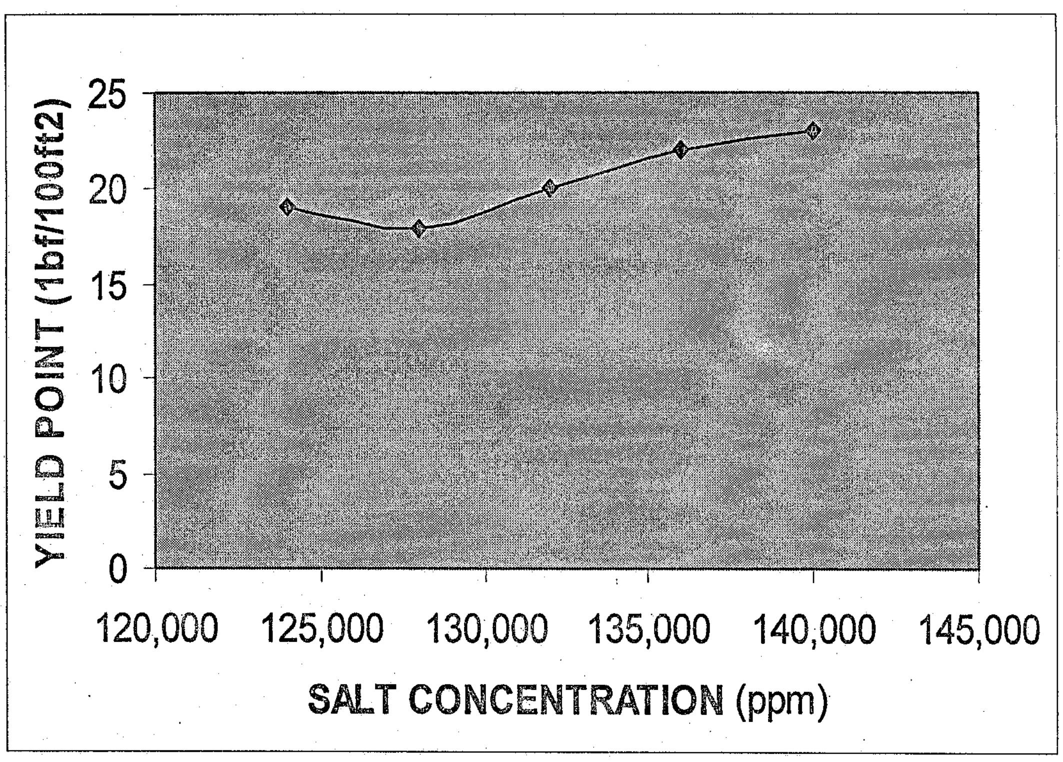

FIGURE 4.4 Graph of Yield Point versus Salt Concentration

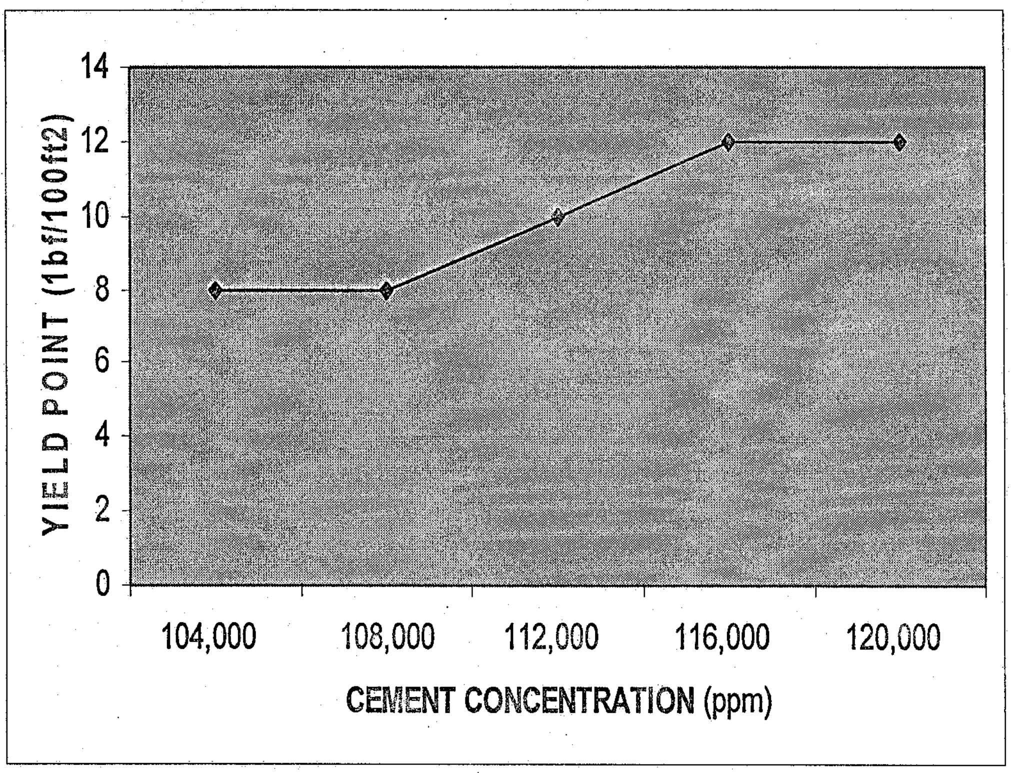

FIGURE 4.5 Graph of Yield Point versus Cement Concentration

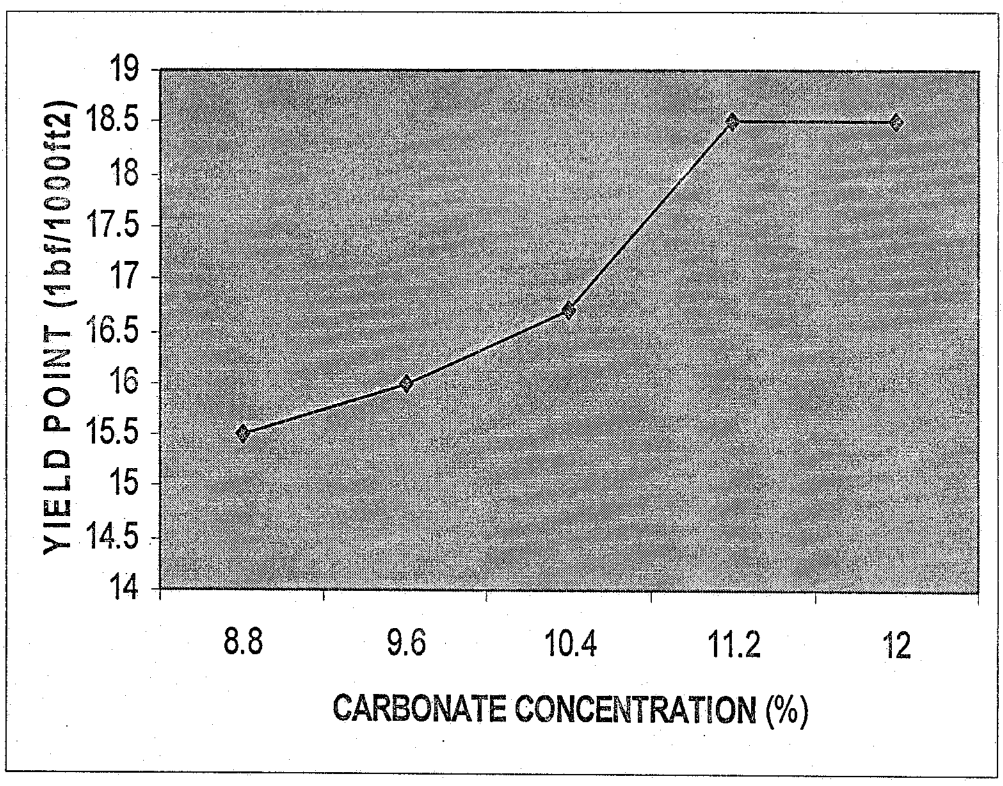

FIGURE 4.6 Graph of Yield Point versus Carbonate Volume

APPENDIX II

CALCULATION OF RESULT FOR LIGNOSULFONATE MUD.

Apparent viscosity (AV) = $\frac{\text{600rpm reading}}{2}$

Plastic viscosity (PV) = 600rpm reading - 300rpm reading

Yield point (YP) = 300rpm reading – PV

Apparent viscosity (AV) in (cp)

600rpm reading = $\frac{48}{2}$ = 24cp

Plastic viscosity (PV)

= 600rpm reading – 300rpm reading

PV = 46 – 30 = 12cp

Yield Point

YP = 30 – 12 = 18 Ibf/100ft^2

CALCULATION OF RESULT FOR MUD WITH SALT (NaCl) CONTAMINATION

Apparent viscosity (AV)

For 124,000ppm of salt

AV = $\frac{71}{2}$ = 36cp

For 128,000ppm

AV = $\frac{72}{2}$ = 36cp

For 132,000ppm

AV = $\frac{78}{2}$ = 39cp.

For 136,000ppm

AV = $\frac{81}{2}$ = 40.5cp

For 140,000ppm

$AV = \frac{83}{2} = 41.5cp$

Plastic viscosity (PV)

For 124,000ppm

PV = 71-45 = 26cp

For 238,000ppm

PV = 78-49 = 29cp

For 136,000ppm

PV = 81-51.5 = 29.5cp

For 140,000ppm

PV = 83-53 = 30cp.

Yield point (YP)

For 124,000ppm

YP = 45-26 = 19 Ibf/100ft^2

For 128,000ppm

YP = 45-27 = 18 Ibf/100ft^2

For 132,000ppm

YP = 49-29 = 20 Ibf/100ft^2

For 136,000ppm

YP = 51.5 – 29.5 = 22 Ibf/100ft^2

For 140,000ppm

YP = 53 – 30 = 23 Ibf/100ft^2.

CALCULATION OF RESULT FOR LIGNOSOLFONATE MUD WITH CEMENT CONTAMINANT

Apparent viscosity (AV)

For 104,000ppm

AV = 62/2 = 31cp

For 108,000ppm

$$AV = \frac{64}{2} = 32cp$$

For 112,000ppm

$$AV = \frac{70}{2} = 35cp$$

For 116,000ppm

$$AV = \frac{76}{2} = 38cp$$

For 120,000ppm

$$AV = \frac{84}{2} = 42cp$$

Plastic viscosity (PV)

For 104,000ppm

$PV = 62 - 35$

$PV = 27cp$

For 108,000ppm

$PV = 64 - 36$

$PV = 28cp$

For 112,000ppm

$PV = 70 - 40$

$PV = 30cp$

For 116,000ppm

$PV = 76 - 44$

$PV = 32cp$

For 120,000ppm

$PV = 84 - 48$

$PV = 36cp$

Yield point (YP)

For 104,000ppm

YP = 300rpm reading – PV

YP = 35 – 27 = 8 Ibf/100ft^2

For 108,000ppm

YP = 36 – 28 = 8 Ibf/100ft^2

For 112,000ppm

YP = 40 – 30 = 10 Ibf/100ft^2

For 116,000ppm

YP = 44 – 32 = 12 Ibf/100ft^2

For 120,000ppm

YP = 48 – 36 = 12 Ibf/100ft^2

CALCULATION RESULT OF LIGNOSOLFONATE MUD WITH CARBONATE CONTAMINANT

Apparent viscosity (AV) $= \frac{\text{600rpm reading}}{2}$

For 8.8%

$AV = \frac{72.5}{2} = 36.25cp$

For 9.6%

$AV = \frac{74}{2} = 37cp$

For 10.4%

$AV = \frac{76.3}{2} = 38.3cp$

For 11.2%

$AV = \frac{82.5}{2} = 41.23cp$

For 12%

AV = 84.5% = 42.23cp.

Plastic viscosity (PV) = 600rmp reading – 300rpm reading

For 8.8%

PV = 72.5 – 44.0 = 28.5cp.

For 9.6%

PV = 74.0 – 46.0 = 29cp

For 10.4%

PV = 76.3 – 46.5 = 29.8cp

For 11.2%

PV = 82.5 – 50.5 = 32.0cp

For 12%

PV = 84.5 – 51.5 = 33.0cp

Yield point (YP) = 300rpm reading – PV

For 8.8%

YP = 440 – 28.5 = 15.5 Ibf/100ft^2

For 9.6%

YP = 45.0 – 290 = 16.0 Ibf/100ft^2

For 10.4%

YP = 46.5 – 29.8 = 16.7 Ibf/100ft^2

For 11.2%

YP = 50.5% - 32.0 = 18.5 Ibf/100ft^2

For 12%

YP = 57.5 – 33.0 = 18.5 Ibf/100ft^2

CONVERSION OF GRAMS PER LITRE (g/L) TO POUNDS PER MILLION

FOR SALT CONTAMINANT

For 31g of salt

1000ml = 1 litre

$$250ml = \frac{250}{1000} = 0.25 \text{ litre}$$

$$\text{To g/litre} = \frac{31g}{0.25 \text{ litre}} = 124g/litre$$

g /litre → ppm

124 g/litre x 1000 = 124,000ppm

For 32g of salt

$$\frac{32g}{0.25 \text{ litre}} = 128g/litre$$

g/litre → ppm = 128 x 1000 = 128,000ppm

For 33g of salt

$$\frac{33g}{0.25 \text{ litre}} = 132g/litre$$

g/litre → ppm = 132 x 1000 = 132,000ppm

For 34g of salt

$$\frac{34g}{0.25 \text{ litre}} = 136g/litre.$$

g/litre → ppm = 136 x 1000 = 136,000ppm

For 35g of salt.

$$\frac{35g}{0.25 \text{ litre}} = 140g/litre$$

g/litre → ppm = 140 x 1000 = 140,000ppm

CONVERSION OF GRAMS PER LITRE (g/L) TO POUNDS PER MILLION FOR CEMENT

For 26g of cement

1000ml = 1 litre

$250ml = \frac{250}{1000} = 0.25$ litre

$\frac{26}{0.25} = 104$g/litre

g/litre → ppm = 104 x 1000 = 104,000ppm.

For 27g cement.

$\frac{27}{0.25} = 10.8$g/litre

g/litre → ppm = 10.8 x 1000 = 108,000ppm.

For 28g cement.

$\frac{28}{0.25} = 112$g/litre

g/litre → ppm = 112 x 1000 = 112,000ppm.

For 28g cement.

$\frac{29}{0.25} = 116$g/litre

g/litre → ppm = 116 x 1000 = 116,000ppm.

For 30g cement.

$\frac{30}{0.25} = 120$g/litre

g/litre → ppm = 120 x 1000 = 120,000ppm.

CONVERSION OF $CaCO_3$ IN PERCENTAGE

$\frac{22}{250} x \frac{100}{1} = 8.5\%$

$\frac{24}{250} x \frac{100}{1} = 9.6\%$

$$\frac{6}{0} \times \frac{100}{1} = 10.4\%$$

$$\frac{8}{50} \times \frac{100}{1} = 11.2\%$$

$$\frac{0}{50} \times \frac{100}{1} = 12\%$$