Drilling Fluid Study: **Evaluating the Quantitative Determination Method of Partially-Hydrolyzed Polyacrylamide (PHPA) Polymer in Drilling Fluid**

By

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12375

Dissertation Report submitted in partial fulfilment of
the requirement for the
Bachelor Engineering (Hons)
Petroleum Engineering

JANUARY 2012

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Petroleum Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
Bachelor of Engineering (Hons)
Petroleum Engineering

Approved by,

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January 2012

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the originality work contained herein have not been undertaken or done by unspecified sources or persons.

MOHD RAZMI ZIQRI B AHMAD SHUKRI

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ABSTRACT

This dissertation is purposed to record all the data gathered throughout author's study and research for this project. A deep study of Partially Hydrolyzed Polyacrylamide (PHPA) polymer is conducted and author had selected HyPR-CAP PHPA and Polymer Test Kit to be used in this project. The need for a reliable, quantitative analytical method for the determination of the PHPA polymer content of drilling mud and other water-base fluids has been evident for some time. PHPA is a short-chain polymer which is special from other type of polymer that is used in the mud system either to control wellbore shales or to extend bentonite clay in a low-solids mud. By using Polymer Test Kit – Clapper Type provided by OFI Testing Equipment, Inc (OFITE), this project is run to evaluate the quantitative determination of PHPA in mud system. This kit is supplemented with a cross reference table which is only capable to cross reference the test result to the maximum of 1 g HyPR-CAP. In the HyPR-DRILL field trial, 3 g HyPR-CAP has often been recommended. This has driven the need to expand the cross reference table to 3 g HyPR-CAP. This test determines the polymer concentration in mud systems and also involves measurement of the rate of ammonia generation while the mud filtrate is heated in the presence of sodium hydroxide solution. The ammonia is removed from the reaction vessel with a slow air purge and detected with a Dräger-Tube™. The approximate concentration of polymer is determined by measuring the time required for the Dräger-Tube™ to turn blue. The time for the Dräger-Tube™ to turn blue are taken and compare them to the reference table given by OFITE as we can know the concentration of PHPA polymer in our mud systems. Author managed to evaluate the quantitative determination for HyPR-CAP using Polymer Test Kit but not managed to expand the cross reference. Besides the results are not repeatable and reliable, this method also has lot of interferences as stated in the discussion part.

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Chapter 1: INTRODUCTION

1.1 Project Background

HyPR-DRIL is a new generation High Performance Water Based Mud (HPWBM) used by Scomi Oiltools, which provides wellbore stability, enhanced inhibition and rapid penetration rates. The core components[1] are;-

- HyPR-HIB: Polyamine,
- HyPR-CAP: low molecular weight PHPA,
- Cumulus CPG: cloud point glycol and
- HyPR-DRL: anti-accretion surfactant.

During the field trial of HyPR-DRILL system, it was observed that the HyPR-CAP field testing procedure can be further improved. Due to HyPR-CAP being one of the core components, accurate quantitative testing is required. Regular PHPA test using flocculation method has been extensively tested in previous project test methods for HyPR-DRILL. In the project, it was observed that the flocculation method is unsuitable for HyPR-CAP due to the nature of its short chain PHPA. The short chain PHPA might not undergo the desired flocculation or flocculated PHPA might be too small and cannot be centrifuged down. In the same project, Polymer Test Kit from Ofite was recommended as the preferred test method.

The Polymer Test Kit test determines the PHPA concentration in mud filtrates. This method is based on direct alkaline hydrolysis of a sample of either whole mud or mud filtrate. It involves measurement of the rate of ammonia generation while the mud filtrate is heated in the presence of sodium hydroxide solution. The ammonia is removed from the reaction vessel with a slow air purge and detected with a Dräger-Tube. The tube is packed with an absorbent impregnated with an indicator that changes colour when contacted with ammonia gas. The approximate concentration of PHPA is determined by measuring the time required for the Dräger-Tube to turn blue. This kit is supplemented with a cross reference table. The table is only capable to cross reference the test result to the maximum of 1 g HyPR-CAP. In the HyPR-DRILL field trial, 3 g HyPR-CAP has often been recommended. This has driven the need to expand the cross reference table to 3 g HyPR-CAP.

[1] Refer to Table 1

1.2 Problem Statement

HyPR-CAP which is low molecular weight and short chain PHPA polymer is a vital component in HyPR-DRIL mud system. So the quantitative determination is very important to know the exact value of HyPR-CAP still exists in our mud. Notes that we are recycling back our used mud and for sure some of its component was depleted in our wellbore. It is easy to know how much HyPR-CAP before use because we are the one who mixing it. The problem is to know how much of them remain in the used mud. This is very important because too low amount of HyPR-CAP will result in low performance mud and too high will not economically wise. We need to maintain the properties of our mud throughout the whole operation by maintaining the amount of HyPR-CAP in it.

It was observed that the flocculation method is unsuitable for HyPR-CAP due to the nature of its short chain PHPA. The short chain PHPA might not undergo the desired flocculation or flocculated PHPA might be too small and cannot be centrifuged down.

So the Polymer Test Kit – Clapper Type by OFITE is chosen. This kit is supplemented with a cross reference table. The table is only capable to cross reference the test result to the maximum of 1 g HyPR-CAP. In the HyPR-DRILL field trial, 3 g HyPR-CAP has often been recommended. This has driven the need to expand the cross reference table to 3 g HyPR-CAP.

1.3 Objectives

The objectives of this project are:

1) To evaluate the quantitative determination method of PHPA polymer in drilling fluid.

More research still need to be done to find study in determining the concentration of PHPA polymer in the rig condition. The method that is Polymer Test Kit that provided by OFITE, HyPR-CAP as PHPA polymer and HyPR-DRILL as the mud system will be used in the entire project.

2) To expand the cross reference table in HyPR-CAP field testing protocol. (Table 4)

As mentioned in the problem statements, the provided cross-reference table for evaluating the concentration of PHPA polymer in mud need to be expanded up to 3 g to suit with the current use in the market.

1.4 Scope of Study

Drilling fluids also known as mud are very important in drilling a well. HyPR-CAP (a low molecular PHPA) is a main additive in HyPR-DRIL mud system. So the study of quantitative determination method of PHPA polymer is very important and needed for the sake of drilling using this mud system. Without proper care with the concentration of HyPR-CAP that still existed in the mud system, we cannot recycle the used mud unless with the proper treatments. The HyPR-CAP need to be added as some of them already depleted when we are using it in the borehole for the drilling. We cannot know the amount of HyPR-CAP need to be added in the mud system to maintain the designed properties and rheology of them our mud. By adding too much and excessive amount of HyPR-CAP will cost us more and not economic wise. While too low addition of HyPR-CAP and maybe lower that the requirement will affecting our mud properties and relate to drilling problems. The author is saying that without proper quantified the concentration of HyPR-CAP that we might see it as a very small matter will relate us to many problems especially in the drilling process. In this project, the most effective way in determining the concentration of HyPR-CAP in mud system that also rig-friendly will be revealed and shared.

1.5 Relevancy of the Project

In terms of the relevancy of this project, it poses a great deal of significance to the oil and gas industry. For this project, the author is applying his theoretical in petroleum engineering and practical knowledge after 7-month internship in Research and Engineering Department at Scomi Oiltools, Shah Alam. The study on drilling fluids is very important as the drilling itself is only can be done with the help of drilling fluids. Each and every drilling fluids system has its own properties depending on the need of specific wellbore. This properties need to be maintained throughout the whole drilling process and if not, it will give problems to the drilling process. Hence, the outcome of this project is deemed crucial as this HyPR-DRILL mud system is still new and applied in the current market.

1.6 Feasibility of Project

All the objectives stated earlier are achievable and feasible in terms of this project duration and Final Year Project's time frame. Previously during internship, the author has already been exposed to the drilling fluids business also with the help of Scomi's staff and dedicated UTP supervisor, the author truly believe that this project is feasible. The author is more towards paper research and collecting more information related to the project in the first part of his Final Year Project while focusing more to the lab works, collecting data, discussing and analysing the results in the second part. Since the author already acquired the basic understanding of drilling fluid, it can be concluded that this research project is feasible and the stated objectives can be achieved within the scope of this Final Year Project.

Author divided this project into 2 phases – ‘Final Year Project 1’ and ‘Final Project 2’. The planning and paper study will be done in ‘Final Year Project 1’, and the implementation and testing phases will be carried out in ‘Final Year Project 2’. The research and studies part will be done during ‘Final Year Project 1’ while the results must be delivered by end of ‘Final Year Project 2’.

There is ample time to carry out the project because the author conducts research during ‘Final Year Project 1’ phase, where the duration is one semester (14 weeks). One semester provides enough time for the author to gather important data to be studies for this project.

During the ‘Final Year Project 2’, author will continue the project by having testing the lab based on the information from ‘Final Year Project 1’. The author had been provided 1 whole semester (14 weeks) in order to carry out this task. Since the research and literature review was done during previous stage, the development process will be easier and can be done within the time limit. Since this task does not require any purchase of hardware or tools, so there are no blocking time for author to complete the project. Hence, this project is feasible to be conducted during these 2 semesters.

Chapter 2: LITERATURE REVIEW

2.1 Basic Principle of Drilling Fluids [1]

Basically, drilling fluid or mud is vital in the drilling process. A poor drilling fluid design and selection can be fatal to the drilling process. Drilling efficiency is also important to save the cost operation. During the process, the drilling fluid or mud is pumped to the wellbore through the drill bit continuously. The main function of drilling fluid is to transport the cuttings from the wellbore to the surface. When the mud is circulating from the wellbore to the surface, the cuttings are separated from the mud using a shale shaker and other separation units. When the cuttings are separated, the mud is circulated back to the wellbore; sometime after some treatments.

Another important use of drilling fluid is to control the wellbore pressure. Pressure can come from formation pressure, overburden pressure and tectonic pressure which act towards the wellbore. These pressures must be overcome by balancing the pressure inside the wellbore through hydrostatic pressure of the fluid column. Hydrostatic pressure can be calculated by:

Equation 1: Hydrostatic Pressure

Hydrostatic Pressure (psi) =Height (ft) x Mud Weight (ppg) x 0.052

This hydrostatic pressure is provided by the drilling fluid. The property that affects the hydrostatic pressure is the mud density or mud weight. The mud weight should be calculated precisely to provide the hydrostatic pressure. If the mud weight is insufficient, there would be a "kick" occurs. A "kick" happens when the formation pressure is greater than the hydrostatic pressure and therefore pressing (or kicking) towards the wellbore. If this happens, the diameter of the wellbore would increase, making it difficult to take out the drill string and to circulate the mud. If however, the mud weight is in excess, the hydrostatic pressure would be greater than the formation, resulting in the mud flowing towards the formation. This is called as lost circulation.

Another function of drilling fluid is to isolate fluids from the formation. During the drilling process, there is a chance for the drilling fluid to come into the formation. However, during the mud circulation, eventually the there would be a mud cake built up on the wall surface of the wellbore. This mud cake should have a low permeability to prevent excessive filtrate flowing to the formation.

Another function of drilling fluid is to cool down the drill string. During the drilling process, as the well gets deeper, the geothermal gradient causes the temperature of both formation and drilling fluid to increase. However, the drilling fluid is able to absorb much of the heat that is generated and conducts it away from the formation. There are many other additional functions of drilling fluids such as to maximize the rate of penetration, to control corrosion, to protect the formations drilled and many others. It is impossible to drill a well without a drilling fluid. The property of the drilling fluid must be adjusted to the wellbore condition so it would give the best result in taking out the cuttings, balancing the pressure, etc.

There is several type of mud according to its function. The use of the drilling fluid depends on the rig condition, which area or depth the drilling process is and what type of formation it is.

2.1.1 Water Based Mud (WBM)

Used for low reactive clay or for a low temperature wellbore. Water based mud is the typical mud used under normal condition. It is considered the cheapest among all muds. However, since the base is water, the water can react with the formation resulting in instability. Therefore, the water based mud needs to be formulated to have a good fluid loss control and also enough viscosifier to provide the pressure and suspend the cuttings.

2.1.2 Non – Aqueous Fluid (NAF)

Non – aqueous fluid uses oil or synthetic oil as it base fluid. Hence it is usually called Oil Based Mud (OBM) or Synthetic Based Mud (SBM). Oil based mud is thermally stable, suitable for a wellbore with high temperature. It is also give wellbore stability as it would not react with the formation and has a good fluid loss control. The cuttings created by oil based mud usually have distinctive shape and size. However, since the base is oil, it is relatively harmful to the environment. The disposal of oil based mud to the sea is usually prohibited as it would kill the living creature and disturb its ecosystem. Especially for a country which applies zero-dumping policy, the mud needs to be firstly treated.

2.1.3 Completion Fluid

Completion fluid is a brine fluid that is used during the completion operation, after the well has been drilled but before the production process begins. The brine used can be a single salt solution (e.g. Sodium Chloride (NaCl), Calcium Chloride (CaCl2), etc), or multiple salt solution (e.g. NaCl/NaBr, CaCl2/CaBr2, etc). This fluid contains no solid because it requires protecting the productive zone but still can circulating and transferring any remaining solid as well as controls the pressure. The mixture of brine needs to be carefully examined, monovalent salt (e.g. Sodium) must be mixed with another monovalent salt whereas divalent salt (e.g. Calcium, Zinc) is mixed with another divalent salt. If monovalent salt is mixed with divalent salt, precipitation would occur which can reduce its effectiveness.

2.1.4 Reservoir Drill – In Fluid (RDIF)

It is used to drill the reservoir section of the wellbore. Since the formation contains the production oil or gas, the drilling fluid used must have minimum damage to the formation but still have a maximum performance to drill and bring up the cutting to surface. In reservoir drill-in fluid, minimum amount of solid is preferred in the mud as the solids can go through the formation and damage it. The base fluid use can be water or oil. However, reservoir drill – in fluid must be compatible with the formation. It should not react with the formation since it would alter the properties of the formation.

2.2 Basic equipments used in the lab[2]

Figure 1: HTHP Filter Press

The OFITE HTHP Filter Press is designed for testing drilling fluids and cement under elevated temperatures and pressures. This simulates various downhole conditions and provides a reliable method for determining the effectiveness of the material being tested.

Figure 2: 50-ml Retort Kit

The retort provides a means for separating and measuring the volumes of water, oil, and solids contained in a sample of drilling fluid. A known volume of sample is heated to vaporize the liquid components which are then condensed and collected in a graduated cylinder.

Figure 3: Fann 35 Rheometer

Used to check the rheology properties of drilling fluid:

Apparent Viscosity

- Plastic Viscosity
- Yield Point
- Gel Strength

Figure 4: API Filter Press

Used to test the fluid loss in the drilling fluid for timing of 30 minutes

Uses differential pressure of 100psi

Although does not reflect down hole condition, this test is reliable to know the filtrate at any given moment

[2] Based on Scomi Oiltools Information

Figure 6: Electric Stability Meter

Electrical Stability reading is used to measure the emulsion strength between oil and water in synthetic based mud. ES varies with water-oil ratio. The Unit is in Volts and the test is carried out at whatever the rheology temperature is carried out at.

Figure 5: Mud Balance

To determine mud weight / density. It is design such that the mud cup is balanced by a fixed counterweight at the end - free sliding weight rider. A level bubble is mounted on the beam to allow accurate balancing.

Figure 7: Particle Size Analyzer (PSA)

Commonly used to determine the particle size distribution for mud, fines Lost Circulation Material (LCM) and weighing agent. API standard dictates that barite should have less than 30% of its particle size within 6 microns in diameter.

Figure 8: Aging Cell

Use to stimulate the mud circulation process inside the wellbore. The mud were put inside the cell, pressurize and the cell were roll inside the oven, stimulating the mud behavior at certain temperature and pressure inside the well bore.

Figure 9: March Funnel Viscometer

It can only be used as an indicator of mud stability, or relative changes to mud properties. Time, in seconds for one quart of mud to flow through a marsh funnel is taken. This is not a true viscosity, but serves as a qualitative measure of how thick the mud sample is. The funnel viscosity is useful only for relative comparisons.

2.3 HyPR-DRILL mud system [2]

HyPR-DRIL is a new generation High Performance Water Based Mud (HPWBM), which provides wellbore stability, enhanced inhibition and rapid penetration rates.

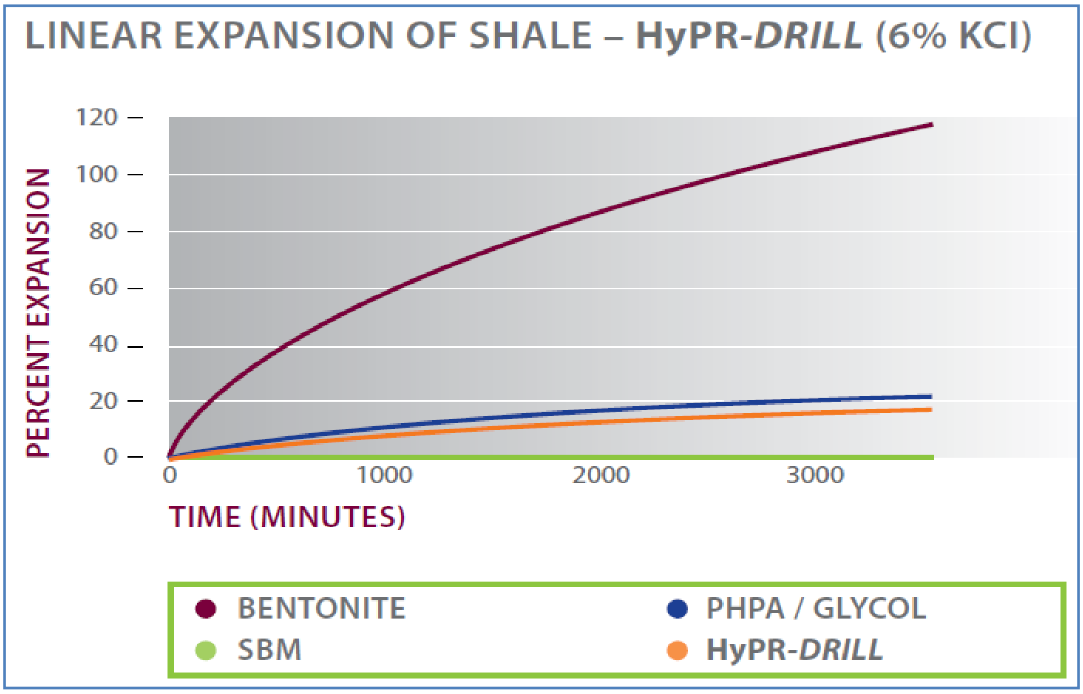
Features & benefits;

- Excellent shale inhibition over other inhibitive WBM.
- Enhanced wellbore stability.
- Reduced drilling cost.
- Reduced waste handling costs & excellent penetration rates.
- Prevention of bit balling and shale accretion on drill string.
- Easily formulated for applications ranging from land to deepwater drilling.

Environmental awareness and the application of stricter regulations are, in many areas, restricting the discharge of cuttings contaminated with synthetic or mineral oil base fluids. These restrictions present logistical and waste management costs, impact on installation design and may present significant health and safety concerns as large quantities of cuttings have to be handled. These restrictions may impact to the economics of marginal developments and stranded oil.

Drawing on a wide ranging review of HPWBM development and performance coupled with extensive testing and development of alternative products in the R&D labs of Scomi Oiltools' Global Research Centre, GRTC, HyPR-DRILL has been developed to match and exceed the performance of other water-based systems currently being used and deliver performance as close as possible to that on an invert emulsion system. Utilising a blend of proprietary ammonium salts in combination with a molecular weight, acrylic based, encapsulating polymer and a newly developed clay accretion inhibitor, HyPR-DRILL delivers benefits normally associated only with non aqueous fluids.

Graph 1: Linear Expansion of Shale in various mud systems



The HyPR-DRILL system which can be utilised in a range of fluids varying from freshwater to saturated sodium chloride consists of the following key products in combination with a range of standard drilling fluid additives:

Table 1: Core HyPR-DRILL System Components

PRODUCT	DESCRIPTION	FUNCTION
HyPR-HIB	Quaternery Ammonium Salt – shale and clay hydration and dispersant suppressant	**HyPR-HIB** restricts the ability of reactive formations, clays and shales, to absorb water from the drilling fluid.
HyPR-CAP	Encapsulation polymer – minimises shale dispersion	**HyPR-FOIL** is a low molecular weight anionic polymer which can be used in high concentrations to provide a polymer coating on the clay and cuttings preventing water absorption and subsequent dispersion. Cuttings remain intact and are readily removed by solids control equipment with minimal dispersion into the circulating system.
HyPR-DRL	ROP Enhancer and bit / drill collar accretion minimisation	**HyPR-DRL** is a proprietary product designed to minimise balling of the bit and drill string and deliver enhanced penetration rates. The blend of lubricants and other products coat the drill-string and bit to reduce and prevent the accretion of water wet, hydrated, cuttings.

Table 2: Typical Formulation and Properties of HyPR-DRILL Mud Systems

PRODUCT	FUNCTION	HyPR-*DRILL* FRESHWATER	HyPR-*DRILL* 6% KCl	HyPR-*DRILL* 20% NaCl
Drillwater (bbl/bbl)	Base fluid	0.83	0.81	0.77
KCl (lb/bbl)	Water activity and cation exchange	NA	18	NA
NaCl (lb/bbl)	Water activity and cation exchange	NA	NA	70
pH	Alkalinity	8.5 - 9.5	8.5 - 9.5	8.5 - 9.5
HyPR-CAP (lb/bbl)	Encapsulating polymer	3	3	3
HyPR-HIB (%)	Shale and clay inhibitor	3	3	3
HyPR-DRL (%)	Anti-accretion additive	2 - 3	2 - 3	2 - 3
CUMULUS CPG (%)	Cloud point glycol	3	3	3
HYDRO-ZAN (lb/bbl)	Viscosifier	1 - 2	1 - 2	1 - 2
HYDRO-STAR NF (lb/bbl)	Filtration control	3 - 5	3 - 5	3 - 5
DRILL-BAR (lb/bbl)	Weighting agent	91	79	41
PROPERTIES		**HyPR-*DRILL* FRESHWATER**	**HyPR-*DRILL* 6% KCL**	**HyPR-*DRILL* 20% NACL**
Density (lb/gal)		10	10	10
Plastic Viscosity (cP)		16 - 24	15 - 20	15 - 20
Yield Point (lb/100 ft^2)		20 - 25	18 - 24	20 - 25
API Fluid Loss (cc/30 min)		< 4	< 4	< 3

Table 3: Products using in HyPR-Drill Mud System

No.	Product	Description
1	**SODA ASH**	SODA ASH is used primarily to treat calcium contamination in water based muds and or make up water.
2	**Potassium Chloride (KCl)**	Potassium chloride, commonly known as KCl or muriate of potash, is a high-purity, dry crystalline inorganic salt used to form clear brine used in workover and completion operations which require densities ranging from 8.4 - 9.7 lb/gal ((1004 – 1164 kg/m3)). It is also used to provide an inhibitive environment for water based drilling fluids.
3	**HYDRO-STAR NF**	HYDRO-STAR NF is a non-fermenting pre gelatinised high-temperature starch used to control filtration in water-base muds.
4	**HYDRO-ZAN**	HYDRO-ZAN Xanthan gum is a high molecular weight biopolymer used for increasing the rheological parameters in water-based drilling fluids. Small quantities provide excellent viscosity for suspending weighting material for all water-based drilling fluids systems. HYDRO-ZAN has the unique ability to produce a fluid that is highly shear-thinning and develops a true

		gel structure.
5	**DRILL BAR**	Weighting agent.
6	**HyPR-CAP**	HyPR-CAP is a low molecular weight acrylamide polymer used to provide clay inhibition and encapsulation of drilled cuttings in water base mud systems.
7	**HyPR-HIB**	HyPR-HIB is the primary clay and shale inhibitor for the HyPR-DRILL High Performance Water Based Mud System. HyPR-HIB is a quaternary ammonium salt providing superior inhibition by preventing water adsorption by clays and shales.
8	**CUMULUS CPG**	CUMULUS CPG is cloud point glycol the primary function of which is shale inhibition for water based muds.
9	**HyPR-DRL**	HyPR-DRL is a proprietary blend of surfactants for use in the HyPR-DRILL high performance water base mud system to prevent accretion of shale cuttings to the BHA and bit. It will be particularly effective when used in conjunction with a PDC drill bit and will prove highly effective in reducing torque and drag as well as enhancing ROP.
10	**Potassium hydroxide (KOH)**	POTASSIUM HYDROXIDE (KOH) is used primarily as a pH modifier and as an alternative to caustic soda. It acts as source of potassium ions in a water based mud system.

2.4 Polymers

A polymer is a molecule consisting of a series of repeating units. The number of units can vary from several to tens of thousands with corresponding variance in chain length and molecular weight. The polymer can be liner or branched and can be synthetic or naturally derived.

The lower molecular weight polymers are used as deflocculants; whereas, the high molecular weight molecules are used as viscosifiers and flocculants. The repeating unit need not always be the same. Copolymers consist of two or more different group joined together and may be 'random' or 'block' depending on how the groups are distributed on the chain.

The two major mechanisms for manufacturing polymers are condensation, which alters the makeup of the repeating units, and addition which utilises the presence of a double bond in the reacting unit to form a long chain. The addition process will generally yield higher molecular weight polymers than will condensation. The condensation process produces a polymer in which the repeating units contain fewer atoms than the monomers from which they were formed. Frequently, water is formed as a by-product of the process. The process requires two or more compounds which react chemically and does not depend upon the presence of a double bond for propagation of the chain.

This mechanism is susceptible to interruption by impurities or any outside influence which would reduce the efficiency of the process. Many commercially available polymers are not readily soluble in water. This is an undesirable property for drilling fluid chemicals. Fortunately, many of the polymers available have been chemically treated in order to make them water-soluble. The solubility of these polyelectrolytes will be affected by the chemical makeup of the drilling fluid, pH, salts and presence of divalent cations, etc.

Major Uses of Polymers;

- **Viscosity** – the longer the molecules the greater the viscosity.
- **Bentonite Extention** – cross-linking bentonite particles to increase the physical interaction between particles.
- **Flocculation** – characterized by an anionic high molecular weight which will enable the polymer to bridge from particle to particle.
- **Deflucculant** – absorb onto the edges of clay particles resulting in the overall negative charge.
- **Filtration Control –** Deflucculant, viscosity of the filtrate and colloidal particles
- **Shale Stabilisation** – polymer attachment to the positively charged sites on the edge of the clay particles in shales. This attachment minimises water invasion into the clay particle and reduces hydration and dispersion.

2.4.1 Acrylamide [3] C_3H_5NO $CH_2{=}CH{-}C({=}O){-}NH_2$

Acrylamide or 2-propenamide (IUPAC); various other names are also used, including propenamide, acrylic acid amide, acrylic amide acrylamide monomer, ethylenecarboxamide, akrylamide (Czech.), or rarely acrylamid or 2-propeamide; acronyms: AA, AAm; CAS Regestry No. 79-06-1; NIOSH # AS 3325000. (Doughton, 1988)

Acrylamide is a white, crystalline, water-soluble compound derived from natural gas via acrylonitrile. It was first prepared and described by C. Moureau in 1983(Carpenter and Davis, 1957), who slowly added dry ammonia to saturate a benzene solution of acryride chloride at 10^{o}C. After boiling and filtration to remove the ammonium chloride, acrylamide precipitated upon cooling. Acrylamide has been commercially available in the U.S. for a little over 30 years (Bikales, 1970). A thorough review of commercial manufacturing data and commercial uses id presented by Davis et al. (1976).

2.4.2 Polyacrylamide [3] $[{-}CH\{C({=}O){-}NH_2\}{-}CH_2{-}]_n$

Polyacrylamide (Molyneux 1983); various other names are also used, including poly(acrylamide), polyacrylic amide, poly(1-carbomoylethylene) (IUPAC); acronyms include Pam, PAAm, and PAM; trade names include Cyanamer (American Cyanamid), and Separan (Dow Chemical). (Doughton, 1988)

Polyacrylamide is unusual in having an extremely high molecular weight (eg. 3 to 15 million number-averages MW) coupled with being very hydrophilic while also being non-ionic. Its solubility in non-aqueous solvents is restricted to those that are very polar (eg. glycerol, formamide, and ethylene glycol). It is insoluble in most other organic solvents (eg. diethyl ether and aromatic hydrocarbons), including those that are miscible with water (eg. methanol, ethanol, acetone); this property forms the basis of many schemes of formulation analysis.

2.5 HyPR-CAP [4]

HyPR-CAP is a low molecular weight acrylamide polymer used to provide clay inhibition and encapsulation of drilled cuttings in water base mud systems.

Typical Properties:

COMMON NAME	Acrylamide polymer	**CHEMICAL FORMULA**	Proprietary
APPEARANCE	Granular powder	**SOLUBILITY IN WATER @ 20 ^{0}C**	Completely
APPEARANCE	White	**pH (5 % solution) @ 25 ^{0}C (77 ^{0}F)**	6 to 8

Applications/Functions:

HyPR-CAP is a very versatile polymer which can be used for oil, gas, water well and mineral drilling. It can be added to fresh, KCl or sea water based drilling fluid systems. HyPR-CAP functions primarily as a shale inhibitor and friction reducer/lubricant. HyPR-CAP can be used alone or in conjunction with KCL to stabilize active shales by decreasing the shale's tendency to absorb water, swell and slough-off. As an additional benefit, fluid loss is often reduced when using this product.

Advantages:

→Readily dispersible and easy to handle.

→Low viscosity allows higher concentrations to be used.

→Enhances solid control efficiency.

→Reduced screen blinding compared with conventional PHPA systems.

Recommended Treatment:

Normal dosage rates are between 1.0 - 4.0 g (2.85 – 11.4 kg/m3). The product may be mixed in concentrations to 5 g+ and added as a premix.

Limitations:

→Should not be used in calcium brines.

→Avoid pH > 10 as the polymer will hydrolyse.

→Pre-treat system with citric acid or sodium bicarbonate before drilling cement.

Chapter 3: METHODOLOGY

3.1 Research Methodology

Basically, there are 8 approaches involved in this project research methodology. Those elements will be further discussed below.

3.1.1 Problem Statement

- HyPR-CAP as a vital component in hyPR-DRILL mud system needs a very good quantitative determination.
- The normal method which is flocculation method is unsuitable due to its short chain PHPA.
- The cross reference table given by OFITE for Polymer Test Kit test is only capable for maximum 1 g but in the field trial, 3 g HyPR-CAP is recommended.

3.1.2 Project Objectives

- To expand the existing cross reference table up to at least 3 g HyPR-CAP.
- To evaluate the quantitative determination method of PHPA polymer in drilling fluid.

3.1.3 Background Study

- Research on drilling fluid related case study.
- Identify the best quantitative determination of HyPR-CAP to be used in the rig condition.

3.1.4 Literature Review & Theory

- Study on basic principle of drilling fluid, basic mud testing and the equipment used.
- Research on HyPR-DRILL mud system, polymers, polyacrylamide and HyPR-CAP itself.

3.1.5 Data Acquisition

- Acquire data from the Polymer test kit test at Scomi Oiltools, Shah Alam and use all the chemicals and equipments needed.

3.1.6 Data Analysis & Calculation

- Analyse the results and try to match with the objectives.
- Determine whether more tests need to be done or not in order to achieve the objectives.

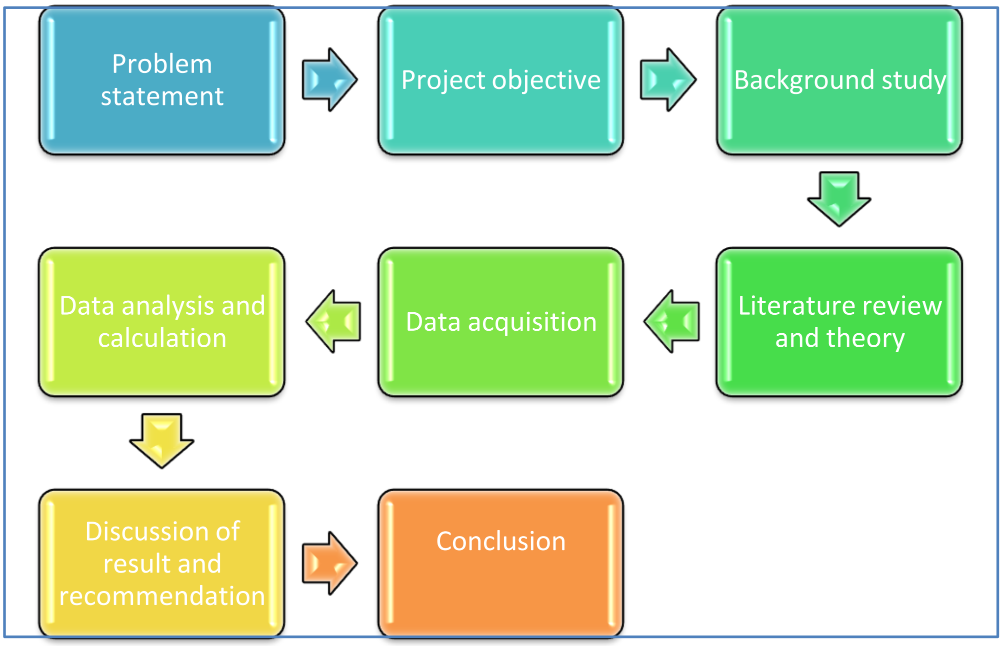
3.1.7 Discussion of Results & Recommendation

- Discuss with Mr. Jasmi, UTP Supervisor and Mr. Gary, Scomi Oiltools Team Leader of R&E Department about the results and analyzed data.
- Identify any other potential better solution and future recommendation about the project.

3.1.8 Conclusion

- Conclude whether the stated objectives earlier is achieved or not
- Propose the better way to achieve the purpose of the project. (If any)

Figure 10: Research Methodology



3.2 Project Activities

The mainly objective for this project is to make experimental test using the Polymer Test Kit given by OFITE[3] and try to expand the existing given cross reference table. The procedure is adopted from OFITE with some minor modification to meet Scomi Oiltools requirements and main procedures. The mud formulation is extracted from Scomi previous field trial. After done the tests, the author will directly discuss with the Scomi staff to make sure the project will run smooth.

3.2.1 Procedure: [5]

The unit must be calibrated first in order to obtain accurate results.

1. Be sure the equipment is clean and dry.
2. Obtain 10 ml mud filtrate using an API filter press.
3. Remove the reaction cylinder from the stainless steel beaker. Fill the stainless steel beaker with 800 ml of water and place it on the hot plate. Heat the water to 190° - 194°F (88° - 90°C).
4. Break both ends of the Dräger-Tube and insert it into the tubing on the far left-hand side of the case. Make sure the numbers increase from bottom to top. Attach the outlet tubing from the glass 250 ml cylinder.
5. Fill a 50 ml syringe with 40 ml of 20% Sodium Hydroxide (NaOH) solution. Inject the NaOH into the reaction cylinder.
6. Add 10 ml of mud to the cylinder and seal it. Attach the cylinder to the apparatus.
7. Start the air pump and timer and record the time required for the blue colour to reach the "70" mark on the Dräger-Tube. Compare this time with the times on the calibration chart. Report the concentration of available polymer as pounds per barrel of product.
8. To clean the apparatus, remove the reaction cylinder and rinse it with water. The other cylinder may be attached directly to the air pump and flushed with air for several minutes. Both glass cylinders should be thoroughly dried before the next test.

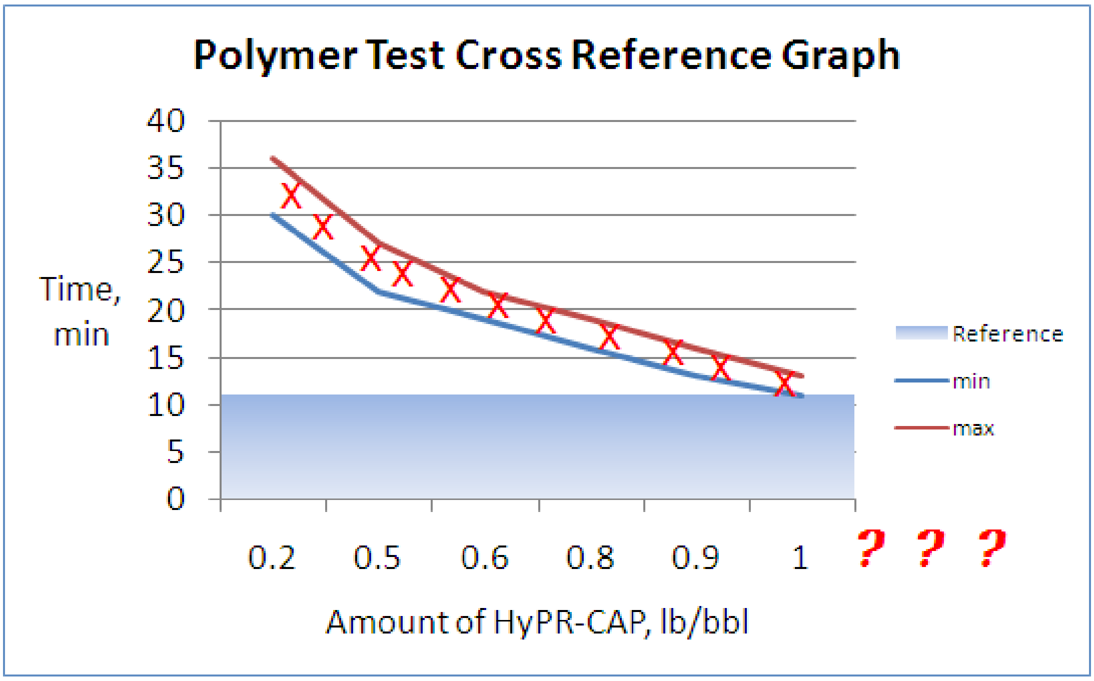
[3] Refer to Tools/Equipment Required

Table 4: Cross reference table given by OFITE

Time to "70" mark (minutes)	HyPR-CAP concentration (g)
Less than 11	Greater than 1
11 to 13	1
13' 01" to 15' 59"	0.9
16 to 19	0.8
19' 01" to 21' 59"	0.6
22 to 27	0.5
Greater than 30	Less than 0.2

The author converted the existing cross reference table that given by OFITE to Graph 2 in order for better understanding of the readers.

Graph 2: Polymer Test - Cross Reference Graph



From the cross reference graph, it is expected to have the results below than 11 minutes for the HyPR-CAP concentration that more than 1 g in the mud system. The author tries to expand that reference graph up to 4 g HyPR-CAP so that it can be easily used in the field trial testing.

3.2.2 Calibration

The procedure is performed with an aqueous solution containing 0.50 g of high molecular weight PHPA polymer. The air flow should be adjusted using the adjustment at the base of the flowmeter and the excess flow valve, so that the time required for the blue color to reach the "70" mark is 24 to 25 minutes. This will require a flow of approximately 100 cc/min. There is some batch-to-batch variations in the Dräger-Tubes™, but one calibration should be sufficient for all Dräger-Tubes™ having scale lengths of 51 to 56 mm. The unit should be recalibrated for Dräger-Tubes™ having scale lengths less than 51 or greater than 56 mm. When it is possible, always use Dräger-Tubes™ from only one batch to obtain the best accuracy. Batch numbers for Dräger- Tubes™ are located on the outside of each box. All Dräger-Tubes™ have an expiration date and should be used prior to this date.

3.2.3 Prepare HyPR-DRILL mud formulation as shown below.[4]

Table 5: HyPR-DRILL Mud Formulation

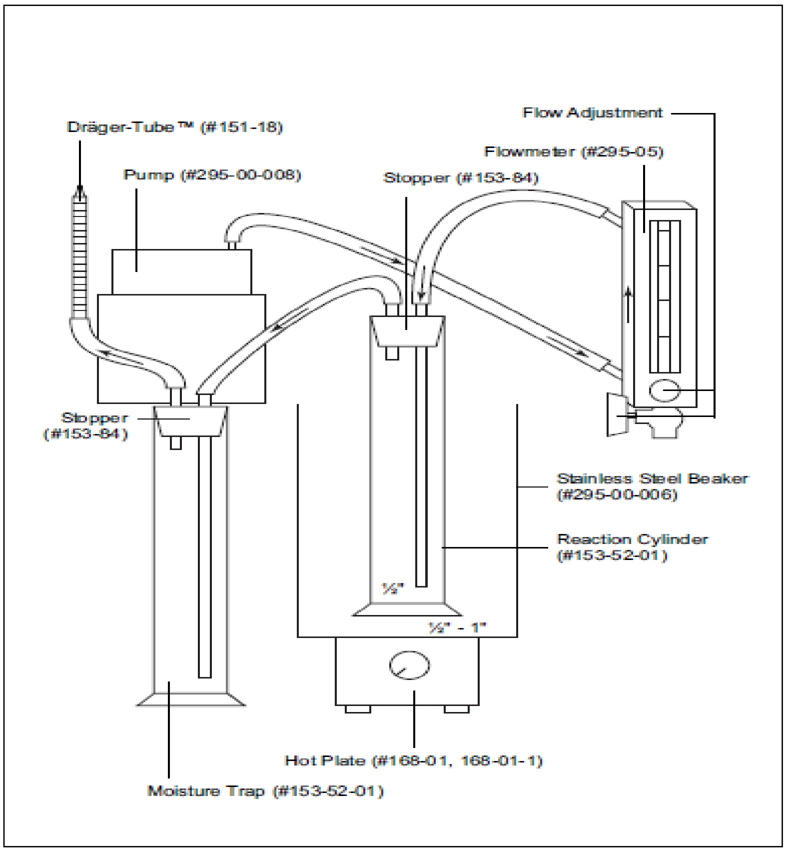
Product	Concentration (g)	Mixing order	Mixing time (minutes)
DRILL WATER	273.7		
SODA ASH	0.2	1	2
KCL	18.2	2	2
HYDRO-STAR NF	6.0	3	5
HYDRO-ZAN	1.0	4	5
DRILL BAR	77.4	5	5
HyPR-CAP	Refer to Table 6	6	5
HyPR-HIB	12.0	7	2
CUMULUS CPG	8.8	8	2
HyPR-DRL	11.0	9	2
Potassium hydroxide	1.0	10	2
Additional mixing time			13
Total mixing time			45

[4] Refer Table 3 for products description.

3.3 Tools / Equipments Required

Figure 10 : Polymer Test Kit - Clapper Type

Figure 11 : Assembly Diagram of Polymer Test Kit



3.4 Gantt Chart & Key Milestone

Figure 12: FYP 1 Gantt Chart

No.	Detail / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Topic selection / confirmation														
2	Preliminary literature review & research study on project														
3	Submission of Extended Proposal							B							
4	~~Acquire the data from mud test~~							R							
5	Project defence and progress evaluation							E							
6	Discussion with the expert on the mud testing							A							
7	~~Analysis on research finding~~							K							
8	Oral presentation														
9	Submission of draft Interim Report														
10	Submission of Interim Report														

Figure 13 : FYP 2 Gantt Chart

No.	Detail / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Acquire the data from mud test														
2	Analysis on research finding														
3	Submission of Progress Report							B							
4	Seminar (compulsory)							R							
5	Poster Exhibition							E							
6	Pre-EDX & draft Final Report submission							A							
7	Submission of Technical Paper							K							
8	EDX														
9	Oral Presentation														
10	Submission of Final Report														

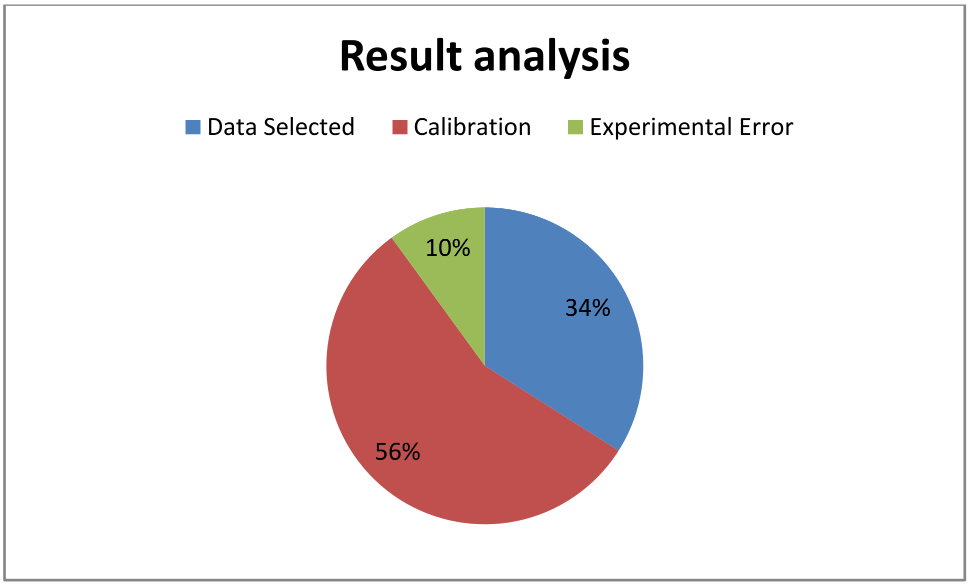
Chapter 4: RESULTS AND DISCUSSION

4.1 Results

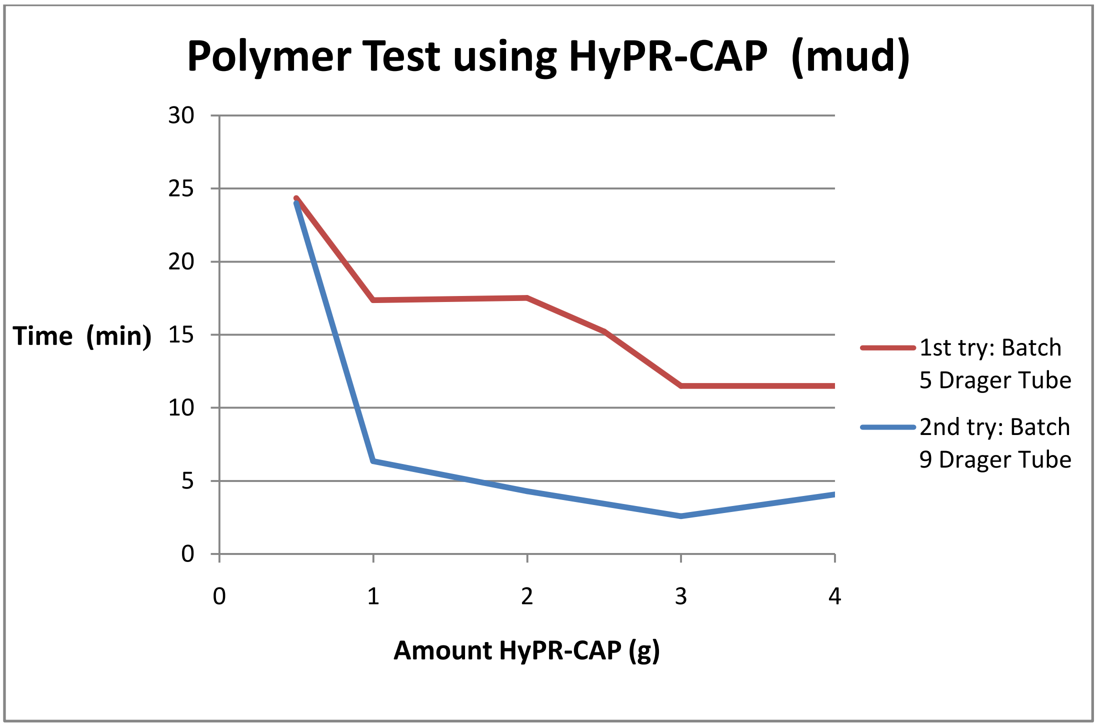
Table 6: The selected results

HyPR-CAP in HyPR-DRILL (g)	Time to end point (min)				
	Mud			Mud Filtrate	
	No Dilution		2x Dilution	No Dilution	2x Dilution
0.0	-	-	-	-	-
0.5	24.36	24.00	24.00	24.35	24.45
1.0	17.37	6.36	17.49	6.29	52.24
1.5	-	-	9.01	-	-
2.0	17.52	4.29	9.22	6.34	-
2.5	15.23	-	-	7.16	-
3.0	11.50	2.58	9.35	5.24	9.57
4.0	11.50	4.07	-	4.49	10.36

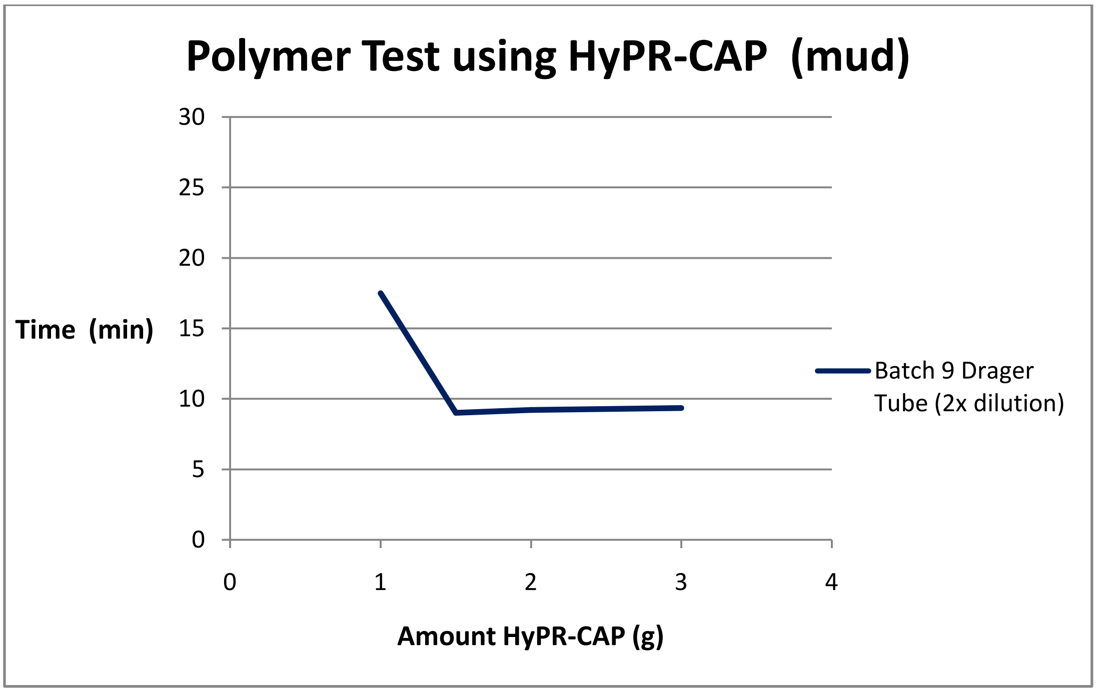
Figure 14: Results analysis



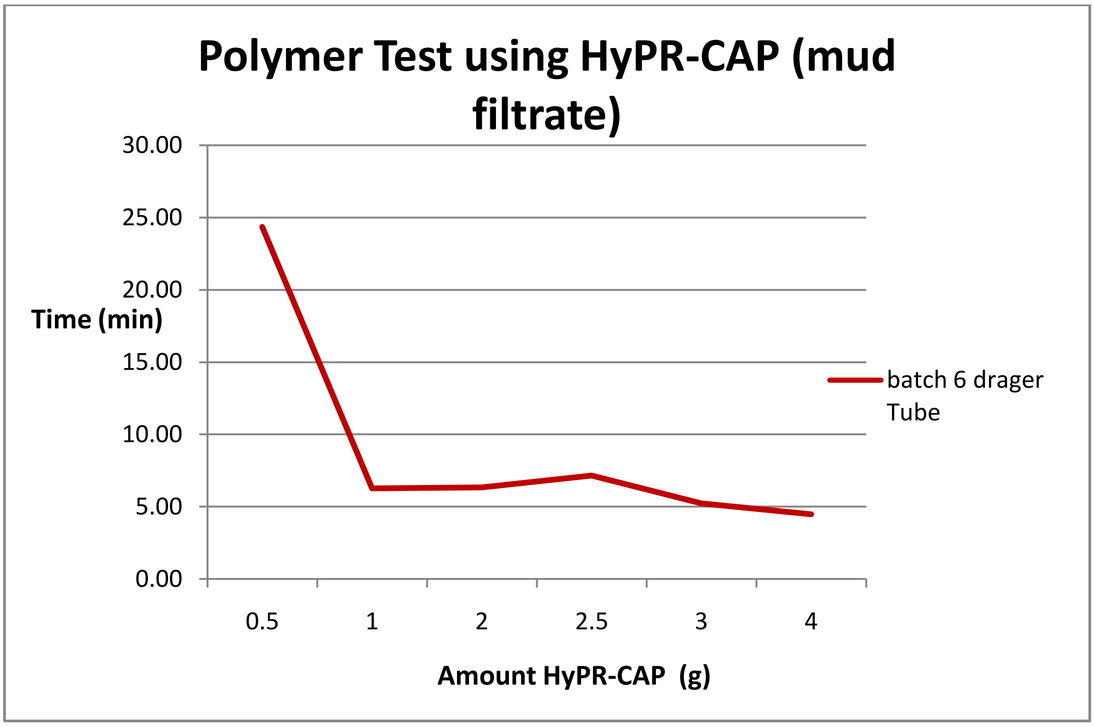
Graph 3: Time (min) VS Amount of HyPR-CAP (g) in mud.



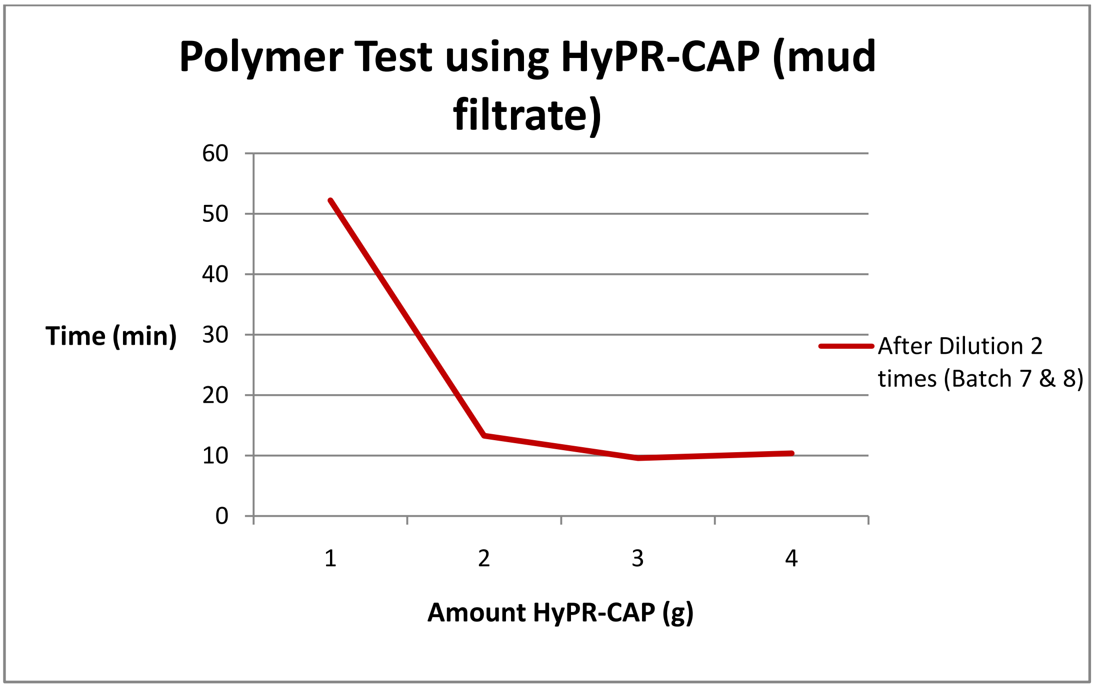
Graph 4: Time (min) VS Amount of HyPR-CAP (g) in mud (2 times dilution).



Graph 5: Time (min) VS Amount of HyPR-CAP (g) in mud filtrate.



Graph 6: Time (min) VS Amount of HyPR-CAP (g) in mud filtrate (2 times dilution).



4.2 Discussion

This is quite a long project and author learned many things all the ways under his Internship Supervisor, Mr. Gary and UTP Supervisor, Mr. Jasmi. Doing research is not a simple and easy thing; one should need knowledge, patience, teamwork, and luck to carry on the research. This project is very important especially in the drilling fluid study due to HyPR-CAP is a main and vital component in HyPR-DRILL mud system that currently used in the Scomi successful field trial.

First of all, Mr. Gary and I have discussed about our workflow process for the test, whether to test this method using the whole mud or filtrate mud because it is not stated in the guideline that is provided by OFITE. So we have decided to run and evaluate this method using both of them.

At the first stage, the author tried to repeat the known results as stated in the cross-reference graph and proceed to expand it while in the same time, evaluating this method. After finished the calibration at 0.5 g HyPR-CAP for both mud and mud filtrate, the author increased the amount of HyPR-CAP tested up to 4 g HyPR-CAP and tried to expand the table. Knowing that the results might be lower due the increasing of amount of HyPR-CAP, the author tried to expand to range of results by diluting the mud system to 2 times using filtrated water.

Refer to Graph 3 and Graph 5; the author did not get any straight line or factor that can relate the results with cross-reference table at the first try (using Batch 5 and 6 Drager Tube). After that, the author tried to repeat to test in mud system (using Batch 9 Drager Tube). The results shown this method is inconsistent and not repeatable as refer to Graph 3. The results after 2 times dilution as shown in Graph 4 and Graph 6 for both tests in mud and mud filtrate also are not as expected.

Overall for this project, author used 10 batches of Drager Tube that consist of 100 units. 56 units are used for calibration, 10 units have experimental errors and only 34 units of Drager Tube left for selected results. So the rate of success for this method is considered small whish is only 34%. For sure in the real situation like in the rig, this low rate of success cannot be accepted. Actually, the calibration of the Dräger-Tubes part is very hard and sometime, author spent the whole day to do it as there is some batch-to-batch variations in the Dräger-Tube as mentioned in the above calibration section. For example, if one person using 5 units of Drager Tube for calibration, only 5 units left for the testing before he/she need to recalibrate again. Besides that, the author noticed that the results will be affected by changing the NaOH solution, the air flow and also other variables. These observations also are supported by SPE paper no. 22580 – A New Method for the Quantitative Determination of the PHPA Polymer Content of Drilling Fluids and Other Aqueous Systems.

According to L.Z. McCulley and E. Malachosky (1991) [6]

> This method has serious shortcomings from an analytical perspective. There is no way to determine if the hydrolysis reaction is truly quantitative, and this method also acknowledge control the test conditions is critical, since small variations in any one of a number of procedural parameters (time, temperature, air flow and amount of caustic present) can affect the results. But the most serious objection, however, relates to the use of filtrate for the analysis.

It is recognized that filtration of a PHPA-containing fluid through a filter cake will result in removal of a portion of the polymer. The extend of the polymer removed is influenced by a number of factors; electrolyte content of the fluid, amount and types of solids in the mud, nature of the filter cake, molecular weight of the polymer, and type and quantity of other polymeric material present. The use of a filtrate sample from the API fluid loss test was therefore considered to be unsuitable for any truly quantitative procedure for the determination of the PHPA concentration in drilling fluids. (McCulley & Malachosky, 1991)

Moreover, this method also is not very suitable with the rig environment due to some reasons; hard for calibration, there are many glass-type equipment and 20% NaOH solution used is dangerous and one need proper PPE to handle it. Lastly, the author cannot proceed to expand the table after evaluating this method and procedures. Besides the results are not repeatable and reliable, this method also has lot of interferences as stated before.

Chapter 5: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

One of the objectives achieved which is to evaluate the quantitative determination method of PHPA polymer in drilling fluid using HyPR-CAP and Polymer Test Kit method. The results shown no consistency and the method also have lot of interferences. The second objective which is to expend the cross reference table cannot be done due to these reasons.

5.2 Recommendations

More research needs to be done in order to find the most suitable method for quantitative determination of HyPR-CAP in mud system especially for rig condition. The author suggestion for the quantitative determination of PHPA polymer in drilling fluid is by referring to the method recommended by SPE paper no. 22580 – A New Method for the Quantitative Determination of the PHPA Polymer Content of Drilling Fluids and Other Aqueous Systems. [6]

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APPENDICES

Table 7: Full Results

Tes t	No.	Amount of HyPR-CAP (g)	Time to reach 70pm (mins)	Calibration / Test	Remarks
1	1	0.5 in water	10.00	Calibration	Out Of Calibration
2	2	0.5 in water	12.60	Calibration	Out Of Calibration
3	3	0.5 in water	17.19	Calibration	Out Of Calibration
4	4	0.5 in water	failed	Calibration	Out Of Calibration
5	5	0.5 in water	failed	Calibration	Out Of Calibration
6	6	0.5 in water	failed	Calibration	Out Of Calibration
7	7	0.5 in water	19.45	Calibration	Out Of Calibration
8	8	0.5 in water	19.50	Calibration	Out Of Calibration
9	9	0.5 in water	24.30	Calibration	Out Of Calibration
10	10	0.0(tap water)	> 40	Calibration	Out Of Calibration
11	1	0.5 in water	failed	Calibration	Out Of Calibration
12	2	0.5 in water	failed	Calibration	Out Of Calibration
13	3	0.5 in water	24.30	Calibration	Out Of Calibration
14	4	1.0 in water	13.30	calibration	Out Of Calibration
15	5	1.5 in water	14.10	Test	done twice
16	6	2.0 in water	9.40	Test	experimental error
17	7	2.5 in water	10.00	Test	experimental error
18	8	3.0 in water	9.05	Test	experimental error
19	9	4.0 in water	9.35	Test	experimental error
20	10	1.5 in water	12.44	Test	done twice
21	1	0.5 in water	12.55	Calibration	Out Of Calibration
22	2	0.5 in water	20.15	Calibration	Out Of Calibration
23	3	0.5 in water	failed	Calibration	Out Of Calibration
24	4	0.5 in water	failed	Calibration	Out Of Calibration
25	5	0.5 in water	24.40	Calibration	Out Of Calibration
26	6	0.5 in mud	17.35	Test	Data selected
27	7	0.5 in filtrate	32.20	Test	Data selected
28	8	1.0 in mud	failed	Test	experimental error
29	9	1.0 in mud	14.20	Test	Data selected
30	10	1.0 in filtrate	26.55	Test	Data selected
31	1	0.5 in water	19.50	Calibration	Out Of Calibration
32	2	0.5 in water	21.05	Calibration	Out Of Calibration
33	3	0.5 in water	25.06	Calibration	Out Of Calibration

34	4	2.0 in mud	20.60	Calibration	Out Of Calibration
35	5	0.5 in water	29.3	Calibration	Out Of Calibration
36	6	0.5 in water	13.12	Calibration	Out Of Calibration
37	7	0.5 in water	19.07	Calibration	Out Of Calibration
38	8	0.5 in water	failed	Calibration	Out Of Calibration
39	9	0.5 in water	26.36	Calibration	Out Of Calibration
40	10	2.0 in mud	10.06	Test	Data selected
41	1	0.5 in mud	15.43	Calibration	Out Of Calibration
42	2	0.5 in mud	18.43	Calibration	Out Of Calibration
43	3	0.5 in mud	27.04	Calibration	Out Of Calibration
44	4	0.5 in mud	26.07	Calibration	Out Of Calibration
45	5	0.5 in mud	24.36	Calibration	Out Of Calibration
46	6	1.0 in mud	17.37	Test	Data selected
47	7	2.0 in mud	17.52	Test	Data selected
48	9	2.5 in mud	15.23	Test	Data selected
49	8	3.0 in mud	11.50	Test	Data selected
50	10	4.0 in mud	11.50	Test	Data selected
51	1	0.5 in filtrate	16.25	Calibration	Out Of Calibration
52	2	0.5 in filtrate	36.36	Calibration	Out Of Calibration
53	3	0.5 in filtrate	33.27	Calibration	Out Of Calibration
54	4	0.5 in filtrate	14.34	Calibration	Out Of Calibration
55	5	0.5 in filtrate	24.35	Calibration	Out Of Calibration
56	6	1.0 in filtrate	6.29	Test	Data selected
57	7	2.0 in filtrate	6.34	Test	Data selected
58	9	2.5 in filtrate	7.16	Test	Data selected
59	8	3.0 in filtrate	5.24	Test	Data selected
60	10	4.0 in filtrate	4.49	Test	Data selected
61	1	0.5 in filtrate	26.25	Calibration	Out Of Calibration
62	2	0.5 in filtrate	29.2	Calibration	Out Of Calibration
63	3	0.5 in filtrate	> 30	Calibration	Out Of Calibration
64	4	0.5 in filtrate	> 30	Calibration	Out Of Calibration
65	5	0.5 in filtrate	> 30	Calibration	Out Of Calibration
66	6	0.5 in filtrate	14.1	Calibration	Out Of Calibration
67	7	0.5 in filtrate	24.1	Calibration	Data selected
68	9	2.0 in filtrate	8.56	Test	Data selected
69	8	2.0 in filtrate (dilute 5x)	> 60	Test	Data selected
70	10	2.0 in filtrate (dilute 2x)	13.28	Test	Data selected
71	1	0.5 in filtrate	31.31	Calibration	Out Of Calibration
72	2	0.5 in filtrate	22.23	Calibration	Out Of

					Calibration
73	3	0.5 in filtrate	> 30	Calibration	Out Of Calibration
74	4	0.5 in filtrate	> 30	Calibration	Out Of Calibration
75	5	0.5 in filtrate	24.45	Calibration	Data selected
76	6	1.0 in filtrate (dilute 2x)	52.24	Test	Data selected
77	7	3.0 in filtrate (dilute 2x)	9.57	Test	Data selected
78	8	4.0 in filtrate (dilute 2x)	10.36	Test	Data selected
79	9	n/a	.	.	Not Use
80	10	n/a	.	.	Not Use
81	1	0.5 in mud	26.09	Calibration	Out Of Calibration
82	2	0.5 in mud	24	Calibration	Data selected
83	3	1.0 in mud	6.36	Test	Data selected
84	4	2.0 in mud	4.29	Test	Data selected
85	5	3.0 in mud	2.58	Test	Data selected
86	6	4.0 in mud	4.07	Test	Data selected
87	7	1.0 in mud (dilute 2x)	17.49	Test	Data selected
88	8	1.5 in mud (dilute 2x)	9.01	Test	Data selected
89	9	2.0 in mud (dilute 2x)	9.22	Test	Data selected
90	10	3.0 in mud (dilute 2x)	9.35	Test	Data selected
91	1	0.5 in mud	19.03	Calibration	Out Of Calibration
92	2	0.5 in mud	16.26	Calibration	Out Of Calibration
93	3	0.5 in mud	19.12	Calibration	Out Of Calibration
94	4	0.5 in mud	>25	Calibration	Out Of Calibration
95	5	0.5 in mud	17.54	Calibration	Out Of Calibration
96	6	0.5 in mud	19.48	Calibration	Out Of Calibration
97	7	0.5 in mud	17.25	Test	Data selected
98	8	0.5 in mud	42.24	Test	Data selected
99	9	n/a	.	.	Not Use
100	10	n/a	.	.	Not Use

Figure 15 : Problems, Solutions & indicators of Mud

PROBLEM	SOLUTIONS AND INDICATORS
Low viscosity	Add water and emulsifier, add gellant. If high temperature add polymeric viscosifier. All of these affect the low-shear viscosity, gel strength and yield point more than the plastic viscosity.
High viscosity	Remove low gravity solids with solids control equipment and/or dilution. Increase o/w ratio if water content is too high. Add oil wetting agent to reduce viscosity.
Water wet solids	Remove water wet solids and add oil wetting agent and oil. Ensure that there is no insoluble calcium chloride in the mud. Water wet solids will blind screens and give low E.S. readings. Suspected water wet solids added to water will disperse easily.
Low ES	Water wet solids, undissolved solids, inadequate concentration of emulsifiers, inadequate concentration of lime for emulsifiers, and some weighting agents (such as hematite) generate low electrical stability readings. All except hematite require chemical treatment. Most muds made with mineral oil will have lower electrical stability than those made with diesel. Low viscosity muds usually have low electrical stability readings.
High solids	Mud viscosity will increase and electrical stability readings will decrease even though emulsifier concentration is adequate. Improve solids removal efficiency. Use dual centrifuge to remove drill solids while recovering the barite and oil phase.
High filtrate	Add additional emulsifier if water appears in filtrate. Organolignite will also emulsify water and lower filtrate. Ensure mud has excess lime. Newly formulated mud may have high HPHT until properly sheared. Sometimes small amounts of water will lower HPHT in high O/W ratio muds. Organolignites are not effective when bottom hole temperature is less than about 150°F.
Acid gas	Detected in mud by drop in alkalinity. If H_2S is detected by the Garrett Gas Train, alkalinity has decreased so increase lime additions. Maintain lime additions and add sulfide scavenger such as Zinc Oxide. If carbon dioxide is present, add lime.
Mud losses	If loss is not complete, use oil-wettable fibrous material or solid bridging material such as calcium carbonate. Use same technique for seepage losses to minimize thick filter cake and differential sticking. If losses are complete, consider organophilic clay squeeze, cement or displacing to water based mud until loss zone is cased off.
Free top oil	After periods of inactivity, free oil may cover the surface of the pits. Agitate the mud in the pits or add organophilic clay to increase viscosity.
Free top oil	After periods of inactivity, free oil may cover the surface of the pits. Agitate the mud in the pits or add organophilic clay to increase viscosity.

Figure 16 : On the Job Training (Certificate to Perform the Test)

Scomi

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ON-THE-JOB TRAINING

Training Log

Department / Section: RESEARCH & ENGINEERING	Job Title:	Start Date of OJT:
Name of Trainee: MOHD RAZMI ZIQRI B AHMAD SHOKRI	NRIC No.: 891127-08-6107 / Date of Birth: 27 NOV	End of Date of OJT:

Task No.	Main Tasks	Date of Training	Min OJT Hours	Actual OJT Hours	PR* (after OJT)	**Trainee can perform the task: Trainer's Name	Trainer's initial	Trainee's Initial
1.0.	SBM mixing	23/5/11	4	8	A	Gary Phoon		
2.0.	WBM mixing	13/6/11	4	8	A	"		
3.0.	Rheology Check with Fann 35	"	2	16	A	"		
4.0.	OFITE Polymer Test Kit	2/3/11	3	24	A	"		
5.0.	API Filter Press	13/6/11	2	8	A	"		
6.0.	CEC Test	"	1	2	B	"		
7.0.	HTHP Filter Press	"	4	16	A	"		
8.0.	Preparing aging cell for hot-roll	"	2	8	A	"		
9.0.	De-pressurized aging cell after hot-roll	"	2	8	A	"		
10.0.	Linear swell meter	10/6/11	4	4	B	"		
Total No. of OJT Hours:			28	102				

Checked by:	Overall Performance* : A
Name: GARY PHOON KAH HOE	Name of Section Head: GARY PHOON KAH HOE
Designation: TEAM LEADER- R&E	Signature:
Remarks (if any) : Items 7.0, 8.0 and 9.0 ~~and 10~~ can only be performed with supervision of a permanent staff. Item 10.0 should not be performed by intern	Date: 16/6/2011

Note: ***OJT trainer/s to rate the performance of trainee after the OJT using the performance rating scale indicate below***

* ***PR (Performance Rating):*** ***A – Very Good*** ***B – Good*** ***C – Satisfactory*** ***D – Inadequate***

** **OJT trainer and trainee to confirm that the trainee can perform the task**

Picture 1: Test on Progress

Picture 2: Hamilton Beach Mixer Used

Picture 3: Mud Cup Used

Picture 4: Products Used

Picture 5: Diluted 20% NaOH

Picture 6: Author doing the test