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 20ºC (68º 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 ft^2

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^2

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

Hydrostatic Head (psi) =

Fluid weight (lb/gal) x depth (feet) x .052

Example:10 lb/gal x 100 feet x .052

= 52.0 PSI

Solids Content Calculation

% Solids* = (Fluid Weight, lb/gal - 8.3) X 8

% Solids = (11.3 - 8.3) X 8

3 X 8 = 24% Solids

* by volume - assumes 2.6 S.G. solids

Density

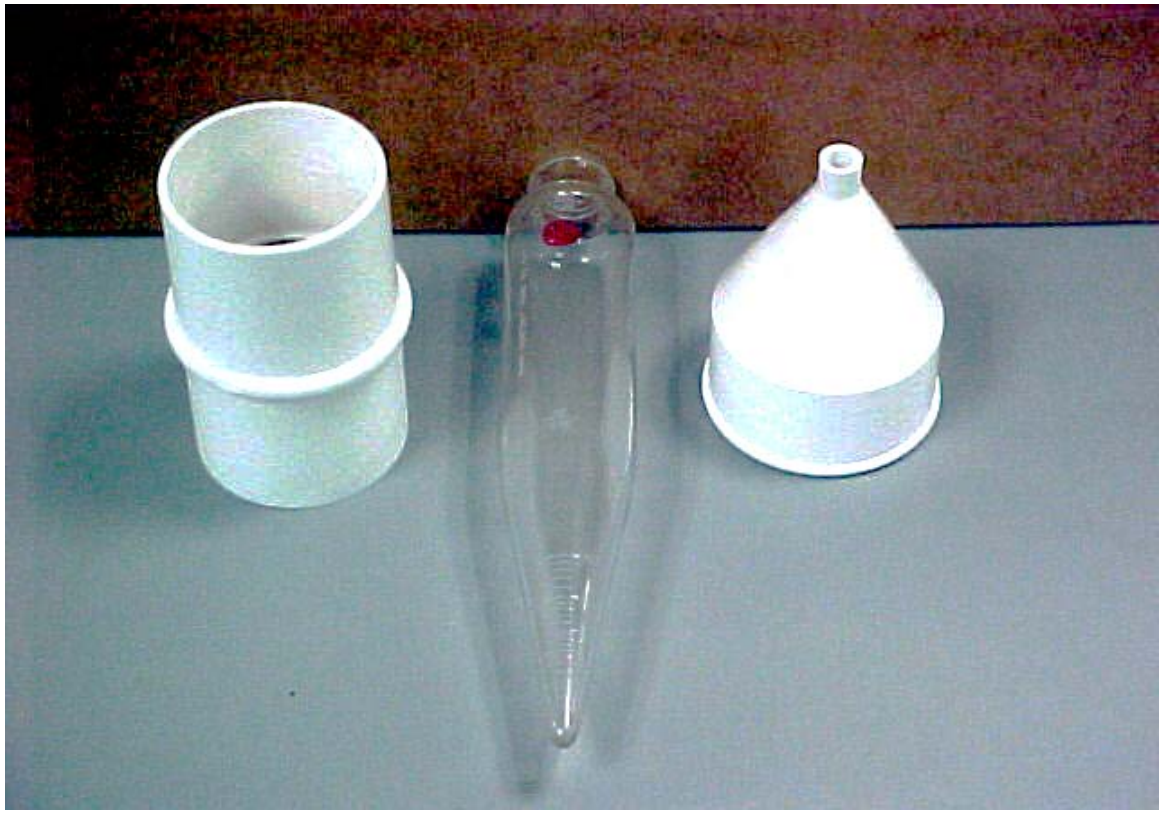
- Desirable value - as low as possible

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

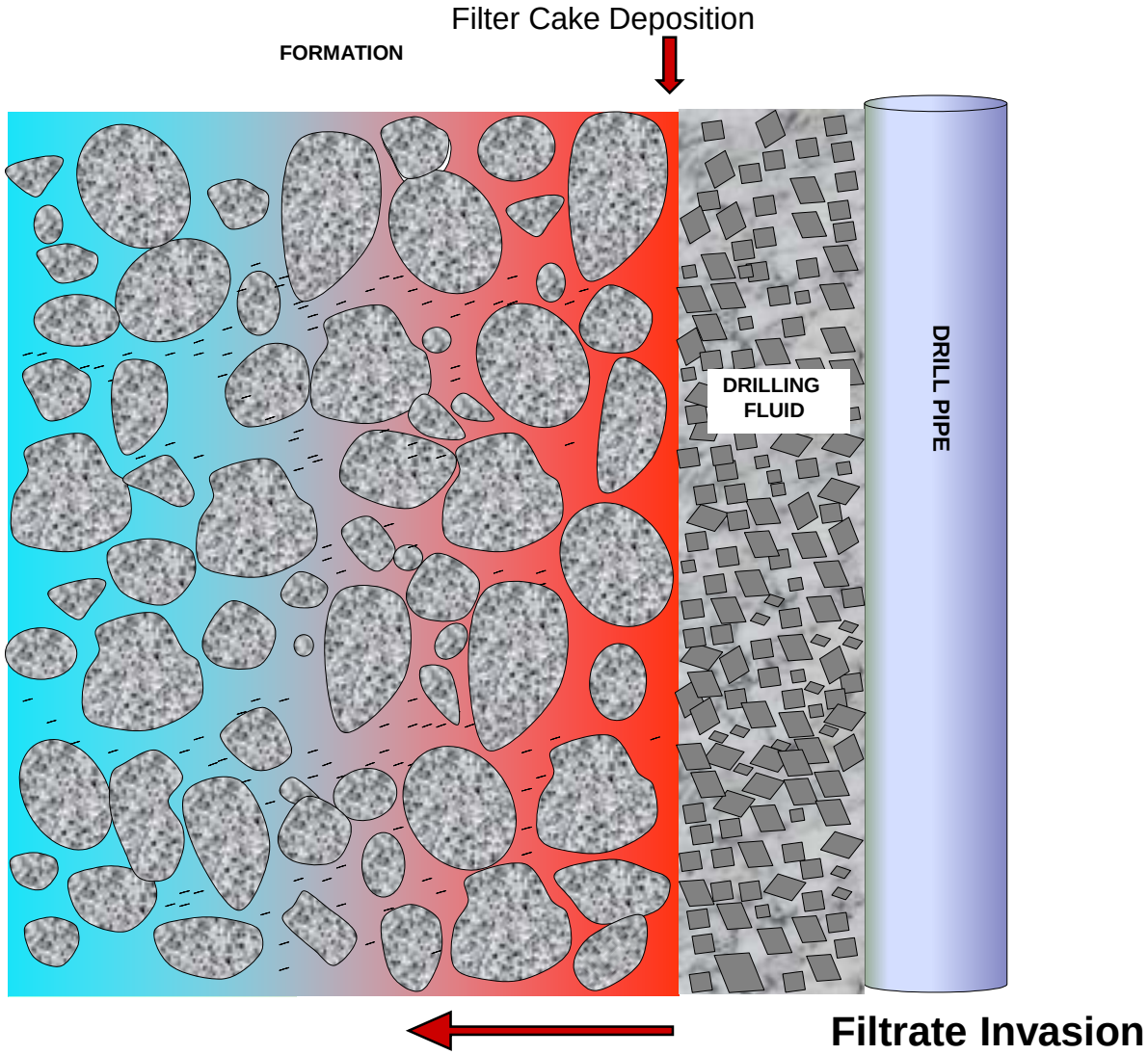
Filtration Properties

Filtrate Volume and
Filter Cake Thickness

Filtration

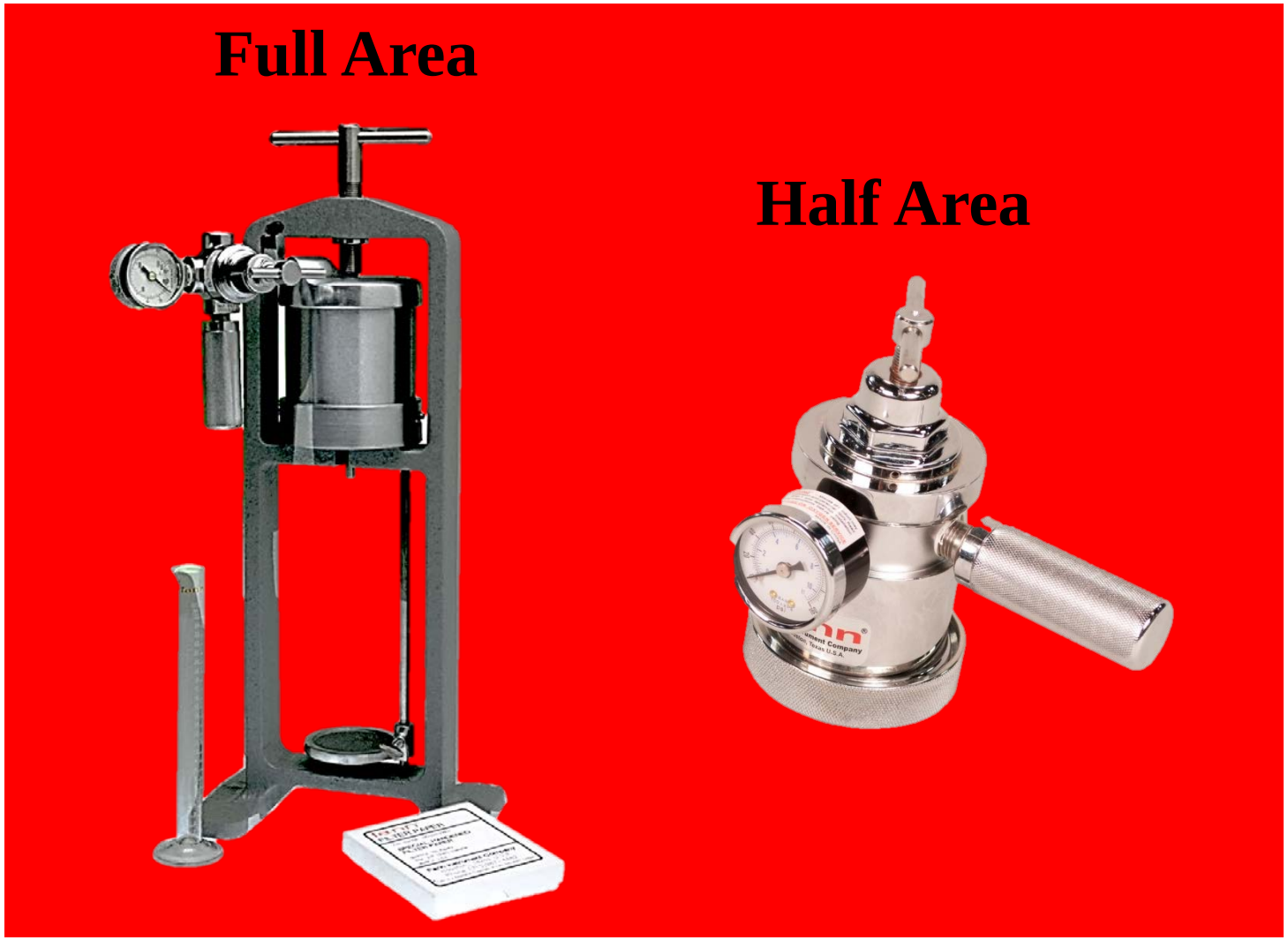
- Measured with API Filter Press
- Filtrate reported in milliliters/30 minutes
- Filter Cake reported in 32nds of an inch or millimeters
- Why?
  - Wallcake building
  - Borehole stability
    - » Filtrate is the water phase of the drilling fluid available to react with the formation and drilled solids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

Mechanics of Filtration

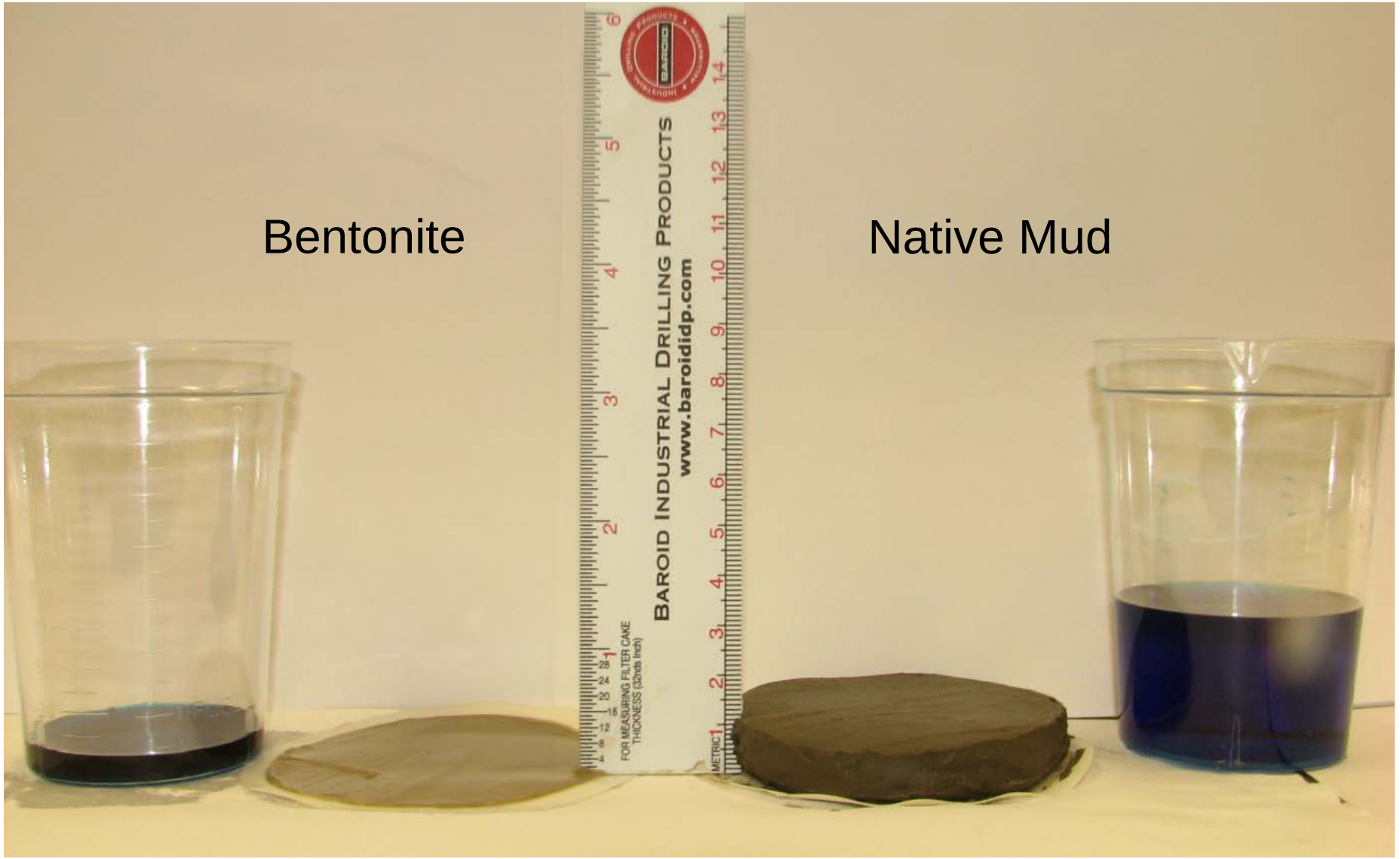


Filtration

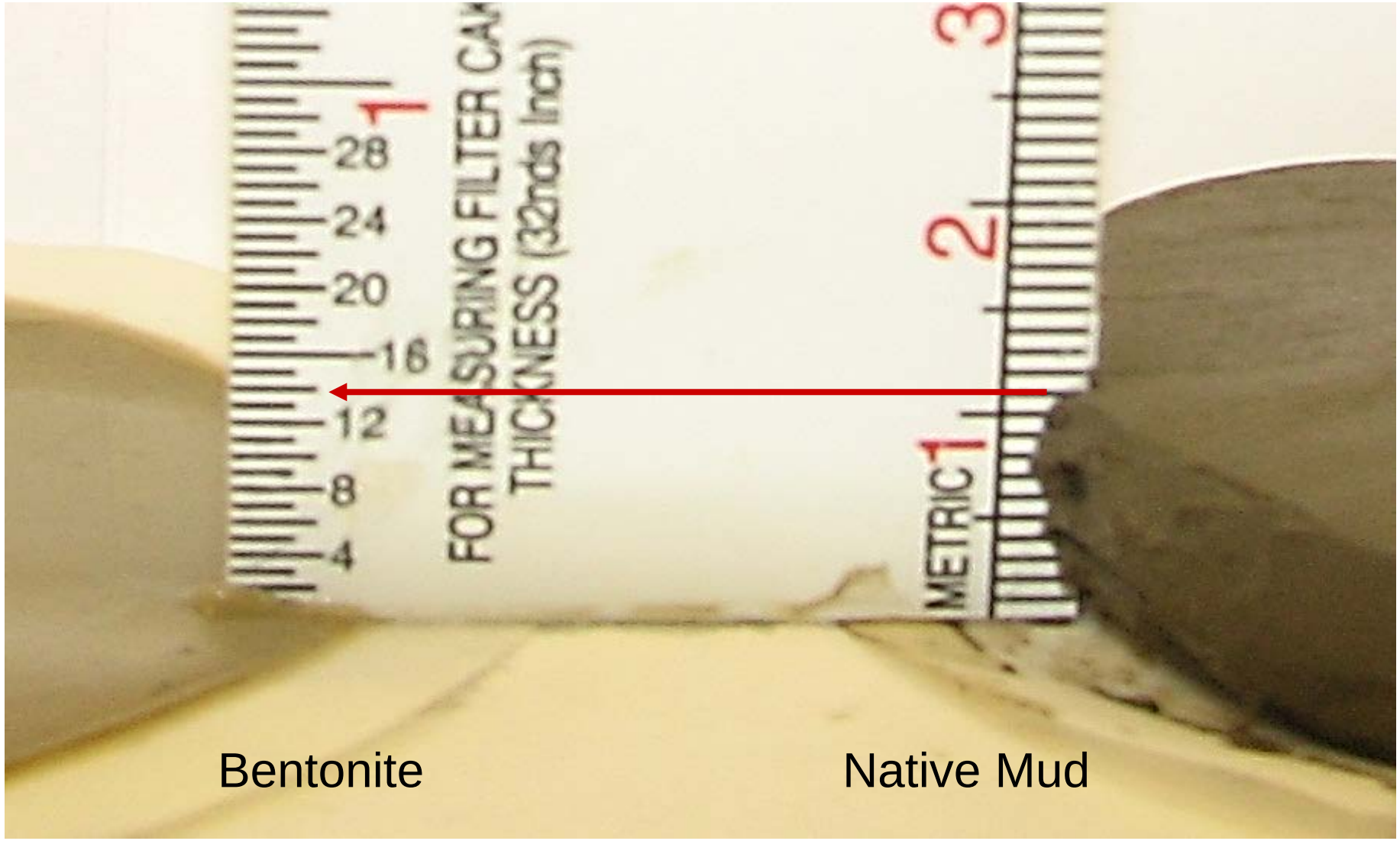
Filter Presses



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

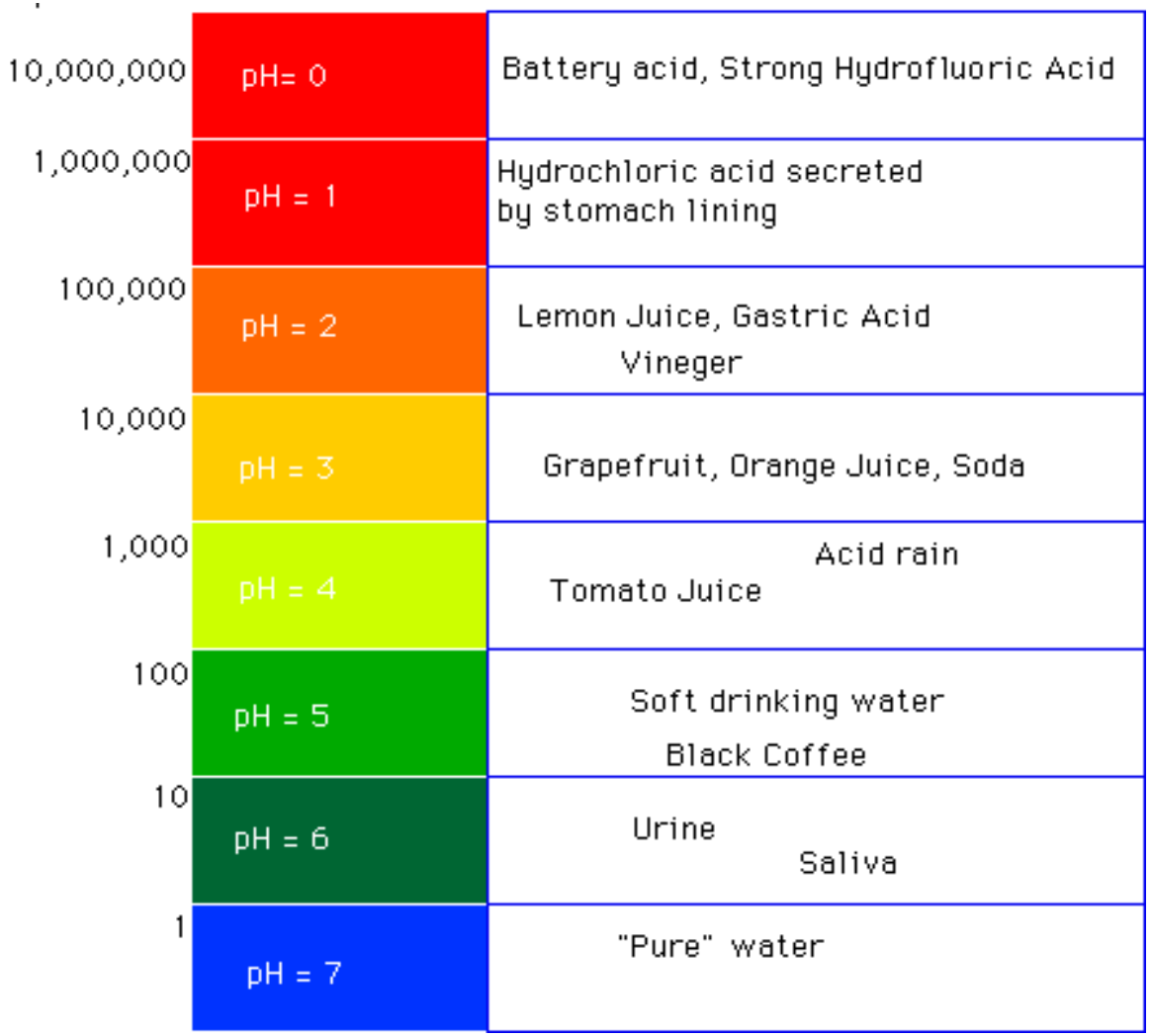
Are Desirable

Less Than 100 mg/l is Recommended

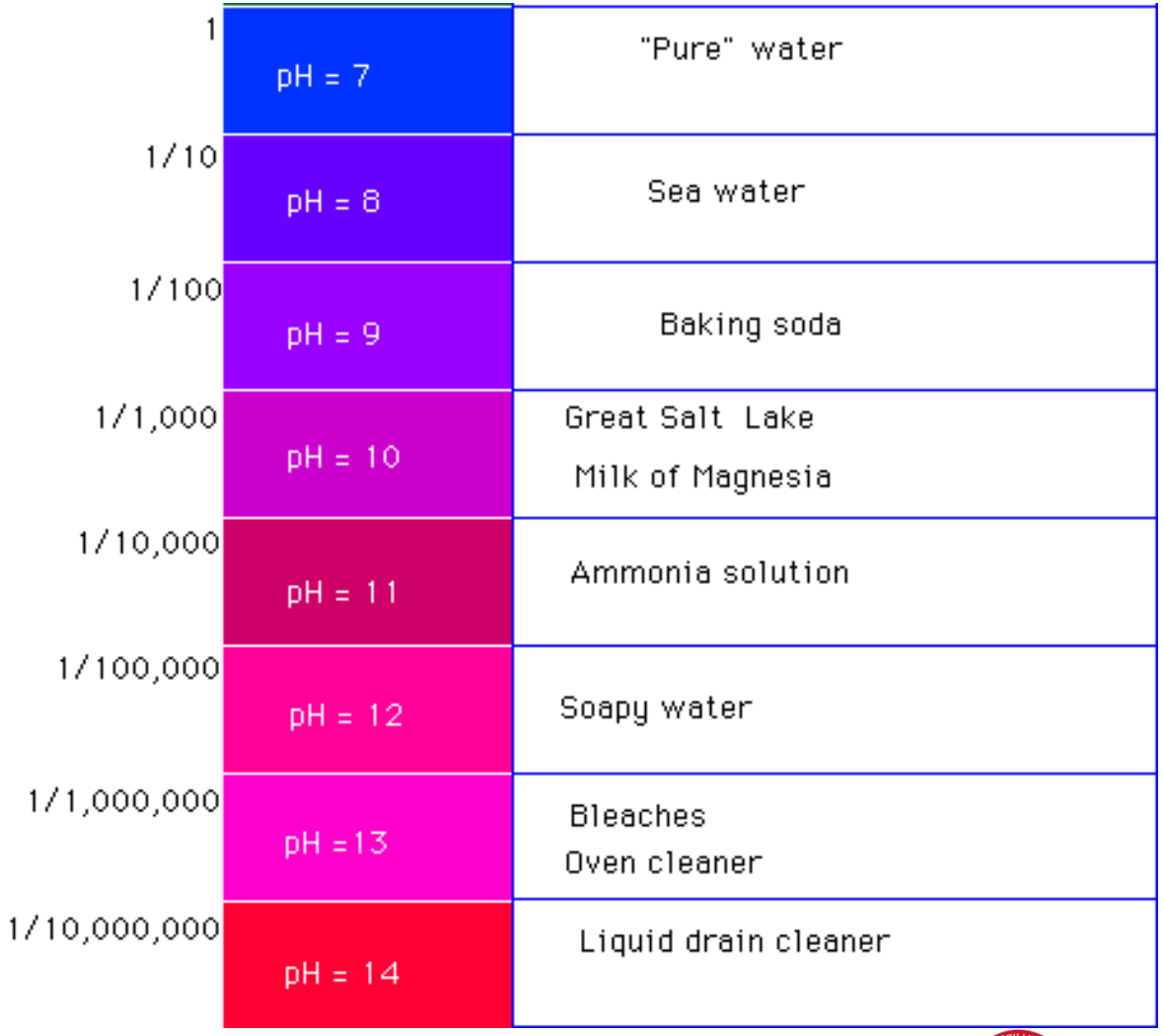
pH

- 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



Alkaline



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
- Viscosity
- Rheological Properties
- Filtration Properties
- Sand Content
- pH & Calcium

- Mass/volume or fluid weight
- Resistance to flow
- Flow Properties; PV, YP, Gel strengths
- Filtrate volume and Filter cake thickness
- Particles > 74 microns
- Chemical analysis

Questions?