



Drilling Fluid Properties

The Language of Drilling Fluids

2020 Basic Drilling Fluids Workshop

Houston, TX

Fluid properties are the language of drilling fluids

- Drilling Fluid Properties describe the fluid
- Drilling Fluid Properties tell us if the fluid is performing its functions
 - The properties tell us if the fluid is working for us or against us
- Understanding properties allows:
 - Building desirable fluid properties initially
 - Maintaining desirable fluid properties during use



Drilling Fluid Properties

- Viscosity
- Rheology
- Density
- Sand Content
- Filtration
- Calcium Hardness
- pH



Viscosity

- Thickness of the fluid
 - The only property we can see
- Defined as the fluids “Resistance to flow”
- Measured with a Marsh Funnel Viscometer
- Measured with a Rheometer
- Why?
 - Relates to hole cleaning, cuttings removal, borehole stability and pumping pressures



Marsh Funnel Viscosity

Marsh Funnel and Cup



- Field measurement of the thickness of a fluid
- Reported in seconds per quart or seconds per liter

Marsh Funnel Reference Viscosity

Viscosity of water at 20°C (68° F)

26 sec/qt

or

27 sec/liter



Marsh Funnel Viscosity

- Varies greatly, generally 30 to 75 seconds per quart
- Lower viscosity is desirable while maintaining suspension and gel strength
- Higher viscosities contribute to higher pumping pressures



Rheology

- Rheology is the study of how matter deforms and flows.
 - It is primarily concerned with the relationship of shear stress and shear rate and the impact these have on flow characteristics inside tubulars and annular spaces.
- Shear rate – pump volume, and shear stress – pump pressure, really describe Viscosity – resistance to flowing when a force is applied
- Rheology is the science of viscosity
- Measured with a Rheometer
- Tells us what actually creates the viscosity we see



fann® Rheometers

Model 280 Field Rheometer



Model 35A Lab Viscometer



Rheological Properties

- Plastic Viscosity, PV
 - Determined by size, shape, and number of solids in the mud
 - Measured in centipoise
- Yield Point, YP
 - Measures the attractive forces between the particles in the mud
 - Measured in lb/100 ft²



Rheological Properties

- Gel Strengths
 - Measures the strength of the gelled structure of a drilling fluid while at rest
 - Measured at 10 seconds and 10 minutes
 - Reported in lb/100 ft²



Rheological Properties PV, YP and Gel Strengths

- Why?
 - PV and YP tells us what actually creates the viscosity we see
 - Yield point defines carrying ability when fluid is in motion
 - Gel strengths define suspension ability when fluid is static
 - Gel strengths indicate the relative force required to initiate fluid flow
 - PV and YP used for hydraulics and pressure loss equations



Density

- Mass per unit volume
 - Weight of the fluid
- Measured with a mud balance
- Why?
 - Used to calculate hydrostatic head
 - Used to calculate total solids content of the mud
 - Used to determine the efficiency of solids control equipment



Density

Mud Balance



- Reads in Pounds Per Gallon (lb/gal), Specific Gravity, Pounds per Cubic Foot, and PSI per 1000 Feet of Depth
 - Pounds per gallon (lb/gal) or Specific Gravity (SG) are the standard measurements for drilling applications

Density Reference

**Water has a weight of 8.34 lb/gal
or
a Specific Gravity of 1.0**

Calibrate Mud Balance With Water

Hydrostatic Head Calculation

$$\text{Hydrostatic Head (psi)} = \text{Fluid weight (lb/gal)} \times \text{depth (feet)} \times .052$$

$$\text{Example: } 10 \text{ lb/gal} \times 100 \text{ feet} \times .052 \\ = 52.0 \text{ PSI}$$



Solids Content Calculation

$$\% \text{ Solids}^* = (\text{Fluid Weight, lb/gal} - 8.3) \times 8$$

$$\% \text{ Solids} = (11.3 - 8.3) \times 8$$

$$3 \times 8 = 24\% \text{ Solids}$$

* by volume - assumes 2.6 S.G. solids



Density

- Desirable value - as low as possible



Sand Content

- Measures the sand sized particle content of the drilling fluid
 - Sand is a size and not a mineral for testing purposes
 - Sand size is defined as anything retained on a 200 mesh screen (greater than 74 microns)
- Measured with a Sand Content Test Kit
- Reported as % by volume
- Why?
 - Indicates the abrasive constituent of the drilling fluid
 - High sand content slows penetration rate
 - High sand content contaminates samples



Sand Content

Sand Content Test Kit



Sand Content

- Desirable values
 - As Low as Possible for all drilling applications
 - Less than or equal to 1% is preferred



Filtration Properties

Filtrate Volume and
Filter Cake Thickness

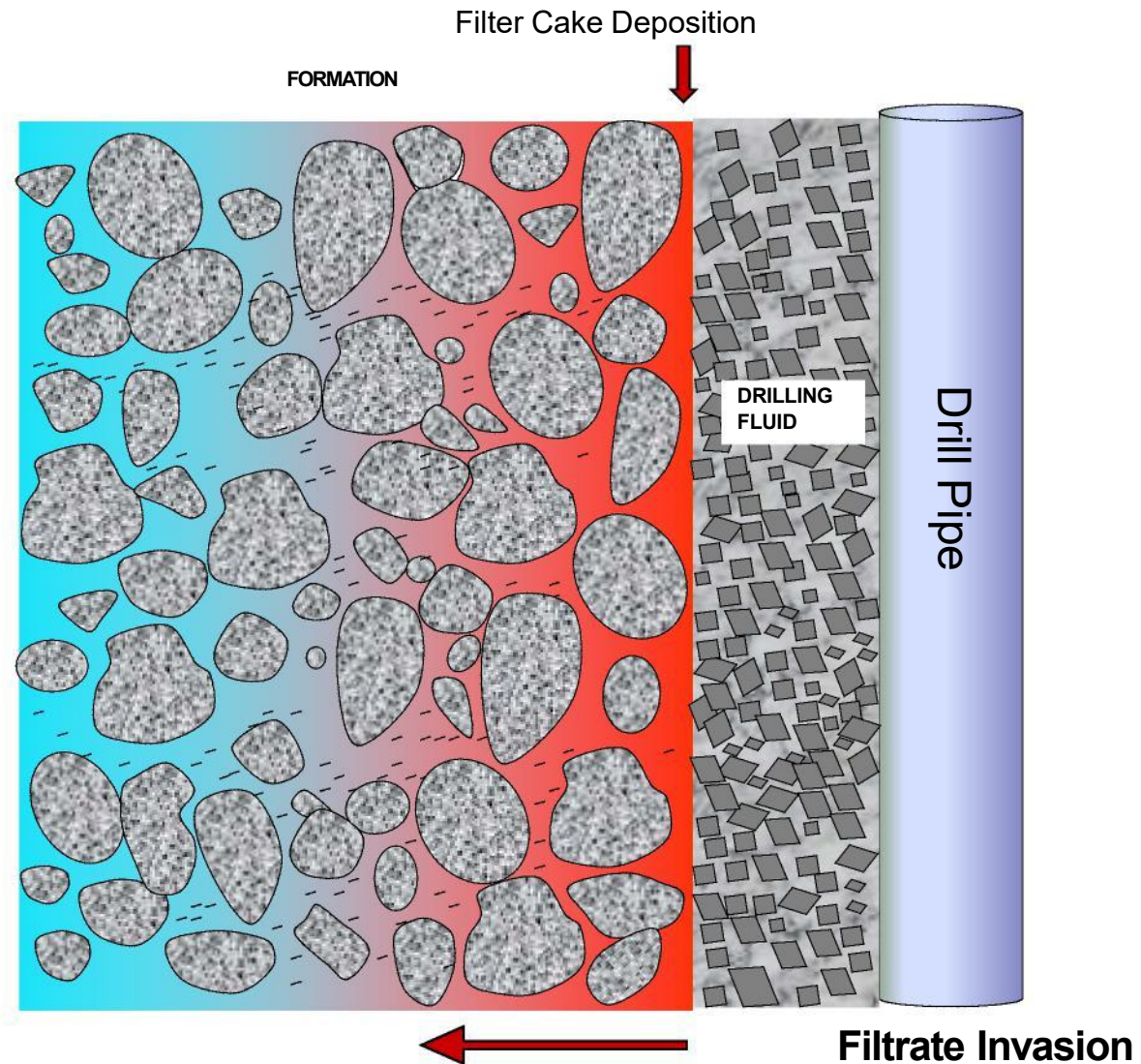


Filtration

- Measured with API Filter Press
- Filtrate reported in milliliters/30 minutes
- Filter Cake reported in 32nds of an inch or millimeters
- Why?
 - Wallcake building
 - Borehole stability
 - »Filtrate is the water phase of the drilling fluid available to react with the formation and drilled solids
 - Protect the formation and formation fluids
 - Sample integrity
 - Minimize stuck pipe



Mechanics of Filtration



Filtration

Filter Presses

Full Area



Half Area



Filter Cake Deposition & Thickness



Filter Cake Deposition & Thickness.



Filtration

- Low filtrate volumes generally denote tighter, firmer filter cakes
- Filtrate volume less than 15 milliliters / 30 minutes is desirable for most applications
- Filtercake less than 2/32 inch is recommended



Total Hardness / Calcium Hardness

- Measures the concentration of cations contributing to total hardness
- Check the hardness of the make up water and mud filtrate
- Measured with calcium indicator strips or titrations
- Reported in milligrams per liter calcium (mg/l)
- Why?
 - Retards hydration of bentonite and polymers
 - Indicates contaminants picked up while drilling



Hardness

Total Hardness Test Strips



Hardness.

**Calcium Levels As Low As Possible
Are Desirable
Less Than 100 mg/l is Recommended**



pH

- Indicates the Acidity or Alkalinity of a Fluid
 - A pH of 7 is neutral
 - Acidic environments range from 0 to less than 7
 - Alkaline environments range from greater than 7 to 14
- Check the pH of the make up water and mud filtrate
- Measured with pH strips, papers or meters
- Why?
 - Slightly alkaline is optimal for hydration of bentonite and polymers



Acid

10,000,000	pH = 0	Battery acid, Strong Hydrofluoric Acid
1,000,000	pH = 1	Hydrochloric acid secreted by stomach lining
100,000	pH = 2	Lemon Juice, Gastric Acid Vinegar
10,000	pH = 3	Grapefruit, Orange Juice, Soda
1,000	pH = 4	Tomato Juice Acid rain
100	pH = 5	Soft drinking water Black Coffee
10	pH = 6	Urine Saliva
1	pH = 7	"Pure" water

Alkaline

1	pH = 7	"Pure" water
1/10	pH = 8	Sea water
1/100	pH = 9	Baking soda
1/1,000	pH = 10	Great Salt Lake Milk of Magnesia
1/10,000	pH = 11	Ammonia solution
1/100,000	pH = 12	Soapy water
1/1,000,000	pH = 13	Bleaches Oven cleaner
1/10,000,000	pH = 14	Liquid drain cleaner

pH

Wide-Range pH Strips (0 To 14)



pH

**pH 8.5 – 9.5 is optimal
for hydration of bentonite and polymers**



Properties of Drilling Fluids

- Density
 - Mass/volume or fluid weight
- Viscosity
 - Resistance to flow
- Rheological Properties
 - Flow Properties; PV, YP, Gel strengths
- Filtration Properties
 - Filtrate volume and Filter cake thickness
 - Particles > 74 microns
 - Chemical analysis
- Sand Content
- pH & Calcium



Questions?

