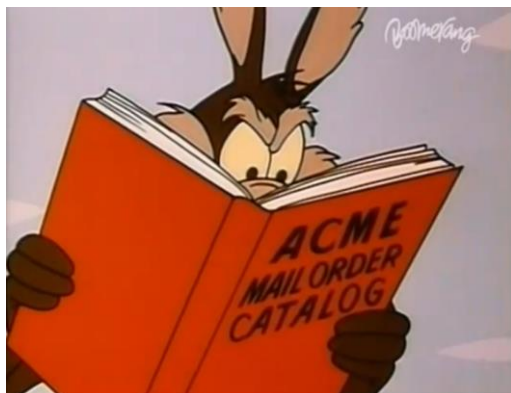


What is a Water Well

**water well** — an excavation that is drilled, cored, bored, washed, driven, dug, jetted, or otherwise constructed for the purposes of extracting groundwater, monitoring groundwater, using the geothermal properties of the earth, or injecting water into an aquifer or subsurface reservoir

definition from the  
**National Ground Water Association's**  
*Lexicon of Groundwater and Water Well System Terms*

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Construct the Well

- █ Excavate
- █ Set casing
- █ Gravel pack / open hole completion
- █ Seal the annular space
- █ Develop the well for production

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An **Excavation** Means A Hole In The Ground

- █ Drill a hole
  1. Create a cutting
  2. Clean the hole
  3. Stabilize the bore
  4. Protect the formation and formation fluids

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Excavate

1. Create a cutting

- What geology are we intersecting
  - Coarse soils
    - Sand, gravel, rock
  - Fine soils
    - Clay and shale
- What tooling do we use
- Drilling fluid additives
- Mud properties

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Excavate

2. Clean the hole

- Get the cuttings out of the way
- Cuttings size, annular velocity and fluid hydraulics

$$AV = Po \times \left( \frac{24.52}{(D_h^2 - D_p^2)} \right)$$

- Remove them from the mud
- Drilling fluid additives
- Mud properties

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Excavate

3. Stabilize the hole

- Geology
- Drilling fluid additives
- Mud properties

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Excavate

4. Protect the formation and formation fluids

- Don't contaminate the ground water
- Don't plug up the production zone
- Drilling practices
- Drilling fluid additives
- Mud properties

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Construction

- Set casing
- Filter pack
- Drilling practices
- Mud properties

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Seal The Annular Space

- Grout
  - Bentonite
  - Cement
- Effectiveness depends on the drilling phase

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### Develop

- Develop the well for production
  - Remove any impediments to production
  - Defined development program
  - Drilling practices
  - Drilling fluid additives
  - Mud properties

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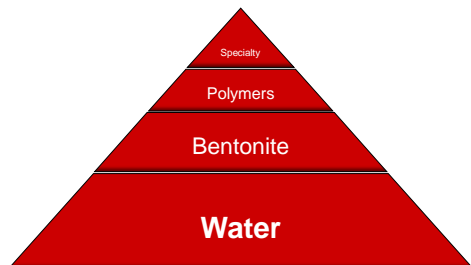
### Introduction To Drilling Fluids

- Drilling Fluids are part of the good drilling practices success formula
- What are Drilling Fluids?
- What do Drilling Fluids do?
- How do they do what they do?
- The understanding of drilling fluids starts with learning the language of drilling fluids – in other words the functions and properties of drilling fluids

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### What is Drilling Fluid?



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### What does a Drilling Fluid do? Functions of Drilling Fluids

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### Functions of a DRILLING FLUID

- ❖ Remove cuttings from the bit and transport them to the surface



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### Functions of a DRILLING FLUID

- ❖ Allow the cuttings to be removed at the surface



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Functions of a DRILLING FLUID

- ❖ Suspend cuttings when not circulating



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Functions of a DRILLING FLUID

- ❖ Stabilize and support the Wellbore

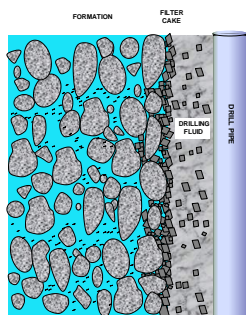


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Functions of a DRILLING FLUID

- ❖ Protect the formation and the formation fluids



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Functions of a DRILLING FLUID

- ❖ Insure reliable geologic information



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Functions of a DRILLING FLUID

- ❖ Control subsurface pressures



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Functions of a DRILLING FLUID

- ❖ Cool and Lubricate the bit and drillstring

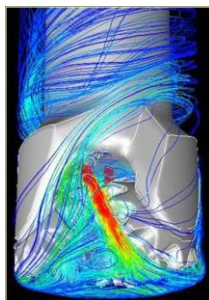
Friction  
=  
Heat

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Functions of a DRILLING FLUID

❖ Transmit hydraulic energy to the bit



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Functions of a DRILLING FLUID

❖ Maximize Wellbore Value



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How does a Drilling Fluid perform its functions?  
Properties of Drilling Fluids

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How Do We Know If a Drilling Fluid Can...

1. Remove cuttings from the bit and transport them to the surface
2. Allow the cuttings to be removed at the surface
3. Suspend cuttings when not circulating
4. Stabilize and support the Wellbore
5. Protect the formation and the formation fluids
6. Insure reliable geologic information
7. Control subsurface pressures
8. Cool and Lubricate the bit and drillstring
9. Transmit hydraulic energy to the bit
10. Maximize Wellbore Value

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Drilling Fluid Properties

- Fluid properties are the language of drilling fluids
- Drilling Fluid Properties tell us if the fluid is working for us or against us
  - They tell us if the fluid is performing its functions
- Allows
  - Building desirable fluid properties initially
  - Maintaining desirable fluid properties during use

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Drilling Fluid Properties

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

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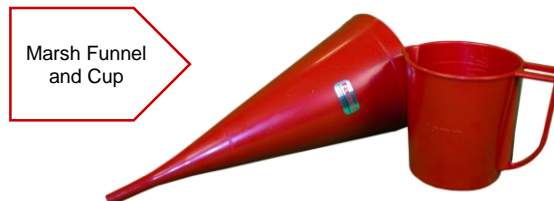
## Viscosity

- Defined as the fluids "Resistance to flow"
- Thickness of the fluid
- Measured with a Marsh Funnel Viscometer
- Measured with a Rheometer
- Why?
  - Relates to hole cleaning, cuttings settling, borehole stability and pumping pressures

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## Marsh Funnel Viscosity



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

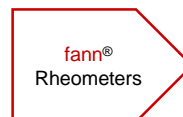
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## Rheology

- 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

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Model 35A Lab Viscometer



Model 280 Field Rheometer



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## Rheological Properties

- Plastic Viscosity, PV
  - Determined by size, shape, and number of solids in the mud
  - Measured in centipoise
- Yield Point, YP
  - Measures the forces between the particles in the mud
  - Relates to the carrying capacity of the fluid in motion
  - Measured in lb/100 ft<sup>2</sup>

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## Rheological Properties PV and YP

- Why?
  - Tells us what actually creates the viscosity we see
  - Yield point defines carrying ability when fluid is in motion
  - Provides data for hydraulics and pressure loss equations

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### 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 ft<sup>2</sup>

#### Why?

- Gel strengths define suspension ability when fluid is static
- Indicates relative force required to initiate fluid flow

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### Density

#### Mass per unit volume

- Weight of the fluid

#### Measured with a mud balance

#### Why?

- Used to calculate total solids content of the mud
- Used to calculate hydrostatic head
- Used to determine the efficiency of solids control equipment

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### 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

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### 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

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### Sand Content

Sand Content Test Kit

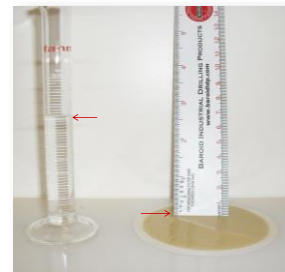


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### Filtration Properties

Filtrate Volume and Filter Cake Thickness



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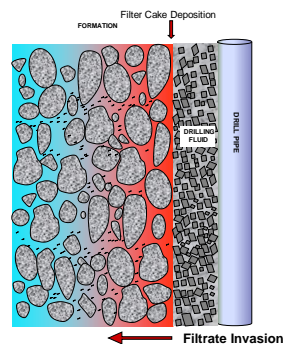
### Filtration

- 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

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### Mechanics of Filtration



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### Total Hardness / Calcium Hardness

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

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### Hardness

Total Hardness Test Strips



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### 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

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### pH

Wide-Range pH Strips (0 To 14)



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### 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
- Sand Content            ➤ Particles > 74 microns
- pH & Calcium          ➤ Chemical analysis

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### Water As Your Drilling Fluid?

- Water by itself does NOT perform any of the drilling fluid functions well
- Water may CAUSE drilling problems

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### Are You Expecting This?



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HALLIBURTON