DRILLING FLUIDS

Contents

INTRODUCTION

The drilling-fluid system—commonly known as the "mud system"—is the single component of the well-construction process that remains in contact with the wellbore throughout the entire drilling operation.

Drilling-fluid systems are designed and formulated to perform efficiently under expected wellbore conditions.

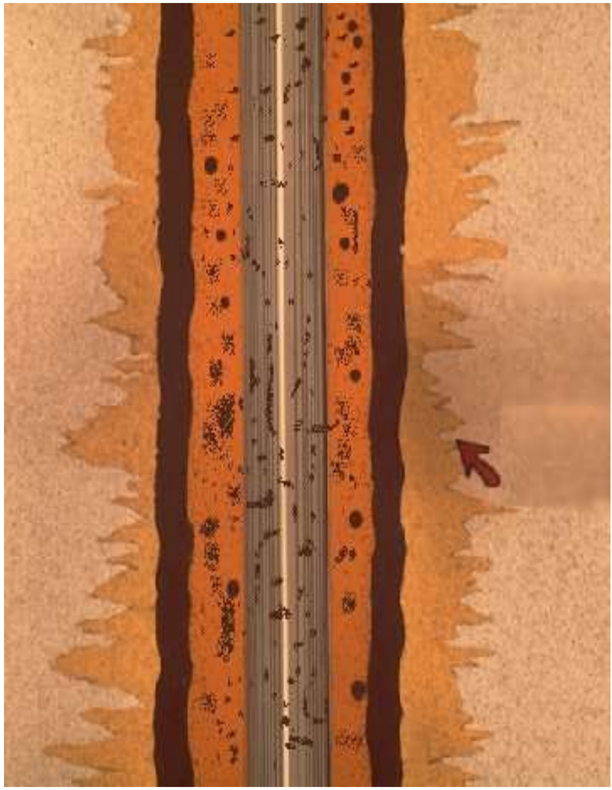
Advances in drilling-fluid technology have made it possible to implement a cost-effective, fit-for-purpose system for each interval in the well-construction process.

Drilling Fluid Function

1.Transport cutting and dispose to surface - The drilling fluid brings the drilled

material to the ground surface

either by mud rheology and velocity



Drilling Fluid Function

2. Clean drill bits – As drilling fluid exits the bit jets, fluid velocity removes cutting from the bit teeth and bit body.

This prevents bit ball up situation.

Drilling Fluid Function

3. Provide hydrostatic pressure to control well while drilling –Hydrostatic pressure provided from drilling fluid is the primary well control. Mud weight should be high enough

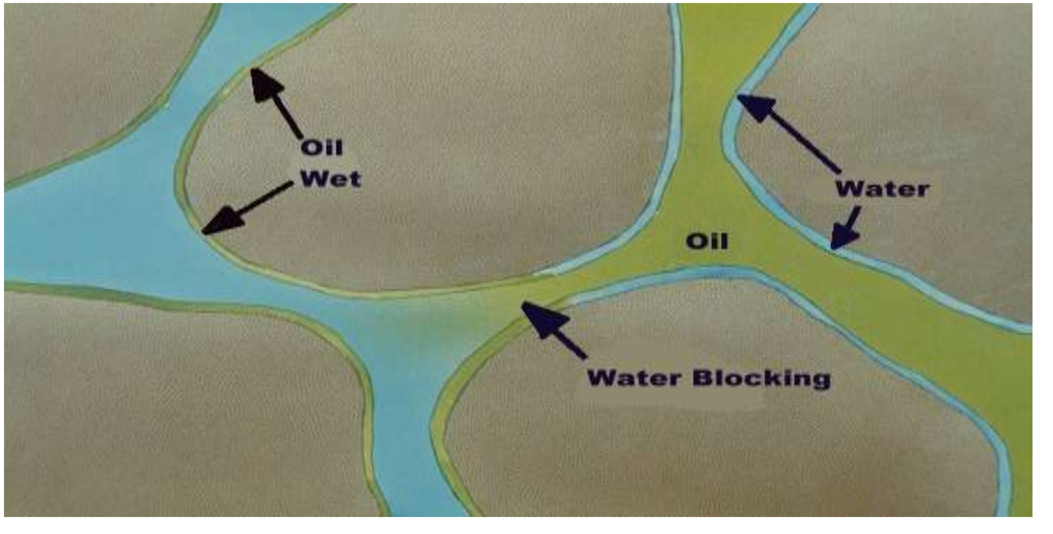
to control formation pressure while drilling.

Drilling Fluid Function

4. Prevent excessive mud loss - While drilling, clay particle will form a thin layer over porous zones called "mud cake" or "filter cake". Mud cake acts as barrier to prevent excessive drilling fluid loss into formation and provides wellbore stability..

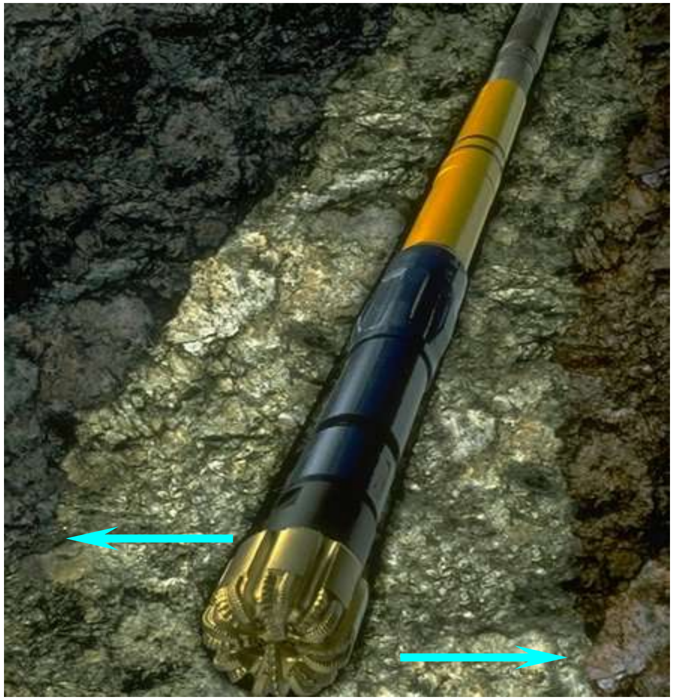
Drilling Fluid Function

5. Prevent formation damage by using reservoir drill-in fluid – While drilling long reach zone in horizontal wells, the special drilling fluid will be utilized in order to prevent formation damage.



Drilling Fluid Function

6. Provide hydraulic pressure to down hole assembly (BHA)- as mud motor, measuring while drilling (MWD), logging while drilling (LWD), etc – Without enough hydraulic power, down hole tool will not be properly operated, hence, drilling fluid plays essential role to provide power to sophisticated down hole tool.



Drilling Fluid Function

7. Facilitate down hole measurement as open hole logging, MWD, LWD, mud logging, – Mud will assist tool to measure everything down hole.

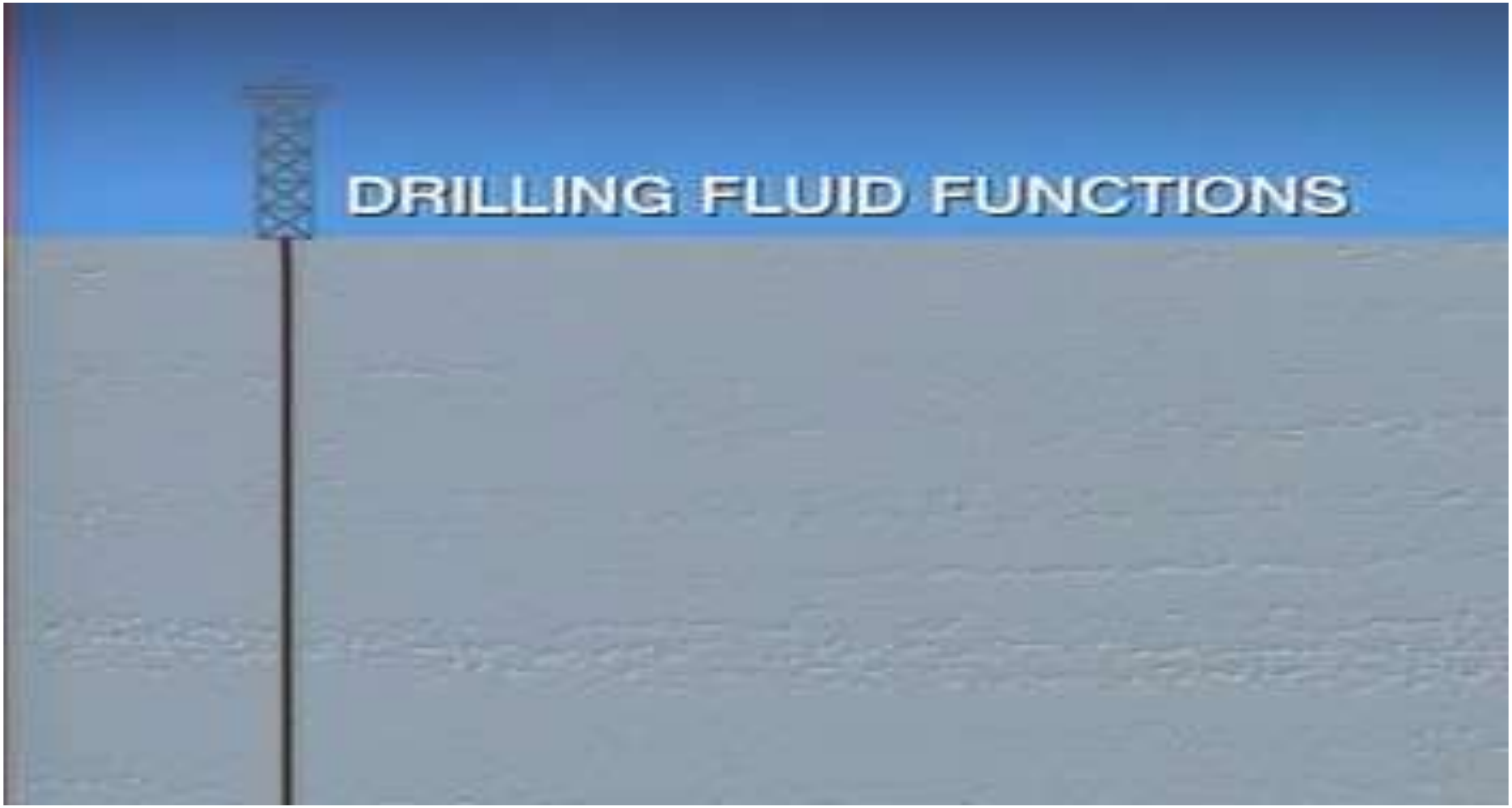
Drilling Fluid Function

8.Clean, Cool, and Lubricate the Bit and Drill string

9.Transmit hydraulic horsepower to the bit.

Drilling Fluid Function

Drilling Fluid Function



Drilling Fluid Selection

*T*he following requirements and criteria should be applied when considering the selection of drilling fluid or fluids for a particular well. It should be noted that it is common to utilise two or three different fluid types on one well.

- *P*ore pressure /fracture gradient plots to establish the minimum / maximum mud weights to be used on the whole well,

Drilling Fluid Selection

- Offset well data (drilling completion reports, mud recaps, mud logs etc.) from similar wells in the area to help establish successful systems, problematic formations, potential hazards, estimated drilling time etc.

- Geological plot of the prognosed lithology.

- Casing design to give each casing point and the casing programmer. This will give a good indication of what the mud has to deal with per hole section i.e. formation type, hole size and length etc.
- Basic mud properties required over each hole section.

Drilling Fluid Additives

There are many drilling fluid additives which are used to either change the mud weight(density) or change its chemical properties .

1.Weighting Materials:

Weighting materials (densifiers) are compounds that are dissolved or suspended in drilling fluid to increase its density. They are used to control formation pressures and to help combat the effects of sloughing or heaving shales that may be encountered in stressed areas.

Any substance that is denser than water and that does not adversely affect other properties of the drilling fluid can be used as a weighting material

Drilling Fluid Additives

Mud weights higher than water (8.3 ppg) are required to control formation pressures and to help combat the effects of sloughing or heaving shales that may be encountered in stressed areas.

Material	Principal Component	Specific Gravity	Hardness (Moh's Scale)
Galena	PbS	7.4-7.7	2.5-2.7
Hematite	Fe_2O_3	4.9-5.3	5.5-6.5
Magnetite	Fe_3O_4	5.0-5.2	5.5-6.5
Iron Oxide (manufactured)	Fe_2O_3	4.7	---
Iilmenite	$FeO \cdot TiO_2$	4.5-5.1	5.0-6.0
Barite	$BaSO_4$	4.2-4.5	2.5-3.5
Siderite	$FeCO_3$	3.7-3.9	3.5-4.0
Celesite	$SrSO_4$	3.7-3.9	3.0-3.5
Dolomite	$CaCO_3 \cdot MgCO_3$	2.8-2.9	3.5-4.0
Calcite	$CaCO_3$	2.6-2.8	3.0

Materials used as densities

Barite

Barite is preferred to other weighting materials because of its low cost and high purity.

Barite is normally used when mud weights in excess of 10 ppg are required.

Barite can be Aa very high muds weights (22.0 ppg))

the rheological properties of the fluid used to achieve densities up to (22.0 ppg) in both water-based and oil -based muds. become extremely difficult to control affected due to the increased solids content.

Materials used as densities

2. Iron Minerals

Iron ores have specific gravities in excess of 5.

They are more erosive than other weighting materials and may contain toxic materials.

The mineral iron comes from several iron ores sources including: haematite/magnetite, Illmenite and siderite. Iron ores are available in nearly unlimited quantities worldwide.

Because iron ores always contain impurities, problems such as thickening of muds and temperature instability are seen in water- based fluids weighted with ground, naturally

occurring iron ores

The most commonly used iron minerals are:

- Iron Oxides
- Iron Titanate:
- Iron Carbonate

Materials used as densities

3. Calcium Carbonates

Calcium carbonate ($CaCO_3$) is one of the most useful weighting agents especially in no damaging

drilling fluids. Its main advantage comes from the its ability to react and dissolve in hydrochloric acid. Hence any filter cake formed on productive zones can be easily removed thereby enhancing production. Calcium carbonate is dispersed in oil muds more

4. Lead Sulphides

5. Soluble Salts

Materials used as Viscosifiers

1.Clays are added to water to provide the viscosity and yield point properties necessary to lift the drilling cutting or to keep them in suspension.

There are two types of clay currently in use for making water-base muds.

Bentoniticclay (using in fresh water)

Attapulgite(or salt gel) (using in both fresh and saltwater).

2. Polymers are chemicals consistingof chains made up of manyrepeated small units called monomers

Types of drilling Fluid

Three types of drilling mud are in common use:

- **water-base mud**
- **oil-base mud**
- **Gas based fluids**

Water Base Mud

This fluid is the mud in which water is the continuous phase. This is the most common drilling mud used in oil drilling.

The following designations are normally used to define the classifications of water base drilling fluid

the classifications of water base drilling fluid

Non-dispersed-Non - inhibited		
Non-dispersed - Inhibited	Dispersed - Non-inhibited	Dispersed - Inhibited

Oil base mud

This drilling mud is made up of oil as the continuous phase. Diesel oil is widely used to provide the oil phase.

This type of mud is commonly used in <u>swelling shale</u> formation.

There are two types of oil-based muds:

- **Invert Emulsion Oil Muds.**
- **Pseudo Oil Based Mud .**

Disadvantage of Oil-base mud

The main disadvantage of Oil-base mud are:

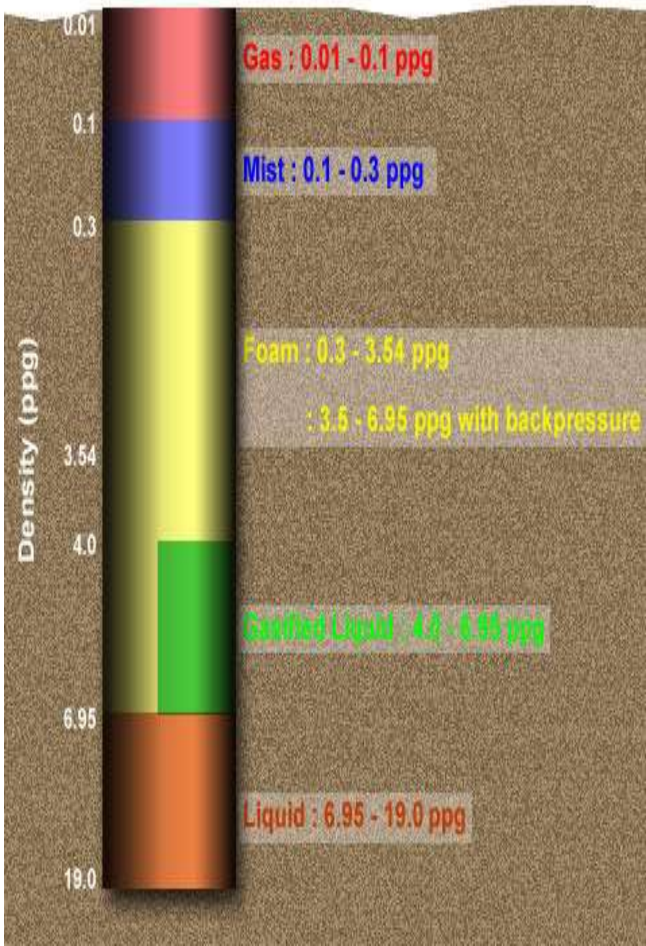
- the environment is contaminated flammability becomes a hazard drilled-solids removal from an oil-base mud is usually more difficult than from a water-base mud.

- electric logging is more difficult with oil-base mud

gas based fluids

There are four main types of gas based fluids:

1. **Air**
2. **Mist**
3. **Foam**
4. **Aerated Drilling Fluid**



Drilling Fluids Properties

- **Mud weight or mud density.**
- **Funnel Viscosity.**
- **Plastic Viscosity (PV).**
- **Gel Strengths.**
- **Yield Point.**
- **Fluid Loss and Filter Cake.**

Density

((Any accepted terminology that indicates the weight per unit volume of drilling fluid))

- **-Pounds per gallon (ppg).**
- **-Pounds per cubic feet (pcf).**
- **-Gram per cubic centimeter (g/cc).**
- **-Kilogram per liter (kg/l).**

Density

Mud weight is measured in the field using a mud balance, as shown in Fig..

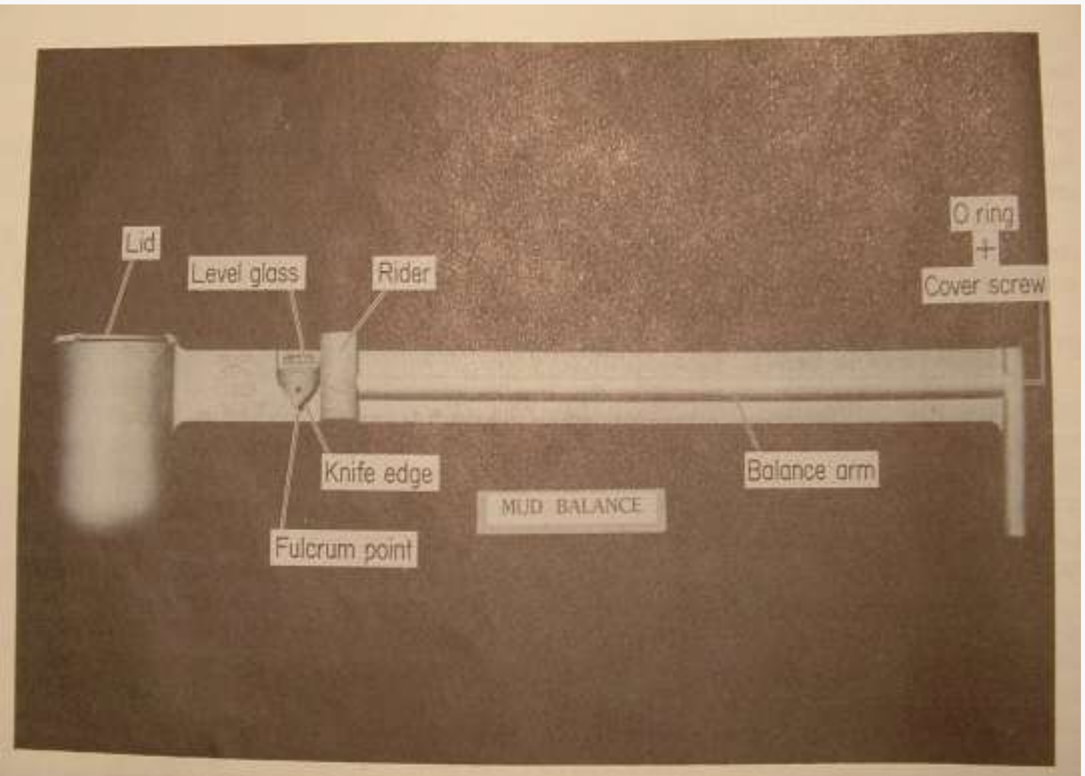
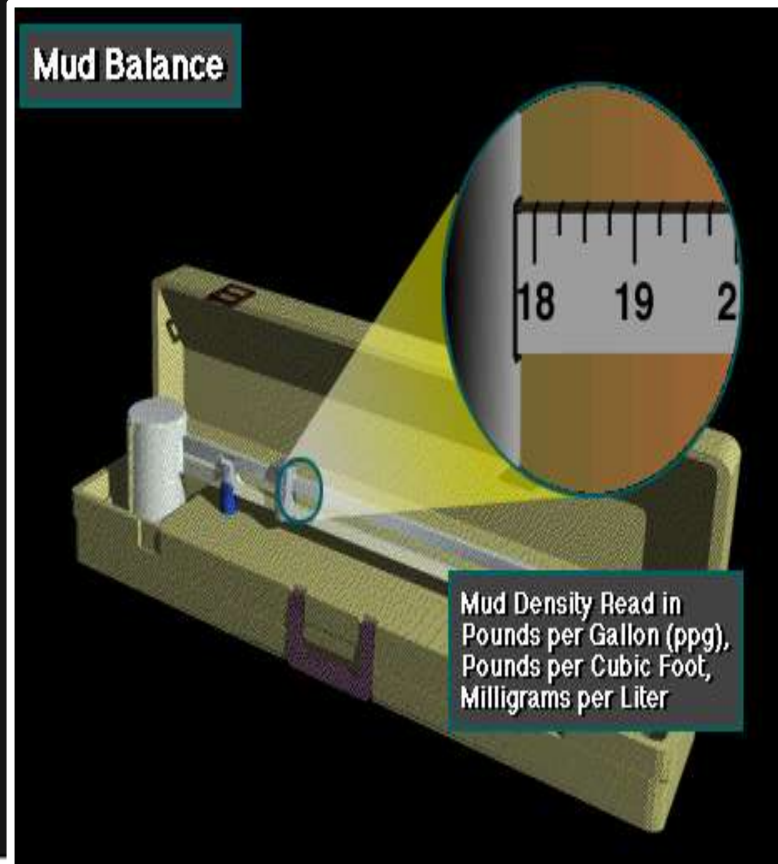


Fig. 6.5. Diagram of mud balance[1]. (Courtesy of Baroid/NL)



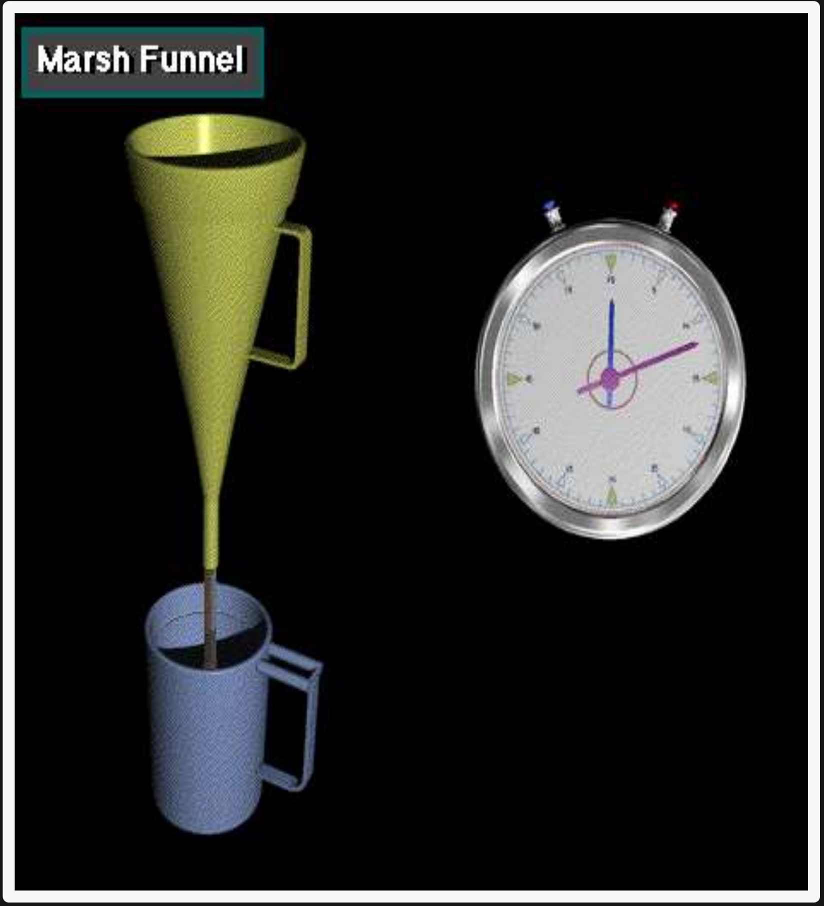
viscosity

Viscosity is a measure of the internal resistance of a fluid to flow))

<u>1- Funnel Viscosity</u>

Apparent Viscosity (vis)

is the measured times it takes for one quart of mud to gravity feed through a hole of a specific diameter.



Viscosity

<u>2. Plastic viscosity (Pv)</u>

is that part of flow resistance in a mud caused primarily by the friction between the suspended particles and by the viscosity of the continuous liquid phase

The viscosities are defined as follows:

$\mu_p = \phi_{600} - \phi_{300}$

$\mu_{aF} = ½\ \phi_{600}$

$Y_b = \phi_{300} - \mu_p$

Where μ_p = plastic viscosity, cp

μ_{aF} = apparent viscosity, cp

Y_b = Bingham yield point, lb/100 ft^2

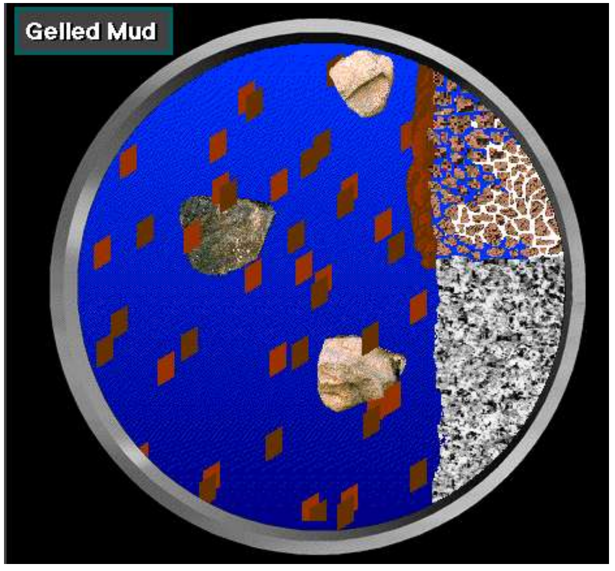
ϕ = Torque readings from instrument dial at 600 and 300 rpm.

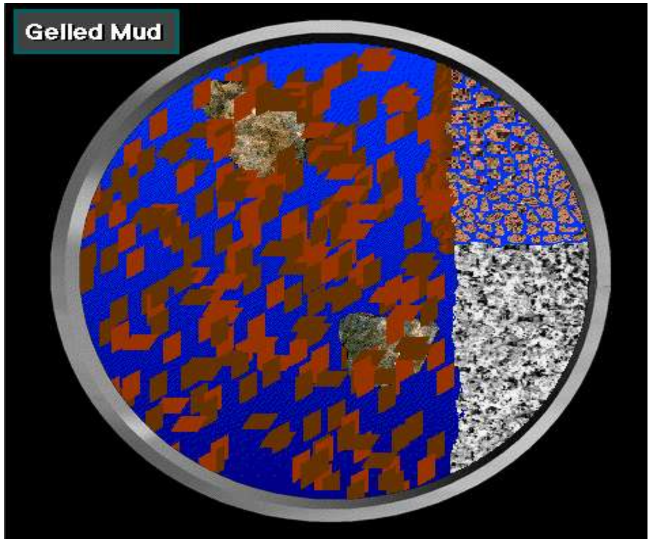
Gel strength

<u>Gel strength (Gel)</u>

The gel strength of a mud is a measure of the shearing stress necessary to initiate a finite rate of shear.

With proper gel strength can help suspend solids in the hole and allow them to settle out on the surface, excessive gel strength can cause a number drilling problems.





Yield point (Yp)

is a measurement under flowing conditions of the forces in the mud which cause gel structure to develop when the mud is at res

Fluid Loss and Filter Cake

The filtration, water loss or wall building test is conducted with a filter press.

The rate at which filtrate will invade permeable zone and the thickness of the filter cake that will be deposited on the wall of the hole as filtration takes place are important keys to trouble-free drilling

Drilling Mud Problems

- Water flows
- CO_2 intrusions
- Contaminations.
- Cement / Lime Contamination.
- Sodium Chloride Contamination.
- Calcium / Magnesium Contamination.
- Carbonate / Bicarbonate Contamination.
- Hydrogen Sulphide (H_2S) Contamination..

Drilling hazards

The following are some of the most common hazards in drilling and can be overcome by proper control of the mud properties.

1.Salt section hole enlargement

Salt section can be eroded by the drilling fluid and causes hole enlargement. These enlargement will require larger mud volume to fill the system and in case of casing the hole, larger cement volume is required.

To avoid these problems a

salt saturated mud system is prepared

prior to drilling the salt bed.

2.Heaving shale problems

Areas with shale sections containing bentonite or other hydratable clays will continually absorb water, swell and slough into the hole.

Such beds are referred to as heaving shales and constitute a severe drilling hazard when encountered.

Pipe sticking, excessive solid buildup in the mud and hole bridging are typical problems.

Various treatments of the mud are sometimes successful, such as

Changing mud system to high calcium content by adding lime, gypsum etc which reduces the tendency of the mud to hydrate water sensitive clays.

- Increasing circulation rate for more rapid removal of particles.
- Increasing mud density for greater wall support
- Decreasing water loss mud
- Changing to oil emulsion mud
- Changing to oil-based mud.

3.Blowouts

Blowout is the most spectacular, expensive and highly feared hazard of drilling.

This occurs when encountered formation pressure exceed the mud column pressure which allows the formation fluids to blow out of the hole.

Mud density or the mud weight is the principal factor in controlling this hazard.

In drilling a blow out preventer (BOP) stack is always attached at the top of the conductor pipe. In case of a gas kick (a sign that may lead to a blow out) the BOP stack can close the annular space between the drilling pipe and the conductor pipe or casing or shut the whole hole (with a blind ram of the BOP).

4.Lost Circulation

Lost circulation means the loss of substantial amount of drilling mud to an encountered formation.

Lost circulation materials are commonly circulated in the mud system both as a cure and a continuous preventive.

These materials are the fibrous materials such as the hay, sawdust or padi husk and lamellated (flat and platy) materials such as mica, cellophane.