5) Acidity or Alkalinity (PH):

❑ pH Determination

- $pH = \log \frac{1}{[H^+]}$ or $[H^+] = 10^{-pH}$
- $[H^+]$ represents the hydrogen ion concentration in gram mols per litre
- In any aqueous solution the product $[H^+]$ $[OH^-]$ must remain constant.

$$[H^+] \times [OH^-] = 1.0 \times 10^{-14}$$

- An increase in $[H^+]$ requires a corresponding decrease in $[OH^-]$ solution. When $[H^+] > [OH^-]$, the solution is said to be acidic, and when $[OH^-] > [H^+]$, it is said to be alkaline.
- A pH 7 is neutral, $[H^+] = [OH^-] = 1.0 \times 10^{-7}$ mol/L

(0 – 7) PH Acidic, (8 -14) pH Alkalinity (drilling fluids)

Importance

1) As an indicator for controlling corrosion (PH > 7).
2) Controlling solubility of Calcium Ions (At high PH Low solubility of Ca, which suitable for drilling carbonates formations).
3) Clay dispersion is good when PH (8-11), flocculation of clay occur when PH< 8 or PH > 11.

➢ **The Principal Functions of the Drilling Fluid**

The principal functions of the drilling fluid are:

1. Subsurface pressure control
2. Cuttings removal and transport
3. Suspension of solid particles
4. Sealing of permeable formations

5. Stabilizing the wellbore
6. Preventing formation damage
7. Cooling and lubricating the bit and drill string
8. Transmitting hydraulic horsepower to the bit
9. Facilitating the collection of formation data
10. Partial support of drill string and casing weights
11. Controlling corrosion
12. Assisting in cementing and completion

1. Subsurface pressure control

A column of drilling fluid exerts a hydrostatic pressure that, in field units, is equal to

$P = 0.052 \times \rho_m \times TVD$

Where:

P: Hydrostatic pressure of fluid column in wellbore, psi;

ρ_m: Mud weight in pounds per gallon (ppg)

TVD: True Vertical Depth, ft - during normal drilling operations, this corresponds to the height of the fluid column in the wellbore.

2. Cuttings Removal and Transport

Circulation of the drilling fluid causes cuttings to rise from the bottom of the hole to the surface. Efficient cuttings removal requires circulating rates that are sufficient to override the force of gravity acting upon the cuttings. Other factors affecting the cuttings removal include **drilling fluid density and rheology, annular velocity, hole angle, and cuttings-slip velocity.**

Velocity - Increasing annular velocity generally improves cuttings transport. Variables include pump output, borehole size and drill string size.

Density - Increasing mud density increases the carrying capacity through the buoyant effect on cuttings.

Viscosity - Increasing viscosity often improves cuttings removal.

Pipe Rotation - Rotation tends to throw cuttings into areas of high fluid velocity from low velocity areas next to the borehole wall and drill string.

Hole Angle - Increasing hole angle generally makes cuttings transport more difficult.

In most cases, the rig hydraulics program provides for an annular velocity sufficient to result in a net upward movement of the cuttings. Annular velocity is determined by the cross-sectional area of the annulus and the pump output.

3. Suspension of Solid Particles

When the rig's mud pumps are shut down and circulation is halted (e.g., during connections, trips or downtime), cuttings that have not been removed from the hole must be held in suspension. Otherwise, they will fall to the bottom (or, in highly deviated wells, to the low side) of the hole. The rate of fall of a particle through a column of drilling fluid depends on **the density of the particle and the fluid, the size of the particle, the viscosity of the fluid, and the thixotropic (gel-strength) properties of the fluid**. The controlled gelling of the fluid prevents the solid particles from settling, or at least reduces their rate of fall. High gel strengths also require higher pump pressure to break circulation. In some cases, it may be necessary to circulate for several hours before a trip in order to clean the hole of cuttings and to prevent fill in the bottom of the hole from occurring during a round trip.

4. Sealing of permeable formation

As the drill bit penetrates a permeable formation, the liquid portion of the drilling fluid filters into the formation and the solids form a relatively impermeable "cake" on the borehole wall. The quality of this filter cake governs the rate of filtrate loss to the formation. Drilling fluid systems should be designed to deposit a thin, low permeability filter cake on the formation to limit the invasion of mud filtrate. This improves wellbore stability and prevents a number of drilling and production problems. Potential problems related to thick filter cake and excessive filtration include **“tight” hole conditions, poor log quality, increased torque and drag, stuck pipe, lost circulation and formation damage.**

Bentonite is the best base material from which to build a tough, low-permeability filter cake. Polymers are also used for this purpose.

5. Stabilizing the Wellbore

The borehole walls are normally competent immediately after the bit penetrates a section. Wellbore stability is a complex balance of mechanical and chemical factors. The chemical composition and mud properties must combine to provide a stable wellbore until casing can be run and cemented. Regardless of the chemical composition of the fluid and other factors, the weight of the mud must be within the necessary range to balance the mechanical forces acting on the wellbore. The other cause of borehole instability is a chemical reaction between the drilling fluid and the formations drilled. In most cases, this instability is a result of water absorption by the shale. Inhibitive fluids (calcium, sodium, potassium, and oil-base fluids) aid in preventing formation swelling, but even more important is the placement of a quality filter cake on the walls to keep fluid invasion to a minimum.

6. Preventing Formation Damage

Any reduction in a producing formation's natural porosity or permeability is considered to be formation damage. If a large volume of drilling-fluid filtrate invades a formation, it may damage the formation and hinder hydrocarbon production.

There are several factors to consider when selecting a drilling fluid:

- Fluid compatibility with the producing reservoir
- Presence of hydratable or swelling formation clays
- Fractured formations
- The possible reduction of permeability by invasion of nonacid soluble materials into the formation.

7. Cooling and Lubricating the Bit

Friction at the bit, and between the drillstring and wellbore, generates a considerable amount of heat. The circulating drilling fluid transports the heat away from these frictional sites by absorbing it into the liquid phase of the fluid and carrying it away.

The laying down of a thin wall of "mud cake" on the wellbore aids in reducing torque and drag. The amount of lubrication provided by a drilling fluid varies widely and depends on the type and quantity of drill solids and weight material, and also on the chemical composition of the system as expressed in terms of pH, salinity and hardness. Indications of poor lubrication are high torque and drag, abnormal wear, and heat checking of drillstring components.

8. Transmitting Hydraulic Horsepower to the Bit

During circulation, the rate of fluid flow should be regulated so that the mud pumps deliver the optimal amount of hydraulic energy to clean the hole ahead of the bit. Hydraulic energy also provides power for mud motors to rotate the bit and for Measurement While Drilling (MWD) and Logging While Drilling (LWD) tools. Hydraulics programs are based on sizing the bit nozzles to maximize the hydraulic horsepower or impact force imparted to the bottom of the well.

9. Facilitating the Collection of Formation Data

The drilling fluid program and formation evaluation program are closely related. As drilling proceeds, for example, mud loggers monitor mud returns and drilled cuttings for signs of oil and gas. They examine the cuttings for mineral composition, paleontology and visual signs of hydrocarbons. This information is recorded on a mud log that shows lithology, penetration rate, gas detection and oil-stained cuttings, plus other important geological and drilling parameters. Measurement-While-Drilling (MWD) and Logging-While-Drilling (LWD) procedures are likewise influenced by the mud program, as is the selection of wireline logging tools for post-drilling evaluation.

10.Partial support of Drill String and Casing Weights

With average well depths increasing, the weight supported by the surface wellhead equipment is becoming an increasingly crucial factor in drilling. Both drillpipe and casing are buoyed by a force equal to the weight of the drilling fluid that they displace. When the drilling fluid density is increased, the total weight supported by the surface equipment is reduced considerably.

The equation below gives the buoyancy factor for steel.

$$\mathbf{BF} = \frac{(65.4 - \mathbf{MW\ (ppg)})}{65.4} \quad \text{-----} \quad \mathbf{(42)}$$

Where:

BF= Buoyancy Factor

Multiply the buoyancy factor by the tubular's air weight to obtain the buoyed weight (hook load). For example, a drillstring with an air weight of 250000 lb will show a hook load of 218000 lb in an 8.33 lb/gal fluid and 192700 lb in a 15 lb/gal fluid.

11.Control corrosion (in acceptable level)

- Drill-string and casing if continuous contact with drilling fluid may cause form of corrosion.
- Dissolved gases (oxygen, carbon dioxide, hydrogen sulfide) cause serious corrosions problems;
    - cause rapid, catastrophic failure
    - deadly to human after short period of time
    - Low pH (acidic) aggravates corrosion, so use corrosion coupons to monitor corrosion type, rates and to tell correct chemical inhibitor is used in correct amount.
    - Mud aeration, foaming and other O_2 trapped conditions cause corrosion damage in short period time.
    - When drilling in high H_2S, elevated the pH fluids + sulfide scavenging chemical (zinc).

12.Assistance in Cementing and Completion

The drilling fluid must produce a wellbore into which casing can be run and cemented effectively, and which does not impede completion operations. During casing runs, the mud must remain fluid and minimize pressure surges so that fracture-induced lost circulation does not occur. The mud should have a thin, slick filter cake. To cement casing properly, the mud must be completely displaced by the spacers, flushes and cement. Effective mud displacement requires that the hole be near-gauge and that the mud have low viscosity and low, non-progressive gel strengths. Completion operations such as perforating and gravel packing also require a near-gauge wellbore and may be affected by mud characteristics.