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A DETAIL STUDY ON MUD LOGGING OPERATIONS IN WELL SITE

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Abstract: Mud logging is a service that qualitatively and quantitatively obtains data from, and makes observations of drilled formation rocks, drilling fluids and drilling parameters in order to formulate and display concepts of the optional, in situ characteristics of formations rocks with the primary goal of delineating hydrocarbon “shows” worthy of Testing.

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Mud logging service first focused on monitoring the drilling mud returns qualitatively for oil and gas content. This included watching the mud returns for oil sheen, monitoring the gas evolving from the mud as it depressed at the surface, and examining the drill cuttings to determine the rock type that had been drilled, as well as looking for indication of oil on the cuttings. Detection of the onset of abnormal formation pressure using drilling parameters was proposed with the introduction of the D-exponent and gas chromography.

The traditional products delivered by a Mud-Logging vendor include: Geological Evaluation, Petro-physical reservoir formation evaluation and Drilling Engineering Support Services.

One of the Important safety instruments in drilling in the mud logging unit which assists in real time the drilling operation and react for any potential or actual Hazards.

In this Thesis we are clearly explained everything that related to drilling Mud logging Operations.

1. Introduction

Mud Logging was introduced as a commercial service in 1939. Mud Logging provides for continuous on-site inspection, detection, and evaluation of the rocks as they are being drilled with regards to correlation and potential hydrocarbon production. The process of acquiring this data and its subsequent evaluation are very important factors for all drilling programs. Its effectiveness depends primarily upon the Mud Logger.

Mud Logging is standard on Wildcat , Exploratory and development wells. Mud logging is used as a correlative tool to enable operators to change or modify their well programs so that possible productive formations are not missed

Mud logging is not complex in principle, does not interfere with the drilling process, and the results are available almost immediately.

2. Well Logging (Wireline Logging)

Operators use wireline logging almost universally to evaluate formations in oilfield drilling. The well plan (GTO) usually calls for suites (sets) of electric logs in each open hole section, prior to the setting of the casing string. A final set of logs covers the open hole remaining after the well has been drilled to T.D (Target Depth). Wireline logging is generally carried out by different contractors (Schlumberger, Halliburton etc) in some places it is also carried out by the operating company (ONGC).

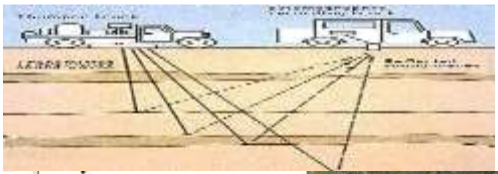
Electric logs can be run in open or cased hole. Most logs run during the drilling of a well evaluate open hole only. Cased hole logs require special tools and are run after casing, and usually during the production phase of the well.

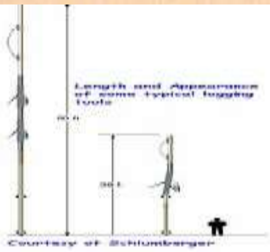
Electric logging consists of lowering a device used to measure the electric resistance of the rock layers in the 'down hole' portion of the well. This is done by running an electric current through the rock formation and measuring the resistance that it encounters along its way. This gives geologists an idea of the fluid contentand characteristics. A newer version of electric logging, called induction electric logging, provides much the same types of readings but is more easily performed and provides data that is more easily interpreted.

The depth of the well is measured with the help of the rope that is used to run the tool in to the well. The tool is generally run in to the bottom of the well or as far down as possible. All logs are recorded as the string is pulled up except for Temperature log which is measured while running in hole. The general logs that are recorded are Gamma Ray (GR), Resistivity, Sonic, Density etc..

Gamma Ray log measures the natural formation radioactivity. Since shales and clays tend to contain higher concentration of radioactive material as compared to sands or Limestones these can easily be identified.

Neutron logs respond to the amount of hydrogen present in the formation. For clean formations with liquid filled pores, the log corresponds to the formation porosity.





Well Problems

During drilling, various difficulties are encountered in the form of cavings, crooked holes, loss of mud, or a well kick. These problems hamper normal drilling procedures. An uncontrolled well kick could lead to a catastrophic blowout. A **Blowout** is the uncontrolled flow of gas, oil, or other fluids from a well which occurs when the pressure within the well exceeds the pressure in the borehole applied to it by the column of drilling fluid

In most cases the troublesome zones in the formation are cased off as soon as possible. The drilling crew takes care of these complications, before a serious problem resulting in loss of life or equipment can occur.

Hole problems can be classified under three major headings (1) pipe sticking (2) sloughing shale; and (3) lost circulation.

- **Pipe Sticking**

This is the condition when part of the drill pipe or collars are stuck in the hole. When this occurs, pipe movement and in turn further drilling progress, are inhibited.

In practice, pipe sticking problems are conveniently classified as (a) differential sticking (b) mechanical sticking and (c) key seating.

Differential pipe sticking : arises when the differential pressure (diff between hydrostatic pressure ofmud and formation pore pressure) becomes excessively large across a porous and permeable formation such as sandstone or limestone. Other conditions most conducive to differential sticking include a thick filter cake and when a drill string is left motionless for some time inside the open hole. Differential pipe sticking can normally be recognized when pipe movement in the upward or downward direction is impossible but free circulation is easily established, since obstruction exists on only one side of the pipe. In a complete stuck pipe situation, neither circulation nor pipe movement are possible.

Prevention of differential sticking can be done by (a) reducing the differential pressure (b) reducing the contact area (c) reduction in time during which drill string is kept stationary (d) Oil and Walnut hulls canbe used to reduce friction factor.

Freeing differentially stuck pipe

If, despite the above precautions the pipe does become stuck, a number of methods can be used to free the stuck pipe. The most commonly used methods include (a) Hydrostatic reduction (b) spotting fluids (c) back-off operations (d) DST (for recovering fish) and (e) fishing.

Mechanically stuck pipe

A pipe can become mechanically stuck when (a) drill cuttingsor sloughing formations pack of the annular space around the drill string (b) a drill string is run too fast, such that it hits a bridge or a tight spot or the bottom of the hole or (c) pullinginto a key seat.

Tight spots can result from drilling undersized holes due to theuse of worn drill bits. Tight spots can normally be recognized during tripping out as extra overpull. To prevent mechanical sticking tight spots should be reamed prior to drilling new sections of hole.

Key-seating: In a dog legged hole containing soft formations, a drill pipe tool joint can drill an extrahole or a key seat in addition to the major hole created by the bit. A key seat can only be formed if the formation drilled is soft and the hanging weight below the dog leg is large enough to create a substantial lateral force.

a. **Mud Loss or Lost Circulation**

Lost circulation is defined as the partial or complete loss of drilling fluid during drilling, circulating or running casing, or loss of cement during cementing. Lost circulation occurs when the hydrostatic pressure of mud exceeds the breaking strength of the formation, which creates cracks along which the fluid will flow.

All rock types are susceptible to lost circulation but weak and cavernous formations are particularly vulnerable.

The fast running of pipe in the hole causes fluid to surge up the pipe, creating additional pressures in the annulus. The total pressure due to surging effects and the hydrostatic pressure of mud can in certain cases be high enough to fracture uncased formations.

Usually when losses occur during drilling, lost circulation material is spotted across the suspect zone to combat fluid losses.

Mud loss has a number of detrimental effects, which can be summarized as follows:

1. Loss of drilling mud and costly constituents
2. Loss of drilling time
3. Plugging potentially productive zones
4. Blow outs resulting from the decrease in hydrostatic pressure subjected to formations other than the thief zones.
5. Excessive inflow of water
6. Excessive caving of formation

Mud Loss can be reduced or cured by one of the following methods:

- Reducing mud weight until the hydrostatic pressure of mud is equal to the formation pressure.
- Spotting of a pill of mud containing a high concentration of bridging materials against the thief zone.
- Lost circulation materials (LCM) can be classified as fibres, flakes, granular material, and a mixtureof all three. The fibres include plant fibres, glass fibres, mineral fibres and leather. The flakes include cellophane, mica, cotton seed hulls, nut hulls, etc. Granular material includes ground rubber tyres, crushed rock, ground asphalt, asbestos, etc.
- Spotting of bentonite-diesel oil or cement-diesel oil plugs across the thief zones.
- Adoption of special drilling methods such as blind drilling, drilling with underbalance or drilling with air. Blind drilling refers to drilling without returns at the surface, so that the generated cuttings are used to seal off the fractures of the thief zone.

a. **Well-Kick**

A well 'kick' occurs when the formation pressure exceeds the mud pressure. A kick is a sure sign of pressure imbalance. The entry of formation fluid often displaces a measurable amount of drilling fluid at the surface. Statistically most of the kicks occur during swabbing. (vaccum created due to fast pulling out of drill string). For this purpose, blowout preventers are used which can seal off the hole and allow the kick to be circulated out. If proper care is not taken to contain a kick, a blow out can occur.

The most common causes for a kick are:

- A failure to keep the hole full, i.e. filling up the hole on trips with the trip tanks and closelymonitoring the "*hole take*.
- Swabbing. When tripping out, the drill pipe acts as a piston reducing the hydrostatic pressure on theformation.

- Insufficient mud density, mud weight too low.
- Lost circulation. If the mud level in the annulus drops due to lost circulation, the hydrostaticpressure
- will drop accordingly and may allow formation fluids to enter into the well bore.

Kick During Connection:

When drilling close to hydrostatic balance, a flow into the wellbore can occur when the pumps are shut down for a connection. This results from a pressure reduction caused by the removal of the annular pressure loss. When the kelly is lifted, swab pressures can further reduce the bottom hole pressure. A kick during connection is signaled by the following indications:

The well is still flowing when the pumps are shut off. Monitor the flow-out sensor closely. Flow out at the mud flow line should cease in a few seconds after the pumps ware switched off. When monitoring the flow out at the pit tanks, the afterflow is somewhat longer, depending on the type of mud cleaning equipment and the volumes contained in them.

1. An increase in pit volume may be noticed only after the connection. When the levels have stabilized after the pumps are restarted. An increase in pit level indicates that flow into the wellbore has occurred.
2. Loss of pump pressure when resuming drilling. If lighter fluids (oil, gas) have entered the wellbore, less pump pressure is required to lift the mud in the annulus to surface (i.e. a reduction of the hydrostatic pressure in the annulus has occurred).

Kick while Tripping:

The majority of kicks occurs when tripping out of the hole. The reasons for this are the reduction of pressure at the bottom caused by swabbing action of the bit (and also by stabilizers which can be packed with shalesand exert an even greater swab effect than the bit. The swab pressure increases with the speed of the traveling drill string. Usually the trip speed out of the hole is restricted to one or two minutes (or even much slower, depending on pressures estimated) per stand of drill pipe.

Of course, the well must be kept full with mud and the hole take compared with the calculated hole take.

Kick while Drilling:

The first indication that a kick may occur is a drilling break, an increase in ROP. A *significant* drilling break is defined by an increase of ROP by the factor of two, i.e. twice the drilling progress per unit time.

1. Any significant drilling break must be checked for flow. Call the rig floor and request a flowcheck if you have seen a significant drilling break and the driller does not take any action. For a flow check the pumpsare switched off and the well is observed at the rig floor by peeping into the annulus with a torch *and* with a second watch at the shakers or possum belly. The time to observe the well should not be less than five minutes.
2. If there is any indication that the well is not static after the pumps are shut off - call the driller on the rig floor *immediately*.
3. The second indication of a kick is an increase in the flow rate out. Once flow begins, the rate of flow increases proportional to the depth of penetration into the reservoir. Most mudlogging units have computerized alarm that go off when the flow rate[out] is bigger than the flow in.

   If you see any increase of flow out without a corresponding change in pump output -call the driller on the rig floor *immediately* and alert him about the situation.

The third possible indication of a kick while drilling may be seen in an increase in hook load. If the invading fluid is lighter than the mud then the buoyancy of the drill string is reduced and an increase of hook load registered by the sensors.

The fourth possible indication of a kick while drilling may be an increase in the pump rate. The reasons are similar to the ones explained above. The invading fluid is lighter than the mud and the force required to liftthe mud in the annulus is less. The pumps usually respond to this loss in back-pressure with an increase inspeed seen as increased strokes per minutes (SPM).

Lastly Gas, oil, or water-cut mud is also an indication of a kick.

ROP

Rate of Penetration is measured in either of these units (min/mt, Mts/Hrs or ft/hr). **Any sudden change in the rate of penetration is called a drill break.** In drilling only an increase in the ROP is of importance . A higher rate of penetration could indicate a zone of Over pressure.

In case of a drill break, the Mud logger has to first inform the driller and then the geologist.

As a standard procedure the driller will stop drilling, stop RPM, stop Pumps, lift the Kelly above the rotary table and do a flow check. The mud logger has to monitor the return flow of mud by monitoring the returns sensor and pit volumes. It is desirable that he goes to the flow line (out mud) and physicallychecks if any mud is coming out during this time, as the mud flow sensor may not respond to minor flow rates due to positioning or cleaning problems. In case there is self flow (flow without the pumps being switched on) then it is called +ve flow, if not it is called –ve. In case there is a positive flow check then the logger should measure the rate of flow with help of pit level sensors. This measured value should be immediately reported to the driller and the chemist. Depending on the rate of flow the driller might decide to shut the BOP and go in for kick killing procedures.

In case there is no flow and the zone is of interest then the geologist might ask for bottoms up sample i.e the sample from the zone of drill break. In this case the driller will circulate for one lag time and then depending on the results of sample checking take further action either to continue drilling or Pull out for coring.

The mud logger will have to continuously keep getting the samples during this bottoms up time .It is also imperative that he monitors the pit levels closely by setting alarms as a kick might take place due to slow expansion of gas. It is also important to monitor all, Out coming parameterslike Gas, Mud wt, Mud conductivity and Mud temp.

A ***Kick*** is an uncontrolled influx of formation fluids into the well bore.

Pit Level

Pit levels are very important to be monitored always as any change in these directly indicates well behavior.

An Increase would indicate fluid influx. This could be due to improper Mud weight insufficient to balance the formation pressure. It could also be due to additions at the surface (mud transfer, water addition etc.)

It is important to find the cause and then derive a conclusion as to the cause of the rise in pit levels. Similarly a decrease could mean mud loss into formation (Lost circulation), or excess mud weight orleakages at the surface.

Depending on the causes various actions are taken to prevent increase or decrease in pit levels. Sincethe mud circulation system is closed all changes can be directly correlated to the above.

Note : The Checks and Actions mentioned below are basically stated for Potentiometric pit levelsensors, though there maybe similarities when applied to Ultrasonic sensors also.

Interpretations in Pit levels during Drilling

Description	Possible Origin	Check/enquire	Action/inform
No Variation	Very slow ROP coupled with wateraddition. Float stuck	Check Floats Check sensor connectio ns Vary the pulley andcheck the signal reception	Clean the float withwater so that it is free. Test the connections
Slow and regular **increase** 0.5 to 3Cu.m/hr	Water or mud addition at surface Slow influx of water/oil or gas	Pit levels and sensorGas/pit gain rates	Note the gain and inform driller/ chemist/Tool pusher Put comments on real time charts
Oscillations < 1Cu.m/hr	On floater due to heave or due to sensor being close to agitator	Check calibration	If necessary changethe position and recalibrate
Fast but small **increase**1 to 3 Cu.m/hr	Water or oil influx Gas influx preceded by slow increase dueto gas expansion	Check SPP Enquire with driller Check ROP/ Gas/ Returns/ MW/ Cond/Temp	Monitor active pitvolumes Inform driller/ chemist/Tool pusher Put comments on realtime charts
Fast and large volumes > 20 Cum	Mud transfer Water/oil or Gas influx preceded by gradual increase anddrill break	Check with chemist Check ROP/ Gas/ Returns/ MW/ Cond/Temp	Monitor active pitvolumes Inform driller/ chemist/Tool pusher Put comments on real time charts Shut in well and monitor SIDPP & SICPP.
Slow and regular **decrease** 0.5 to 3 Cu.m/hr	Increase in hole Vol Operations of Desander/ Desilter/Rig Degasser.Filtration loss in hole	Check the hole volume increase in relation to decrease inpit volume Check pits for leakage	Inform the chemist /Mud engineer
Fast **decrease** >3 Cu.m/hr	Mud transfer Mud loss at surfaceMud loss in well	Check with chemistfor any transfer Check the SPP ROP and type of Lithology if any	Inform the chemist /Mud engineer Inform driller Put comment on real time charts

Interpretations in Pit levels during Pipe Connections

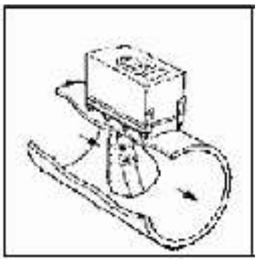
Description	Possible Origin	Check/enquire	Action/inform
No Variation when pump isshut	Float stuck	Check Floats Check sensor connectio ns Vary the pulley andcheck the signal reception	Clean the float withwater so that it is free. Test the connections
Fast **increase** upto 3 Cu.m/hr after resumptionof pumping and stabilization	Pump shut for connection Mud transfer Swabbing	Check SPM and SPPEnquire with chemist Gas after lag time/ Returns	Put comment on volume gained Monitor Gas andreturns
Fast **decrease** >3 Cu.m/hr Decrease after stability and resumption of drilling / circulation	Pump restarting Loss at surface Loss in hole	Check SPM Check with chemistfor any transfer Check the SPP ROP and type of Lithology if any	Monitor stability timeInform the chemist / Mud engineer Inform driller Put comment on realtime charts

Interpretations in Pit levels during Trip (POOH & RIH)

Description	Possible Origin	Check/enquire	Action/inform
No Variation	Float stuck Path by passed	Check Floats Check sensor connections Check the path of flow	Clean the float withwater so that it is free. Test the connections
Increase while POOH	Mud transfer Start of kick due toswabbing	Check with chemistMonitor hole fill proportional to steelvolume	Note the vol from charts Inform driller/ toolpusher. If necessary shut-in well and circulate through choke
Increase while RIH	Check the increase after compensating forsteel volume	Check with chemist for additions of mud.	Note the vol from charts Inform driller If necessary shut-in well and circulate through choke

Mud Flow Rate

Increase in flow out (returns) could be due to kick.
Decrease could be due to lost circulation or leakages at surface



Gas

One of the most important objective of the mud logging unit at well site is to monitor all gases, especially Hydro carbons. These gases are from C1 to C5 (Methane to Pentane). Any increase in their levels is to be treated with a great deal of caution. Depending on the time and concentration they are interpreted as follows:

a) ***Background Gas***: When drilling through the same lithology especially clays and shales it is common for some gas value to be recorded. This is called the zero gas or Background gas. The background gas varies with the field and mud conditions. Generally it is continuously recorded from around 150 m onwards in most fields with proven reserves of Hydrocarbons.

b) ***Pipe connection gas*** : This comes out as a peak after one lag time after a pipe connection and then returns to normal background levels. This is due to the swabbing effect when the pipe is pulled out for a connection.

c) ***Liberated gas*** : This is gas that is liberated during drilling of the formation. This would generally appear one lag time after a porous hydrocarbon bearing formation is drilled. The peak would subside after the gas has been circulated out.

d) ***Produced gas***: This is gas that would keep coming out from the porous hydrocarbon bearing zone if the mud density is not sufficient to balance the formation pressure.

e) ***Trip Gas***: This comes out as a peak one lag time after the resumption of circulation on completion of a round trip. This could be due to swabbing effect during pipe movements or due to improper hole filling.

f) ***Recycled Gas***: This is gas that would show decreasing minor peaks after every cycle time from the time the major peak was detected if it has not been degassed using the degasser. This gas keeps re circulating in the system and could become a real hazard if not taken care of at the earliest. A high viscosity mud also abets its existence in the system. This is also called contaminated gas.

The important points to be noted are that if there is no connection or trip gas after a lag time then the possible reasons for it could be that the **gas line has got choked due to Mud or moisture** or the mud weight is high. Another possible reason is that the formation might have very low porosity/permeability.
It is important that the full gas processing system (gas line, decanting tube, air compressor, silica gel columns) should all be cleaned and dried during a trip. The gas panels should be calibrated prior to resumption of drilling after a trip. It is also advisable to inject gas from a gas bag at the shale shaker and check the travel time from shaker to unit and the difference in percentage.

Lag time calculation and checks should be done at intervals of no more than 150 metres orevery 12 drilling hours whichever is less and before running casing or logging.
The gas trap mud flow meter should be checked for proper operation and cleaned if necessaryduring each cutting sample collection trip.

Recording of Gas Shows

Trip gas, re-circulated gas, and connection gas peaks should be identified and annotated withcorrect lagged depth.
A plot of gas concentration vs ROP should be maintained to enable some degree ofnormalisation of gas shows to ROP.
A common calibration and reporting standard is to use 50 units of total gas equivalent to200ppm C1 (methane).

The Company Representative should be immediately informed if any significant gas increase is encountered (even if not associated with a drilling break), or if evidence of light mudweight is observed (high connection gas or trip gas; persistent gas shows; anomalous Dc exponent), or any indication from early kick devices in slim wells.

The gas trap mud flow meter should be checked for proper operation and cleaned if necessary during each cutting sample collection trip, if not then definitely during a round trip or after 48Hrs whichever is earlier.

Mud Density

Increase in Mudweight could be as a result of addition of barites at surface or due to excess water loss in the formation. If due to water loss to the formation it could cause a thick cake to form across the formation and hence lead to stuck pipe.

Mud density could decrease due to fluid or gas influx into the well from the formation (kick) or dueto the addition of various chemicals which cause frothing or addition of water at surface. Kindly notify this immediately to the driller and Mud chemist.

It is important to note that density of both ingoing and out coming mud should be almost the same so that pressure balance is maintained in the well. Any imbalance will lead to a kick.

Fluctuating **Mud Density In** readings could indicate that the sensors are placed close to the agitatorsor that the sensor is not working. Either place the sensor away from the agitator or repair it if it is bad. This could also be as a result of foaming due to addition of chemicals.

Fluctuating **Mud Density Out** could be as a result of foaming or cuttings clogging the diaphgram. Clean the sensor every time the possum belly is cleaned.

Mud Temperature

Sudden increase in Mud Temperature out relative to Temp_In indicates water influxGradual increase will indicate prolonged drilling in hard formations.

Sudden decrease in Mud Temperature Out indicates gas influx, because gas cools as it expands and rises to the surface. Other reasons for sudden drop in temperatures could be cleaning of Possum belly.

Mud Conductivity

The resistivity of the drilling mud can be measured in the mud pits or - better - at the possum belly. It can be displayed as resistivity (units ohm.m) or its inverse, conductivity (unit mmho/cm) also called milli siemens.
A change in mud resistivity indicates that the mud is mixed with other matter. It may also be that the conductivity of the mud has changed due to mud additives such as KCl.

Interpretations :

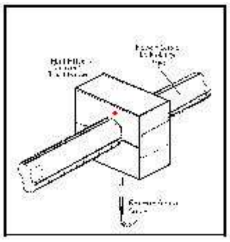
Increase in conductivity In could be because of the addition of chemicals
Decrease in conductivity In could be as a result of addition of water which would also be reflected in Pit volumes.

Conductivity Out could increase as a result of salt water influx or drilling through a salt zone.

Conductivity Out could decrease due to influx of fresh water , oil or gas. It is mainly due to Gas, because conductivity works on the principle of conduction through a medium and gas has less density due to which the conduction decreases.

Rotary Torque

Interpretation: A sudden increase in rotary torque could be as a result of drilling on junk, clay balling or a change in formation.
A gradual increase could indicate bit wear. This could be cross checked by checking for metal pieces in the sample and the number of hours that the bit has been drilling in relation to its rating. In fact any fluctuating increase in the torque has to be informed to the driller, who will cross check by lifting the string off bottom and rotating. A similar response would indicate the stabilizers are hitting the side of the hole. Whilst a decrease off bottom and an increase on bottom would indicate that the bit is worn out and has to be pulled out immediately to avoidfishing problems.



SPP – Stand Pipe Pressure

This parameter is used to calculate several hydraulic parameters used to optimize drilling.
When coring or when drilling with a downhole motor or turbine, the standpipe pressure gives anindication if the downhole gear is performing properly.

Total system pressure loss = (Surface pressure loss + String pressure loss + Pressure lossthrough the bit + Annular pressure loss).

The largest portion of the pressure drop will be when the fluid passes thought the bit. It isdeemed to be optimum when 65% of the total pressure loss is from the bit. However depending on your preference a bit pressure drop between 50 and 65% of the total pressure is acceptable.

Note also that changes in ambient temperature may introduce some variation in the apparent pressures recorded (diurnal base line shift) as the oil in the pressure transducers expands or contracts with temperature. It is essential that the sensor be properly filled with the right kind of oil (Martin Decker) and no air bubbles are entrapped which may cause the expanding and contracting due to temperature.

A decrease in SPP followed by an increase could be due to a sudden increase of Mud density, asa higher mud density tends to go down on its own weight thereby decreasing the pressure required to pump it down.
One of the major reasons for drop in SPP is **Mud Cut** (cut in the drill string) and the logger hasto be very very careful to monitor and report the drop in SPP to the driller immediately. A dropof 2 to 3 kg/cm2 over 5 to 10 minutes without any changes in Mud might be an indication of Mud Cut. In such a case the driller will stop drilling and check for the drop and then pull out.
Other reasons for the drop in SPP could be leakages at surface or decrease of mud weight due the addition of water or chemicals. It could also be due to frothing. Check for the possible reasons and notify driller immediately.
Some times it could be also due to a nozzle loss.
A sudden increase in SPP could be due to blocked nozzle. A slow increase could be as a result of increase in viscosity or cuttings left in hole, generally in a horizontal well.

Weight on Hook - WOH

The *hook load* gives a value for the load on the drilling draw works. The units are kilo-pounds (kps) or tons in a metric environment. This reading is of eminent importance for the driller at the rig floor (it is by far the biggest instrument at the driller's console).
When the drill string is tripped in the hole, just before reaching bottom, the instrument (both on the driller's console and in the mudlogging unit) reads the full weight of the drill string withsome compensation for the buoyancy in the mud. When drilling is resumed, the bit touches the bottom and part of the weight is supported by the bit. This is seen in a *decrease* in hook load. This ***difference* is called *weight on bit* (WOB)**, an important parameter to calculate drilling bit efficiency, and formation parameters such as D'exp.
Compare the readings in the logging unit with the values on the drill floor and cross check withthe calculated hook load (data from driller's work sheet). Hook load recording on Trend screen is very useful as it virtually displays the history of a day's drilling operation. You can see connections, trips, overpull on trips etc.
Make sure this chart is properly annotated with different activities that have taken place.
The hook load sensor and trend screen should never be switched off, even during wirelinelogging and other nondrilling operations.
In more critical situations during a drilling operation, the hook load can also indicate stuck pipe, overpull on trips, etc.

Interpretation : A sudden decrease in hook load during drilling could be due to string failure(cut), though there is no way to predict this, its occurrence should be reported immediately to the driller.
The Mud logger should also calculate the length of the string lost from the pipe weight. A drop in Hook Load while RIH could be due to stuck up.
An increase in Hook Load during POOH (Overpull) could be due to sticking of the pipes to the walls of the well.

Lag Time Calculations

Lag time is the time taken by mud, cuttings, oil, gas, cuttings or any other material to rise form the bottom of the well to the surface. This time is dependent on various factors like hole diameter, depth, string configuration, pump discharge etc. and may vary from a few seconds at shallow depths to few hours at greater depths.
Lag time calculations help us to correlate the cuttings and fluids (oil, water or gas) to the formationthat they originate from.
For calculating the lag time it is essential to calculate the annular volume of the hole as follows:

Ann Vol = Vol of (Open Hole + Casing) – Vol displaced by (Drill pipe + Drill collar) These volumes should

be calculated separately for each section of hole and then added.**Lag strokes** = Annular Volume / Efficient

Pump Capacity

Lag Strokes is strokes required to be pumped for the sample to reach the surface.
Efficient Pump Capacity is the efficiency at which the pump is pumping. Normally this may vary between 95 to 98%.

Lag Time = Lag Strokes / SPM

SPM is the number of strokes that a pump is pumping. If two or more pumps are operating then the strokes of both the pumps have to be added.

In recent times for deep water rigs (floaters) with risers a booster pump is present to improve the flow rate in the riser annulus. In these cases the lag time for both (bit to well head & well head to surface) should be calculated and added up.

Lag time is shown as bottom to surface in Hydraulic program (B-S) while the time required from surface to bottom is shown as (S-B).

Cycle time is the time required for the mud to go from S-B + B-S + from flow line to Mud PitIn.

Correction for Lag Time

Determination and Correction for Lag time becomes essential where cavings are high, as this results in a larger hole volume and higher lag time. In case this is not taken care of then the depth tagging for gas and samples will not be correct. To check for hole over gauge **carbide test**should be run.

Carbide test uses calcium carbide (Cac2) in granular form (preferably 5-10mm) , which reacts vigorously when it comes in contact with water, forming **acetylene (C2H2).**

Note: It should be stored in air tight containers so that it does not get spoilt due to moisture absorption.

This acetylene is detected in the gas chromatograph as C2 after S-B + lag time + excess time taken due to hole enlargement + time taken for sample to reach the unit from the shale shaker.

Ideally from theoretical calculation the B-S time can be found and from injection at shale shaker the time required for the gas to reach the unit is also found. The only variable is the time due to hole enlargement, which can be compensated by feeding the cavings percentage in the real time software.

The following **procedure** has to be followed to perform a carbide lag:

- Weigh about 250 gms of carbide in a tissue paper and keep it ready for use during a pipe connection.
- Take the carbide pouch after resetting the counters to zero in the unit. Go to the rig floor and just before the pipe/Kelly is added insert the carbide in the drill pipe and note the time.
- Come to the unit and note the time when the pumps were started. From the theoretical calculations the lag time is known, hence note the time when the gas is detected. Find the additional time and feed it in real time computer for cavings percentage.
- The additional size of the hole is found by taking the additional time, then multiplying it with the pump discharge. This will give the volume, which can be added to the annular volume in theopen hole section, as the volume in the casing will not change. Then find the hole required for accommodating the additional volume in the open hole.
  E.g if the additional time taken is 2 mins and the pump is pumping 20 lits per stroke at an SPM of 50 then 2 x 50 = 100 strokes at 20 lit/st, it will be 2000 lits. In case the size of the open hole is 12.25" (as per bit size) and the length is 100 mts and assuming that 8" D/C has been lowered and that the annular volume between open hole and D/c is 30 lit/mt, then the additional 2000 lits will get divided at 2000/100 = 20 lit/m in the annulus. This may require additional increase of 66% in hole size which translates into the hole size being 20.33 inch (assuming uniformity). In the G- Mensch Server user has to feed the percentage proportional to increase in lag time as this will be uniformly applied to the full well. In the above example if the original lag time was 25 mins and if now it is 27 mins due to additional 2 mins then the value of cavings factor to be fed is 8 %.

Note: Before the carbide test is done, the theoretical Lag time should be calculated using the GEWS program. The gas panels should have been calibrated and gas injected at the shale shaker using a gas bag and have had the travel time noted and incorporated in the Mensch Server – Gas menu.
Another method is to use raw rice and watch the rice coming out at the shale shaker. Normally carbides should be run every 12 hours or every 500 ft or as per client requirement.

Calcimetry

OFI uses an electronic **Auto Calcimeter** for determination of calcareous percentage of the sample.
The calcimeter measures the amount of carbonate contained in rock samples and can make separateanalysis of :

1 Calcite ($CaCo_3$)
2 Dolomite $Ca,Mg(CO_3)_2$

The calcimeter measures carbonates by subjecting a known volume of rock (1gm) to react with HCl in achamber of constant volume, and recording the pressure produced by CO_2.
$CaCo_3 + 2HCl = CaCl_2 + H_2O + CO_2$

The autocalcimeter consist of a Glass Chamber in which the reaction takes place. The lower half of the chamber can be unscrewed for inserting the sample and HCl ampoule.
The CO_2 pressure is detected by a 5 psi pressure sensor on the top cover which in turn converts the pressure into milli volts and is seen on the OLS computer via a cable. The Calcimeter has to be connected on channel 22 on the 17th serial number from top in the OLS sensors and the graph can be observed in the Utility section under Calcimeter Plot. The graph is plotted as time Vs percentage.

Equipment:

1. Electronic Balance
2. Mortar & Pestle
3. Filter paper
4. HCL ampoules
5. Pure CaCo3 powder
6. 200 mesh sieve

The HCl used in the ampoule is 17.5% strength HCl (50% conc)

Calibration Procedure:

1. Take 1 gm of pure CaCo3
2. Unscrew the lower part of the reaction chamber and place 1 gm of the sample around the slot forholding the HCl ampoule.
3. Take an HCl ampoule and place it in the holder.
4. Close the chamber so that it is just a little tight
5. Break the ampoule with the help of a plunger that is attached to the body of the chamber by screwingit in.
6. Shake the full chamber so that the acid completely reacts with the CaCo3.
7. Note the maximum milli volt reading in the computer and feed the reading as 100%.

For Sample

1. Take washed and dried sample and crush it in a mortar with a pestle.
2. Sieve the powder using a 200 mesh sieve on to a filter paper and measure **1 gm** of sample
3. Repeat steps 2 to 6
4. Note the maximum milli volt after 5 min which will indicate the % of Calcium Carbonate in thesample.

Clean the chamber after the reaction with water and dry it with tissue paper or cloth..After 10-12 test grease the 'O' ring with silicon grease.

The **interpretations** of the curves is as follows:

Pure Limestone ($CaCo_3$): Acid reaction with pure Limestone will result in a rapid straight line moving upwards from 0 to 100% and then it will level off. The shape of the curve will depend on the fineness of the sample and any contaminants like oil.

Calcareous Rocks (50-100% $CaCo_3$): - The curve will still be a straight line, but does not reach 100%. The percentage at which the curve levels off indicates the % of CaCo3.

Limey Rocks (0-50%) $CaCo_3$): The reaction is same other than the CaCo3 content being less than 50%. After the initial rapid reaction the curve levels of at less than 50%.

Note: Oil contamination can be detected by the formation of unusually large gas bubbles as the acid reacts with the sample.

Pure Dolomites [50-100% (Ca, Mg (Co_3) $_2$)] – The reaction starts immediately but slows down with time and the curve is a curved line different from that of Limestone.

Pure Dolomites (100%) will produce a curve above 100%, because the calibration had been done with $CaCo_3$ which has different molecular weight than Dolomite. Corrections for this can be made by multiplying the values by 0.92.

Dolomites (50-100%) – The reaction is similar to that of Dolomite with the exception of a lesserpercentage. Between (50-100%).

The reaction could start immediately or after some time (1min).

Dolomitic Rocks (0-50%) – If the Dolomitic content falls below 50% the rock is called a "Dolomite containing rock". The curve will be similar as dolomites but will level of before 50%.

Note: All values for dolomite should be multiplied by 0.92%.

Calcareous Dolomite: If the rock is predominantly dolomite with a small percentage of limestone then itis called a calcareous dolomite.
The first component to react is the limestone, which will give a straight line increase. Once the limestone has finished reacting then the curve will trace similar to that of dolomite.

By dividing the graph into its components the % of each can be calculated.

Dolomitic Limestones (minimum 50% Calcite): rocks that are principally limestone, but also contain dolomite, are termed dolomitic limestones. The curve is a composite curve similar to that above, but the straight line limestone component is much more important, and rises above the 50% level. The start ofthe dolomite reaction is taken as the point at which the curve starts leveling off. The dolomite content consists of the percentage measured between this point and the maximum curve value.

Mud logger shall undertake:

a) The operation, maintenance, inspection, calibration and repair of all Mud Logging Equipment in the unit.

b) Testing of all mudlogging equipment at every new location

c) Formation Sampling and Analysing which shall include:

- Collection of drilled solids at lagged specified intervals.
- Washing, sieving, and drying of cuttings as specified.
- Bagging and labeling of wet and dried samples.
- Microscopic examination of samples for lithological determination and percentages
- Fluorescence determination on lightly washed cuttings as well as fluorescence determinationand cut of washed cutting in solvent.
- Master log geological interpretation and preparation.
- Preparation and labeling of samples for dispatch.
- Sorting, preparation and dispatch of microfauna.
- Shale density determination.
- Preparation of reports.

d) Handling of Cores which shall include:

- Recovery, sampling (packing and sealing) and orientation of cores.
- Boxing and labeling for dispatch as instructed by COMPANY.
- Lithological description, calcimetry, dolonimetry and shale density of cores.
- Preparation of required core logs and documents.

e) Handling of Sidewall Samples which shall include:

- Lithological description, show evaluation (direct and solvent fluorescence, solvent cut).

f) Gas detection, analysis and evaluation which shall include:

- Continuous gas separation, extraction and drying from the return mud in the flow line.
- Continuous, automatic, detection and record of total gas content in the mud with alarms bothinside and outside of the logging unit (with both acoustic and visual warnings).
- Continuous, automatic chromatography of mud stream gases with recording of hydrocarbongases from C1 to C5 as well as hydrogen sulphide and nitrogen.
- Quantitative evaluation of gas composition and of gas ratios and concentration of formation'sgases at surface conditions.
- Continuous automatic detection of hydrogen sulphide with integrated alarms

g) Continuous drilling and mud parameters recording including but not limited to the followingparameters with optional display on remote monitors :

Total depth with digital display and alarm for sample.

- Rate of penetration versus depth at 1meter intervals. Curve to be plotted on the master log.
- Hook load and weight on bit.
- Pump stroke counters on two mud pumps giving strokes per minutes and total strokes.
- Mud pit volume record for mud pits including trip tank and giving individual volume per pitas well as total volume of mud on hand.
- Continuous recording of mud weights in and out.
- Mud flow in and out with alarms.
- Stand pipe and casing pressure recording.
- "D" Exponent calculation.
- Trip tank flow meter

All real time charts should be kept properly on a per day basis from 00 hrs to 2400 hrs. Each day should have a heading printed at the top.

Note: All charts are the property of the client and should be handed over at the end of a well.

It is also to be noted that all major events should be commented on the corresponding charts when they occur. Examples are : Mud Loss, stuck pipe, Mud transfer, trip gas, over pull etc.

Mud Logger shall maintain key data such as lag calculations, pore pressure estimates, etc. current at all times. All charts and screens shall be correctly annotated at all times (e.g. depths/times of all connections; scale or parameter changes, depths/times of all gas peaks, etc.).

Indicators of increasing pore pressure while drilling :
Gain in pit volume ("kick"). Increase in ROP ("drilling break").Increased torque while drilling.
Drag on trips and connections. Bottom fill after trips (or wiper trips).From drilling returns :

- Increased background gas, connection gas (mud gas may show an increase in carbon dioxide).
  In some areas is has proven empirically true that an inversion of mud chromatograph gas, that is C3 > C2 or C2 > C1 indicates the approach to an overpressured zone. In those areas where this relationship has been established, this indicator is fairly reliable.
- Changes (increase) in flowline temperature. Only applicable, if the drilling is steady and the temperatures stabilized, otherwise external effects will cover the subtle changes of flowline temperature.
- Change of shape of cuttings, typical pressure cavings. The shape of pressure cavings may not be mistaken for swelling or sloughing claystones. This is the most sensitive and still only a qualitative indication. Under overpressure conditions the shales (claystones) have a typical elongated shape. Pressure cavings have similar shape and increase in size.
  Try to establish if the caving lithology comes from the bottom of the hole (new formation) or if a formation drilled higher up caves in.
  If you see shale slivers coming over the shaker screens, that are bigger than the teeth of the drilling bit,the absolute alarm situation has been reached. Inform the company man a.s.a.p.

Indicators calculated or analyzed at the wellsite:

- Shale density decreases or deviates from the trend line.
- Water loss of shale cuttings increases.
- Significant increase in potassium content (mud, mud filtrate and shale water).
- Shale water (filtrate) may have amber color.
- Sharp change in cation exchange capacity ("shale factor" measured by titration with methylene blue).
- Decreasing D-exponent.
  A number of empirical techniques have been developed to calculate pore pressures from wireline logs. The principle of most techniques is to establish a trend line of a parameter (logarithmic plot of resistivity, sonic travel time, density, neutron porosity, etc.) versus depth. Deviations from the trend line are interpreted to be indicative of abnormal pressures. These empirical relations work good in the areas where they were developed. Outside their classical application areas they are less correct, though not necessarily wrong.

Techniques to detect Formation Pressure

The techniques are available for the detection of formation pressure, these are as follows

- Predictive Method
- Drilling Estimated Formation Pressure

Predictive Method : Estimates of formation pressure made before drilling are based onCorrelations from nearby or adjacent wells Seismic data

For development wells the emphasis is on data from previous drilling experiences in the area.

For exploratory wells, only seismic data is available. From seismic data, the average acousticvelocity as a function of depth is determined.

Mud Engineering

Functions of Drilling Mud

Drilling mud is used to carry out the following functions

1. Cool and Lubricate the drill bit
2. Cool and Lubricate the drill string
3. Control formation pressure
4. Carry cuttings out of the hole
5. Stabilise the well bore to prevent it from caving in
6. Help in evaluation and interpretation of well logs

Cool and Lubricate the drill bit: One of the prime functions of mud is to cool the drill bit and lubricate its teeth. Drilling action requires a considerable amount of mechanical energy in the form of weight on bit, rotation and hydraulic energy. A large proportion of this energy is dissipated as heat, which must be removed to allow the drill bit to function properly. Mud also allows to remove the cuttings from the spaces between the teeth of the bit, thereby preventing bit balling.

Mud helps to **cool the drill string** by absorbing the heat generated by the rotating string and releasing it, by convection and radiation at the surface. Mud also provides lubrication by reducing friction between drill string and borehole walls. Lubrication is generally achieved by the addition of bentonite, oil, graphite, etc.

For safe drilling, high formation pressures must be contained within the hole to prevent damage to equipment and injury to drilling personnel. The drilling mud achieves this by providing a hydrostatic pressure greater than the formation pressure. For effective drilling, the difference between the hydrostatic and formation pressures should be zero. In practice however an overbalance of 100 to 200 psi is normally used to provide an adequate safeguard against well kick. The pressure overbalance is sometimes referred to as chip hold down (CHDP) and its value directly influences penetration rate. In general rate decreases as the CHDP increases.

For effective drilling cuttings generated by the bit must be removed immediately. The drilling mud carries these cuttings up the hole and to the surface to be separated from the mud. Hence, mud must also posses the necessary properties to allow cuttings to be separated at the surface and to be recirculated. The carrying capacity of mud depends on several factors, including annular velocity, plastic viscosity and yield point of the mud and slip velocity of the generated cuttings. The mud must also be able to keep the cuttings in suspension when circulation is stopped to prevent them from accumulating on the bottom of the hole and causing stuck pipe.

Mud cake helps to stabilise the walls of the hole somewhat similar to adding a layer of plaster to the interior walls of the house. The pressure differential between the hydrostatic pressure and that of formation pressure is also instrumental in keeping the walls of the borehole stable.

Wire Line logs are run in mud-filled holes in order to ascertain the existence and size of hydrocarbon zones. Open hole logs are also run to determine porosity, boundaries between formations, locations of geo-pressured (or abnormally pressured) formations. Hence drilling mud must possess such properties that it will aid in production of good logs.

Driling Mud

Fresh water has a density of 62.3 lbm/ft3(1000kg/m3) which gives a pressure gradient of 0.433 psi/ft(0.0481 bar/m). Hence for a 10,000 ft (3048m) well the bottom hole pressure due to a full column of water is 4330 psi (299 bar). At this depth normally pressured formations have a pressure gradient of 0.465 psi/ft (0.105 bar/m), giving a formation pressure at 10,000 ft of 4650 psi (321 bar). Hence, if water is used as the drilling fluid at this depth, formation fluids will invade the wall, causing a kick. In actual fact, the formation pressure gradient at 10,000 ft can often be greater than the 0.465 psi/ft given previously and consequently, the pressure differential in the direction of the well will be even greater. To provide mud density is increased by the addition of high gravity solids.

Types of Drilling Mud

Drilling mud is defined as a suspension of solids in a liquid phase; the liquid can be water or oil. Three types of drilling mud are in common use

1. Water base mud
2. Oil base mud
3. Emulsion mud

Water Base Muds : Water-base muds consist of four components

Liquid water (which is the continuous phase and is used to provide initial viscosity)Reactive fractions to provide further viscosity and yield point

Inert fractions to provide the required mud weight andChemical additives
to control mud properties.

The reactive fraction of a water base mud consists of clays such as bentonite and attapulgite. Theinert solids consists of sand, barite, limestone, chert etc.
Clays are added to water to provide the viscosity and yield point properties necessary to lift the drillcuttings or to keep them in suspension.
There are two types of clay currently in use for making water-base muds:
Bentonite clay: this is a member of the morillonite (smectite) groups of clays, and can only be usedwith fresh water since high viscosity and yield point do not develop in saltwater.

Attapulgite (or salt gel): this is a member of the palygorskite group of clays, and has the ability todevelop the required high viscosity in both fresh and saltwater.

High gravity solids are added to increase the weight or density of mud. The following high gravitysolids are currently used:
Barite (or barium sulphate, $BaSO_4$) has specific gravity of 4.2 and is used to prepare mud densitiesin excess of 10 ppg (1.19kg/l). Barite is preferred because of its low cost and high purity.
Lead sulphides such as galena are used as weighting materials because of their high specific gravities allowing mud weight of up to 35 ppg (4.16 kg/l) to be prepared.

Chemical additives: **Chemical additives are used to control viscosity, yield point, gel and fluid loss properties of mud. Two types of chemical additives can be distinguished : thinners and thickners.**
Mud Thinners: Mud thinners operate on the principle of reducing viscosity by breaking the attachment of the clay plates through the edges and faces.

The following is a list of the most widely used thinners:
Phosphates include sodium tetraphosphate and sodium acid pyrophospahate. They are suitable for any pH value but have a temperature limitation of 175DegF (79 Deg C).
Chrome lignosulphonate is the most commonly used thinner, but decomposes at 300 DegF (149 Deg C). This chemical has the ability to deflocculate and disperse the clay particles, thereby reducing viscosity, yield point and water loss.
Lignites: decompose at 350 DegF (177Deg C) They can also be used as water loss control agents. *Surfactants:* (surface tension reducing agents) help thin mud and also reduce water loss. They canalso be used as emulsifiers.

Mud Thickners include the following:
Lime or cement which can be used to thicken mud or increase its viscosity. Viscosity increase is due primarily to flocculation of clay plates, resulting from the replacement of Na^+ cations by Ca^{++} cations.

Polymers are chemicals consisting of large molecules made up of many repeated small units calledmonomers.
Polymers are used for filtration control, viscosity modification, flocculation and shale stabilisation. Polymer muds possess a high shear thinning ability at high shear rates such as those encounteredinside the drill pipes and across the bit. Shear thinning reduces the viscosity of mud and in turnreduces the frictional pressure losses across the bit and inside the pipes. Hence a great proportion of the available hydraulic horsepower can be expended at the bit, resulting in faster penetration ratesand improved hydraulics.
In general three types of polymers can be recognised :
Extenders : include sodium polyacrylate (BENEX) which increases viscosity by flocculating thebentonite

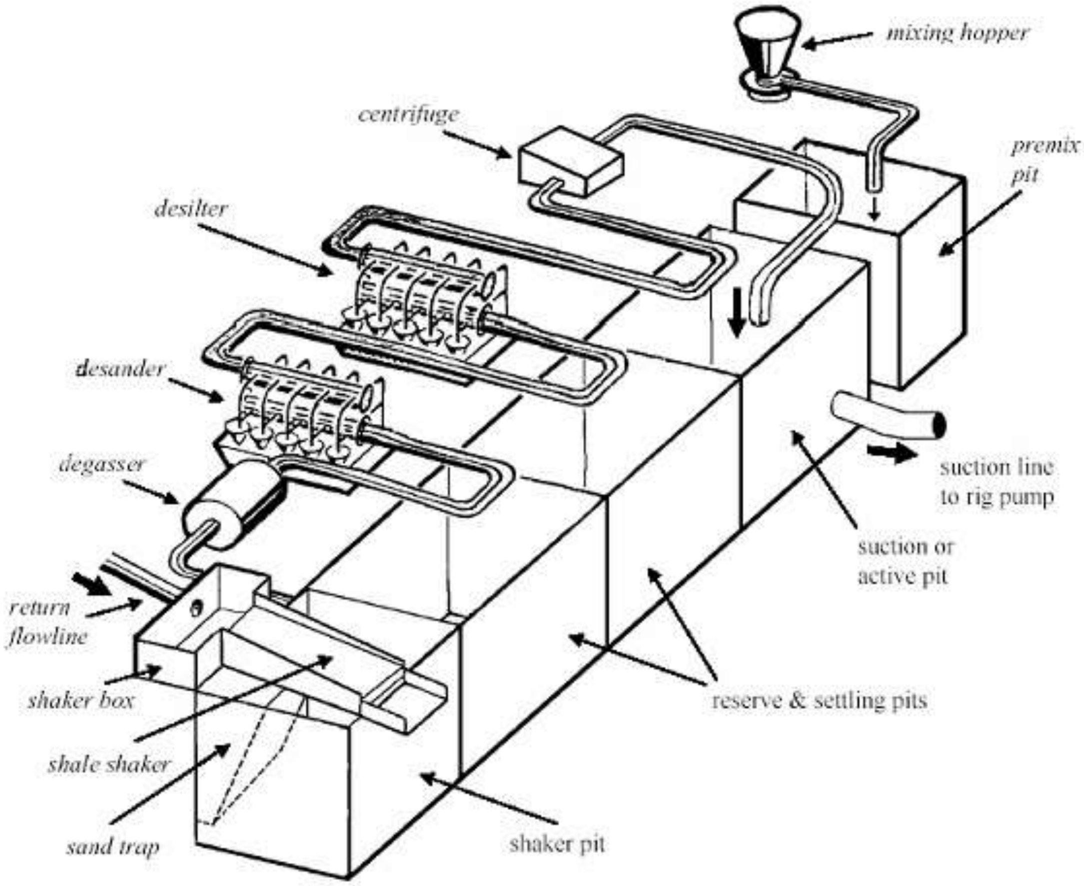
Colloidal Polymers: include sodium carboxy methyl cellulose (CMC), Hydroxyethyl cellulose (HEC) and starch.
Long Chain Polymers include the xanthum gum polymer. The xanthum gum is water soluble biopolymer . The main advantage of xanthum gun polymer is that it can build viscosity in fresh, sea and salt water without assistance from other additives. In general polymer muds have a weight limitation of 13 ppg(1.56 kg/l).

Types of water based muds
The following are the most widely used types of water base muds.
Clear Water : Fresh water and saturated brine can be used to drill hard, compacted and near- normally pressured formations.
Native mud: This mud is made by pumping water down the hole during drilling and letting it react with formations containing clays or shales. The water dissolves the clays and returns to the surface as mud. This mud is characterised by its high solids content and a high filter loss resulting in a thick filter cake.
Calcium Muds*:* The swelling and hydration of clays can be greatly reduced when calcium is added to mud. Calcium muds are superior to freshwater muds when drilling massive sections of Gypsumand anhydrite.
When calcium is added to a suspension of water and bentonite, the calcium cations will replace the sodium cations on the clay platelets. Since the calcium cations will be strongly attached to the surfaces of the clay sheets compared to the sodium cations, the platelets tend to be pulled closer together and the clay structure collapses forming aggregates.
The major advantage of calcium muds is their ability to tolerate a high concentration of drilled solids without these affecting the viscosity of mud.
Lignosulphonate mud*:* This mud is considered suitable when high mud densities are required a) (>14 lb/gal or 1.68

kg/l) b) working under moderately high temperatures of 250 – 300 Deg F (121-149 Deg C) c) high tolerance for contamination by drilled solids, common salt, anhydrite, gypsum and cement is required. d) low filter loss is required.
This type consists of fresh water or salt water, bentonite, chrome or ferro chrome lingo sulphonate, caustic soda, CMC or stabilised starch. Optional materials such as lignite, oil, lubricants, surfactants may be used.
This mud is not suitable for drilling shale sections due to adsorption of water from the mud by the clay surfaces with ultimate heaving of the shale section. The major disadvantage of this mud is the damage it causes to formation permeability. Due to these disadvantages this mud is now seldom used.

Oil Base Muds : are emulsions of water in oil in which crude or diesel oil is in continuous phase and water is the dispersed phase. Oil base muds are sometimes described as 'invert emulsions' since water droplets are emulsified in a continuous phase of oil. True emulsions are those in which the continuous phase is water and oil is the dispersed phase. Water is used mainly to give the emulsion
the required properties of gel strength and barite suspension.
Oil base muds are used to drill holes with severe shale problems and to reduce torque and drag problems in deviated wells. Oil base muds tend to be more stable at high temperatures than water base muds. From completion point of view oil is an excellent drilling fluid, since it does not damage hydrocarbon bearing zones and thus preserves the natural permeability of the area around the well bore. The main disadvantage of oil base muds are a) the environment is contaminated b) flammability becomes a hazard c) drilled solids removal from an oil base mud is usually more difficult than from a water base mud d) electric logging is more difficult with oil base muds.

Emulsion Muds: are those in which water is the continuous phase and oil is the dispersed phase. Oil is added to increase the penetration rate, reduce filter loss, improve lubricity, reduce chances of lost circulation and reduce drag and torque in directional wells. An emulsion mud normally contains 5 – 10% of oil by volume.



Fundamental Properties of Mud

The fundamental properties of mud include

a) weight
b) rheological properties
c) filtrate and filter cake and
d) pH value.

Mud Weight: or more precisely Mud density is defined as the mass of a given sample ofmud divided by its volume. Mud weight is dependent on the quantity of solids in the liquid phase, either in solution or suspended by the particles of the liquid phase. Water has a density of 1. The density of mud can be increased above the density of water by adding a material with a specific gravity greater than that of water. A mud density less than that of water can be achieved by the addition of oil or by aerating the liquid phase.
The units of measurement are **Kg / L** in metric units and **ppg** in API units.1 Kg / L = 8.34 ppg

(pounds per gallon)
Mud weights range from 0.8 for oil based muds to 2.4 Kg/L . Generally they are in the rangeof 1.04 to 1.6 Kg/l.

Rheological properties of mud: The most important rheological properties of mud are a)plastic viscosity b) yield point c) gel strength

RHEOLOGY describes the deformation of a material under the influence of stresses.
Plastic Viscosity: is a property which controls the magnitude of shear stress which develops as one layer of fluid slides over another. It is a measure of the friction between the layers of the fluid and provides a scale for describing the thickness of a given fluid. Viscosity is largely dependent on temperature and for liquids, decreases with increasing temperature; the reverse is true for gases. Because viscosity is dependent on the velocity of the fluid and the pattern of flow, whether laminar or turbulent, absolute or effective viscosity is difficult to measure.

In practice two models are used to describe the flow of fluids: the **Bingham plastic** and Power-law models.
Plastic viscosity is measured in cp (centipoises)
In the field, viscosity is measured with the help of Marsh Funnel. This is a plastic funnel of one litre capacity with a sieve on top. Mud is taken from the possum belly and poured intothe funnel. One finger is kept at the bottom of the funnel to prevent any flow till the time that the person is ready to take the reading. Then the finger is released and the time required for the mud to flow through the funnel is noted in seconds.
In case of gas in mud the time required will increase, as gas tends to move upwards andmud downwards and hence a resistance to flow is introduced.
While plastic viscosity decreases as this is measured as the resistance offered to rotate the cylinder. Since gas offers less resistance, these decreases.

Yield Point: is a measure of the attractive forces between particles of mud resulting from the presence of positive and negative charges on the surfaces of these particles. The yield point is a measure of the forces that cause the mud to gel once it is motionless and it directly affects the carrying capacity of the mud. The units of measurement are lbs / 100 ft^2.

Gel Strength: is a measure of the ability of mud to develop and retain a gel structure. It defines the ability of mud to hold solids in suspension. It also gives an indication of the ability of mud to develop a semi-solid structure when at rest, and to assume a liquid state when in motion. Gel strength is read in lb/100 ftsq directly.

Filtrate and Filter cake: When a drilling mud comes in contact with porous rock, the rock acts as a screen allowing the fluid and small solids to pass through, retaining the larger solids. The fluid lost to the rock is described as filtrate. The layer of solids deposited on the rock surface is described as 'filter cake'. It should be noted that filtration occurs only when there is a positive differential pressure in the direction of the rock. A drilling mud with a high water loss is particularly damaging from the logging and production stand points. A number of additives may be used to reduce the volume of water loss. These include: bentonite, emulsified oil, dispersants, CMC and starch. An ideal mud is one which has a small water loss and deposits a thin, tough filter cake on the surfaces of permeable formations. Filter cake is measured in mm.

pH: The acidity or alkalinity of any solution is normally described by the use of pH value. The pH is defined as the negative logarithm of the hydrogen ion(H+) content of the solution
i.e pH = -log H+. Mud should always have a pH higher than 7 to prevent corrosion to casing, drill pipe etc. Normal muds have a pH of 9.5.

Types of Fluid

Newtonian Fluid: - A Newtonian fluid is defined by a straight-line relationship betweenand Y with a slope equal to the dynamic viscosity of the fluid i.e. In this type of fluid, the viscosity is constant and is only influenced by the change in temperature and pressure eg. Oil and water.
Non – Newtonian Fluid: A Non – Newtonian fluid is a fluid that does not show linear relationship between and Y ie. U is not a constant.

Gas Detection and Analysis

Gas Sampling

Once mud gas reaches surface a portion of it enters the sampling and analytical cycle. Here, additional variables (e.g., extraction efficiency, ambient conditions) come into play that can affect the final analytical results. The two principal mud gas collecting mechanisms used in conventional mud gas logging are the *gas trap sampler* and the *steam still sampler or Vacuummud still.* A third collecting apparatus, the *cuttings gas sampler,* is used to extract gas retained in the cuttings arriving at surface. Although cuttings gas is not obtained totally from the mud system, it is analyzed in the same manner as mud gas and often used in conjunction with it aspart of a full formation logging program.

Gas Trap Sampler

The first separation step in continuous gas logging is taken at the *gas trap.* The principal objective of this trap is to extract a relatively consistent gas sample from the mud for continuous analysis. This is achieved using a degasser which has a chamber on top of which is fitted a motor with a stirrer to liberte the gases from the mud.

Cuttings Gas Sampler

The general method used to sample gases still retained within cuttings is to place the cuttings in a closed container, mechanically disaggregate the sample, and then draw off the liberated gas. The most common configuration for a cuttings gas sampler is a blender jar with a cap fitted with gas- sampling tubing.

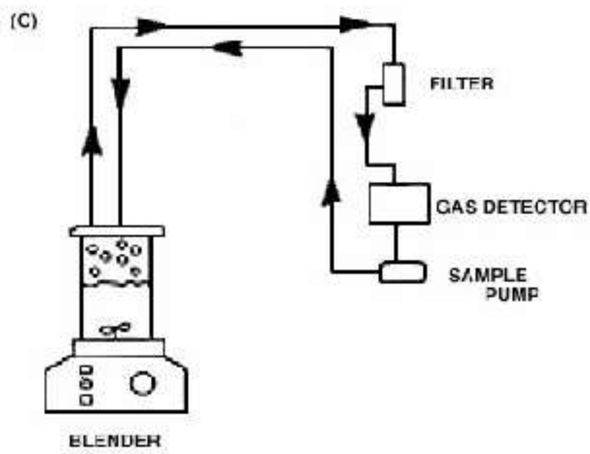


Figure 6 , *Cuttings blender, vacuum tubing and gas detector*

Procedurally, about one cup of fresh cuttings is taken at the shale shaker, placed in the blender, covered with an equivalent amount of clean water, and blended for a specific number of minutes, generally up to two minutes. The shattering action of the blender blades physically breaks the cuttings down so that all pore walls are fractured and contained gases are liberated.

Once the gas is liberated and available for sampling, it can be processed in the manner of any gas batch sample. Typically, a measured amount of gas is drawn off by vacuum and analyzed. Gases contained within cuttings are the most reliable mud-borne samples routinely available at surface to indicate original, if not complete, fluid content at depth. These may be very important in locating the top or bottom of show zones or in detecting first occurrences and trace components. Cuttings gas data can also have application in estimating changes in effective permeability and rock porosity when compared with mud gas data.

The principal limitation of cuttings gas sampling is that, characteristic of all intermittent orbatch samples, it is not continuous. In general, it seldom represents sample density any closer than that used for lithologic descriptions. In addition, if an oil-base mud is used, or contaminants are present, these must be rinsed from the cuttings sample prior to blending. This can affect the validity of the analytical data.

Gas Detection and Measurement

Mud gas detection techniques generally are based on a single diagnostic chemical or physical property of a gas molecule. This means that not all gases can be detected by the same technique. This can be easily recognized due to the fact that not all compounds are combustible, or fluoresce, or react with acid. Therefore, each detection technique used in mud logging has specific capabilities and limitations.

The combinations of different techniques used generally reflect an effective balance between detection level, reliability, and cost.

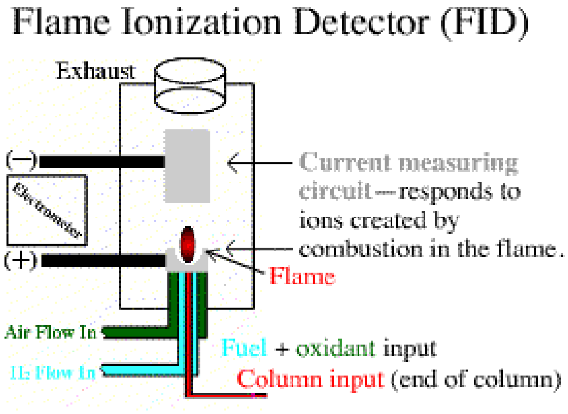
Hydrocarbons give off heat and reaction products when burned. The amount of each depends almost entirely on the specific hydrocarbon molecules present. By measuring one of these combustion products it is possible to approximate or quantify the nature of the original hydrocarbons. This approach is the basis for *catalytic combustion* and *flame ionization* detection used while logging for combustible gases.

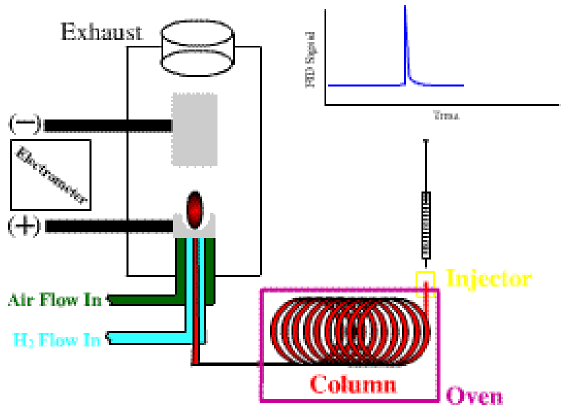
Two other properties commonly used in mud gas detection are based on properties unrelated to combustion; these are *thermal conductivity* and *infrared absorption.* Because such properties do not rely on any oxidizing (or reducing) reactions, they are often used to monitor mud gas mixtures that also contain nonhydrocarbon gases; these include dangerous and undesirable gases like hydrogen sulfide and carbon dioxide.

Flame Ionization Detector (FID)

Introduction

The *Flame Ionization Detector* (FID) is the most useful GC detector available and by far thatmost commonly used in GC analyses. The FID has a very wide dynamic range, a high sensitivity and (with the exception of a few low molecular weight compounds) will detect all substances that contain carbon..

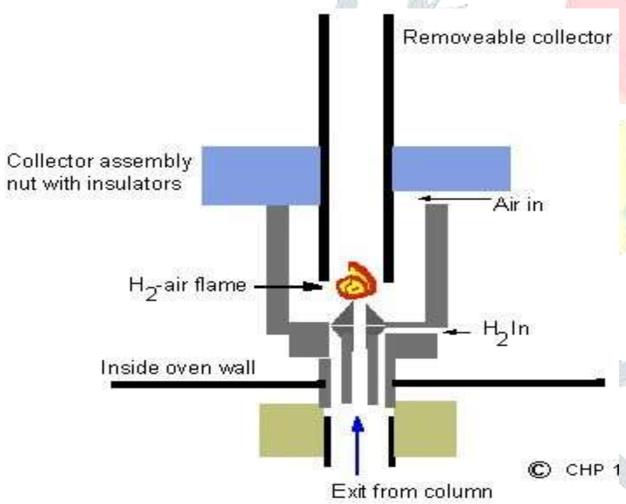




Hydrogen is mixed with the column eluent and burned at a small jet. Surrounding the flame is a cylindrical electrode and a relatively high voltage is applied between the jet and the electrodeto collect the ions that are formed in the flame. The resulting current is amplified by a high impedance amplifier and the output fed to a data acquisition system or a potentiometric recorder.

Usually the small diameter capillary is fitted directly into the bottom of the detector's flame jet. The gaseous eluents from the column are mixed with separately plumbed in hydrogen and air and all are burned on the jet's tip. After the fuel (H_2) and oxidant (O_2 in air) are begun, the flame is lit using a electronic ignitor, actually an electrically heated filament that is turned on only to light the flame.

The charged particles created in that combustion process create a current between the detector's electrodes. One electrode is actually the metallic jet itself, another is close by and above the jet.The gaseous products leave the detector chamber via the exhaust. The detector housing is heated so that gases produced by the combustion (mainly water) do not condense in the detector before leaving the detector chimney.



One of the major areas of application for the FID is in the analysis of hydrocarbons although it is also employed extensively for pharmaceutical analysis, pesticide analysis, forensic chemistry and essential oil analysis Nevertheless, its major area of application is in the analytical laboratories of the hydrocarbon industry.

The flame ionization detector, as implied above, responds both to the concentration of hydrocarbons present and to the number of breakable carbon-hydrogen bonds within them. The output is expressed in % EMA.
The flame ionization detector yields more uniform and linear readings and is less subject to progressive loss of sensitivity. It also has greater sensitivity to very low concentrations. In addition, it will not respond to the presence of hydrogen gas in the mud stream. However, it is the less rugged and is more susceptible to malfunctions under normal wellsite conditions. Daily or more frequent calibrations with a gas standard are recommended to compensate for electronic baseline drift.

CONCLUSION:

Drilling is among the most important and risky activities in the petroleum industry. It requires many heavy materials and qualified people to be cost effective and realized on the time required safely and within budget.

One of the important safety instruments in drilling is the mud logging unit which assists in real time the drilling operation and react for any potential or actual hazards.

Mud logging provides subsurface geological information while drilling a well. Mud logging examines and analyzes geological information contained in formation cutting and drilling mud, to determine if oil and gas are encountered during well drilling. Mud logging also provides critical safety function such as determine pore pressure, kick control and ambient gas monitoring. Mud logging is used whole drilling most exploratory and much development wells, both on and off shore, enhances drilling safety.

Mud logging unit include electronic monitoring of drilling parameters. These parameters include torque, penetration rate, mud levels, pump speed etc. and third-party service provider data.

The mud logging operations and mud loggers is the direct responsibility of the Wellsite Geologist. The main item of concern with mud logging operations is the dissemination of information. The Wellsite Geologist must ensure that the mud loggers provide all rig site personnel with up-to-date, accurate information regarding formation characteristics, changes in the drilling or tripping parameters, hydrocarbon appearances, and safety matters. Communication of this information is vital to the success of the drilling operation.

The Wellsite Geologist should discuss with the mud logging crew the requirements regarding reporting procedures, sampling intervals, log scales, sample shipping locations, and information security.

During the course of the well, the Wellsite Geologist should ensure that the required reports and logs are produced and delivered on time and to the right people.

When the well is completed, the geologist must ensure that all the information collected during the course of the well, and any information given to the mud loggers is returned to the oil company. All final well reports and final logs should be completed before the logging crew and unit are released.