PeE3321- L5

Drilling fluids 2

Drilling fluids

1. The fluid circulation system
2. Types of mud
3. Functions of drilling fluids
4. Rheological properties of drilling mud

Was Covered last lecture

5. Weight of drilling mud
6. Drilling mud additives
7. Selection of drilling mud additives

Will be covered today

Covered in Lecture 5

Concepts

- Be able to calculate mud weight
- Be informed about main types of drilling mud additives
- Know how to design a water based drilling fluid

Calculations

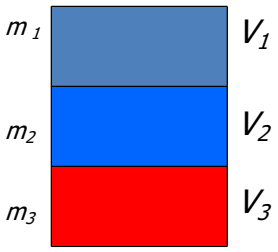
- Drilling fluid density with "ideal mixing"
- Density of drilling fluid when final mud weight is not limited
- Density of drilling fluid for a fixed final volume
- Mud additives

Density of Drilling Mud

Assume perfect mixing. (This will not be correct for chemical additives that will dissolve in the water.)

$$\rho_{mud} = \frac{m_1 + m_2 + m_3}{V_1 + V_2 + V_3}$$

Calculates density of mud



Volume of Drilling Mud

$V_2 = V_1 + V_b = V_1 + \frac{m_b}{\rho_b}$

New mudweight (V_2) from an original mud (V_1) with added weight material (V_b)
m_b is mass of weight material ρ_b is density of weight material

$\rho_2 V_2 = \rho_1 V_1 + m_b$

ρ_2 is density of V_2 and ρ_1 is density of V_1

$V_2 = V_1 * \frac{\rho_b - \rho_1}{\rho_b - \rho_2}$

Density of mud when final volume is not limited

$m_b = (V_2 - V_1)\rho_b$

$V_1 = V_2 * \frac{\rho_b - \rho_2}{\rho_b - \rho_1}$

Density of mud when final volume *is* limited

$m_b = (V_2 - V_1)\rho_b$

Mud additives is material added to a drilling fluid to perform one or more specific functions

Additive	Examples	Purpose
Base fluids	Oil/diesel/synthetics Water/brine Air and gas	The continuous fluid phase in mud where all additives and cutting must be suspended in.
Viscosifiers	Bentonite clay polymers	To change viscous properties like yield point and plastic viscosity for drilling mud.
Weight material	Barite Hematite Calcium Carbonate	A high-specific gravity and finely divided solid material which can produce mud weights from 9 ppg to 19 ppg. used to increase density of a drilling mud. (Dissolved salts that increase fluid density are not called weighting materials.) Barite is the most common, with minimum specific gravity of **4.20** g/cm3. Hematite is a more dense material, with minimum specific gravity of **5.05** g/cm3. Calcium carbonate, specific gravity **2.7 to 2.8**, is considered weighting material but is used more for its acid solubility than for density. Ilmenite, specific gravity of **4.6** has been used in drilling mud and cement.
pH control	Caustic soda (NaOH) Calcium hydroxide Ca(OH)2	PH control in water based muds. High pH prevents tool corrosion and chemical wellbore stability problems.

Mud additives

Additive	Examples	Purpose
Thinners	Calcium hydroxide $Ca(OH)_2$ Caustic soda (NaOH) SAPP (Sodium acid phyrophosphate	Deflocculate the mud. Cancel out the positive and negative charges on clay particles. Will reduce unwanted high viscosity due to flocculation of clay.
Fluid loss control material	Starch Synthetic polymers Guar gum PAC- cellulose based polymers	The leakage of the liquid phase of drilling fluid, slurry or treatment fluid containing solid particles into the formation matrix. The resulting buildup of solid material or filtercake may be undesirable, as may the penetration of filtrate through the formation. Fluid-loss additives are used to control the process and avoid potential reservoir damage.
Shale control materials	PAC- cellulose based polymers	A mud additives that slows or stops hydration, swelling and disintegration of shales.
Lubricant	PAC- cellulose based polymers	Lubricate tools and pipes.

Example # 1

- It is desired to increase the density of 200 bbl of 11 ppg mud to 11.5 ppg. Using barite (density 4.2 g/cc x 8.347 = 35 ppg).

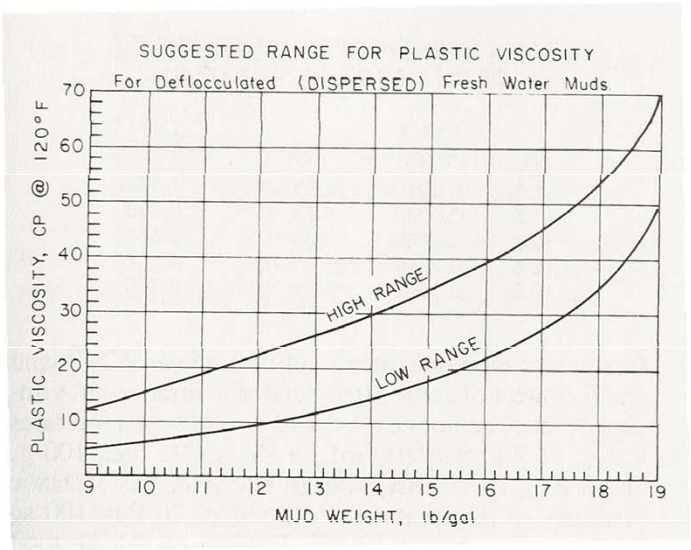
$$V_2 = V_1 * \frac{\rho_b - \rho_1}{\rho_b - \rho_2}$$

$$m_b = (V_2 - V_1)\rho_b$$

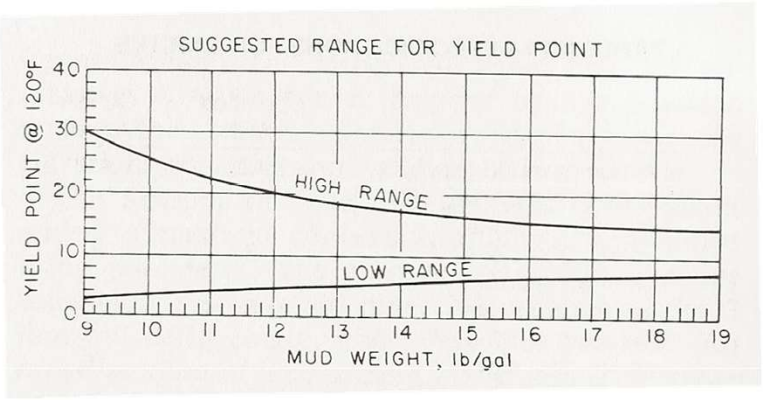
Mixing mud

Step 1	**Start with calculating desired volume of mud (total of the open hole at TD)**
Step 2	**Add needed chemical additives**
Step 3	**Include Viscosifiers**
Step 4	**Add weight material to desired mud weight**
Step 5	**Check that mud has acceptable YP and PV, and PH.**

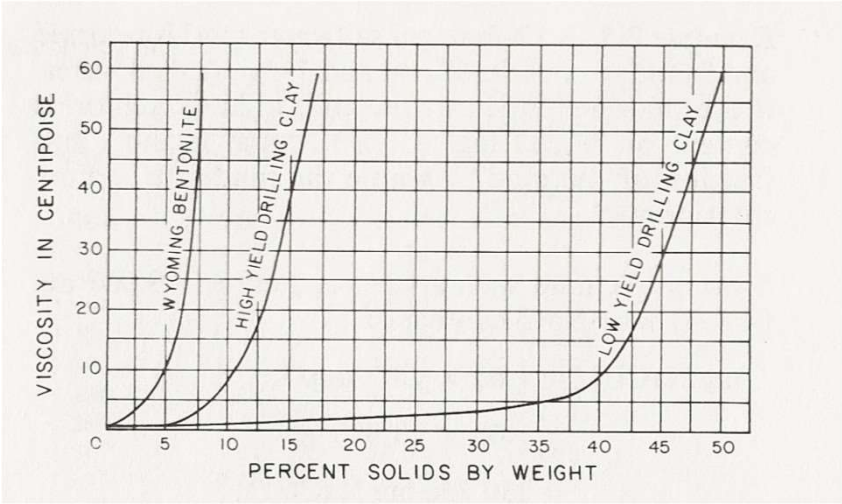
Effect of clay concentration on viscosity of fresh water



Typical range of acceptable yield points for clay/water muds

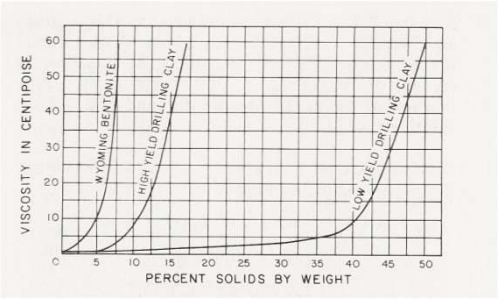


Effect of clay concentration on viscosity of fresh water



Example # 2

Use the graph to select the density of a mud having an apparent viscosity of 20 cp for each of the three clays shown.



Measuring properties of a drilling mud

Property	Apparatus	Purpose
Density	Mud balance	Calibrate with fresh water
Viscosity	Marsh funnel	Funnel viscosity (ROT, 1:4 10 ppg : 40 FV)
	Rheometer/Viscometer	Measure plastic viscosity (ROT; 1:2 1 ppg : 2 PV) Measure gel strength
	Heat cup	Measure viscosity at bottom hole temperatures
Fluid loss and mud cake thickness	Filter press	(ROT 5-10 cc of water during 30 minute test) Thickness of mudcake 1/32-2/32 inch preferred. Thicker than 3/32 inch indicate potential for stuck pipe.
Sand content	Sand content kit	Report % sand which is important for pump and valve wear.
Amount of solids	Retort	Gives % of solids
Bentonite content	Methylene Blue Capacity	Gives Bentonite content in lbs/bbl
pH	pH meter	Mud pH >7 but below 9.2 for wellbore stability and formation damage
Alkalinity chlorides calcium hardness	titration	Amount of caustic, KOH, lime etc in mud Determine salinity levels Determine hardness = calcium and magnesium