The Impact Of Cementing On Proper Well Control

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Learning Objectives

- Explain the main reasons for cementing wells
- Explain the difference between primary and remedial cementing
- Describe slurry properties that must be controlled
- Describe slurry thickening time
- Identify API classes of cement commonly used
- Identify various cement additives and their function
- Discuss good cementing practices
- Explain the benefits of two floats and adequate shoe joint
- Describe methods of evaluating a cement job

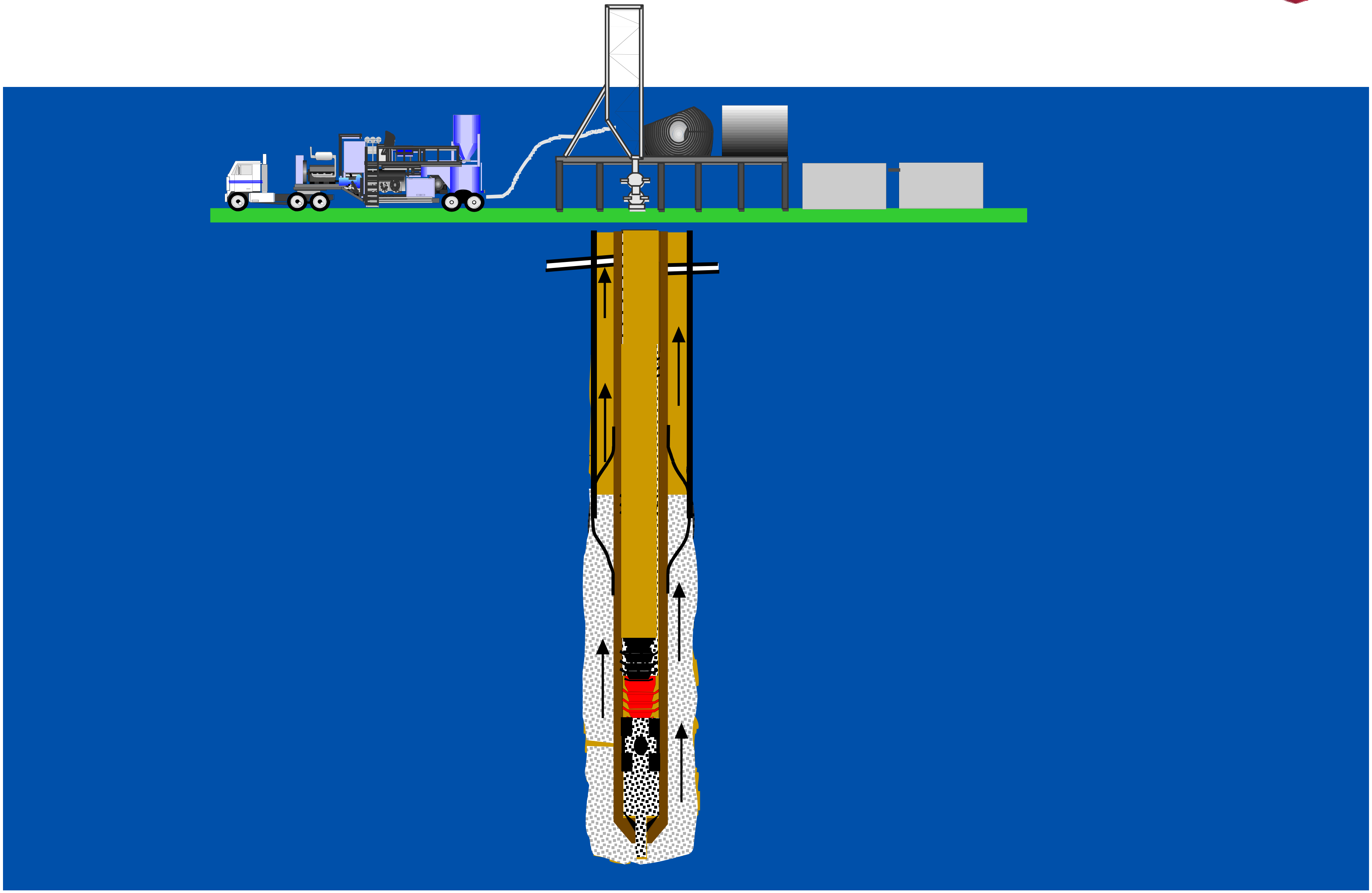
Reasons for Cementing

- Achieve Zonal Isolation
- Provide Casing Support
- Protect Casing

How Cement Jobs are Classified

- Primary Cementing: the technique of placing cement slurries in the annular space between the casing and the borehole.
- Primary Cementing *may* include:
  - Lead Cement - on top
  - Tail Cement - in bottom

Conventional Primary Cementing



Remedial Cementing

- Remedial Cementing: Is any process used to repair a primary cement job or which falls outside the definition of primary cementing

- Examples include:
  - Cement plugs
  - Squeeze cementing

Migration Paths in Cementing Annulus

"In the annulus, there are three possible paths for fluid movement; *the cement/ rock interface, the cement/ casing interface,* and the cement matrix"

-G. Di Lullo and P. Rae, IADC / SPE 62745

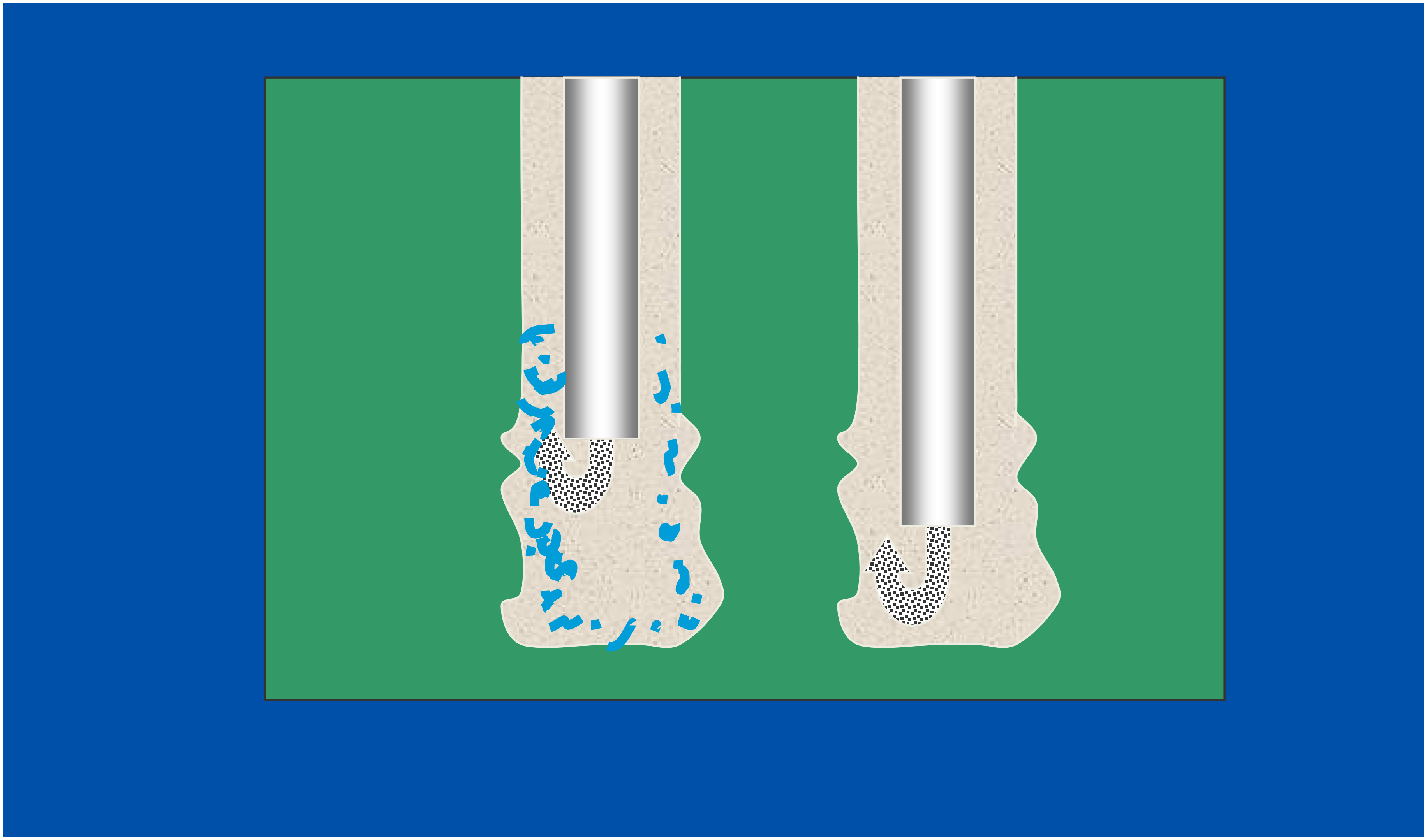
Contributing Factors for Good Cement Job

- Slurry design/ testing
- Mixing procedures
- Good mud removal technique
- Proper placement of cement slurry
- Field supervision

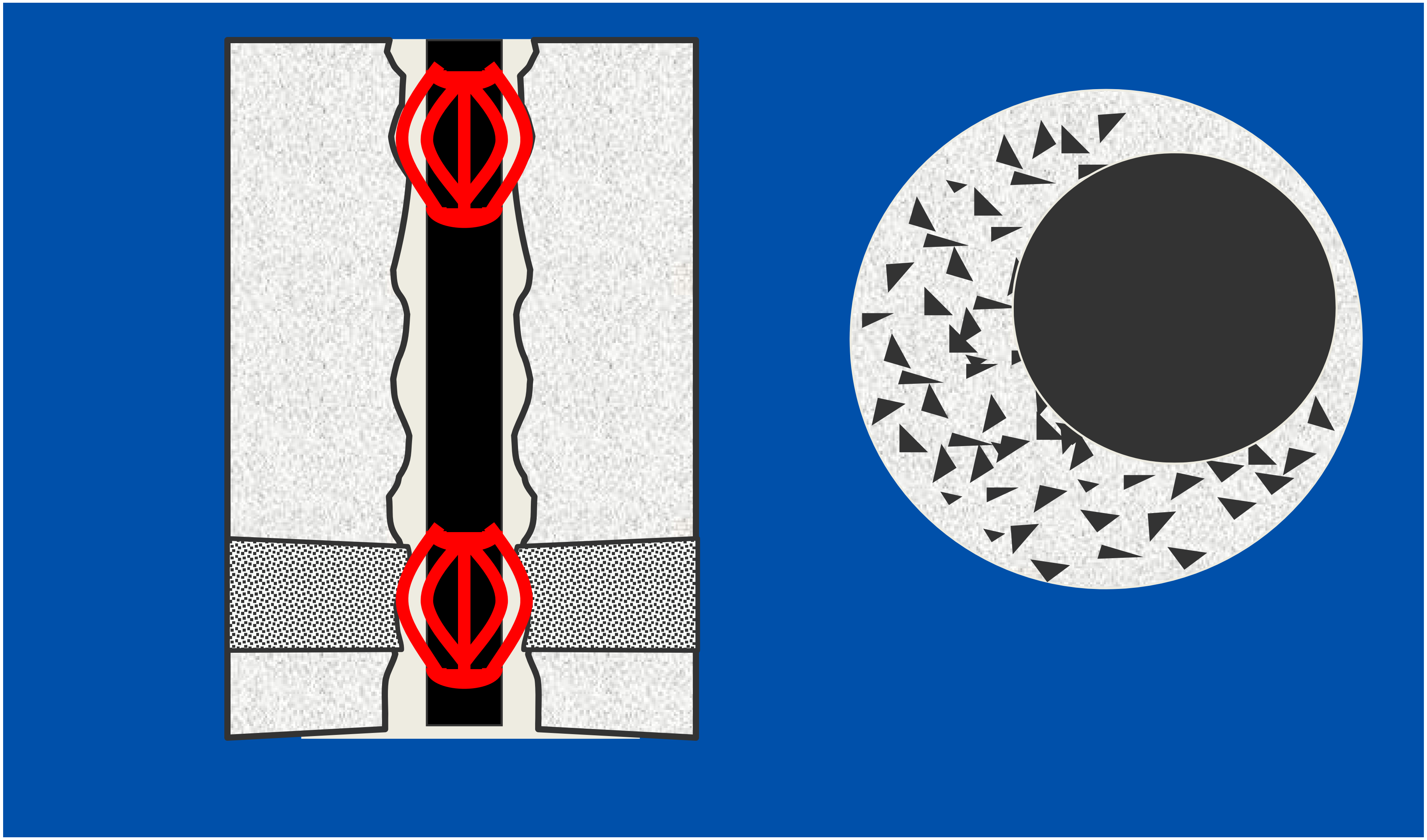
Hole Conditioning

- Condition mud to as low a yield point and gel strength as practical consistent with cuttings removal and suspension and hole stability
- Move casing during conditioning
- Condition until flowline and suction mud propertied have stabilized at optimum values
- Mud conditioning also cools the well

Casing Movement



Centralizers



Slurry Design

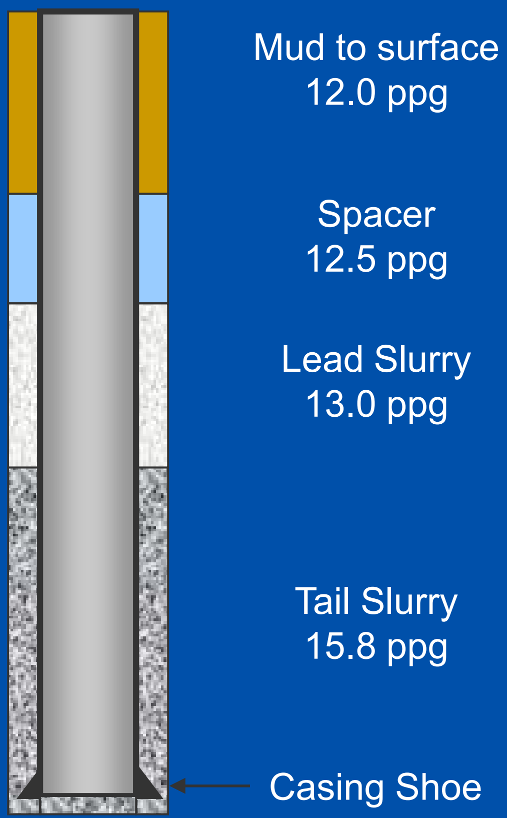
- Density
  - Solids/ Water ratio
- Thickening Time
- Fluid Loss
- Free Water
- Rheology
- Compressive Strength

- Gas Tight Slurry Design???
- Foamed Slurry Design??

- Future?
  - Tensile Strength
  - Young's Modulus
  - Poisson's Ratio

Slurry Density Hierarchy**

- Spacer at least one-half ppg heavier than mud
- Lead slurry at least one-half ppg heavier than the spacer
- Tail slurry always heavier than the lead slurry



Example

** When pumping “normal” circulation, not reverse circulation

Slurry Thickening Time

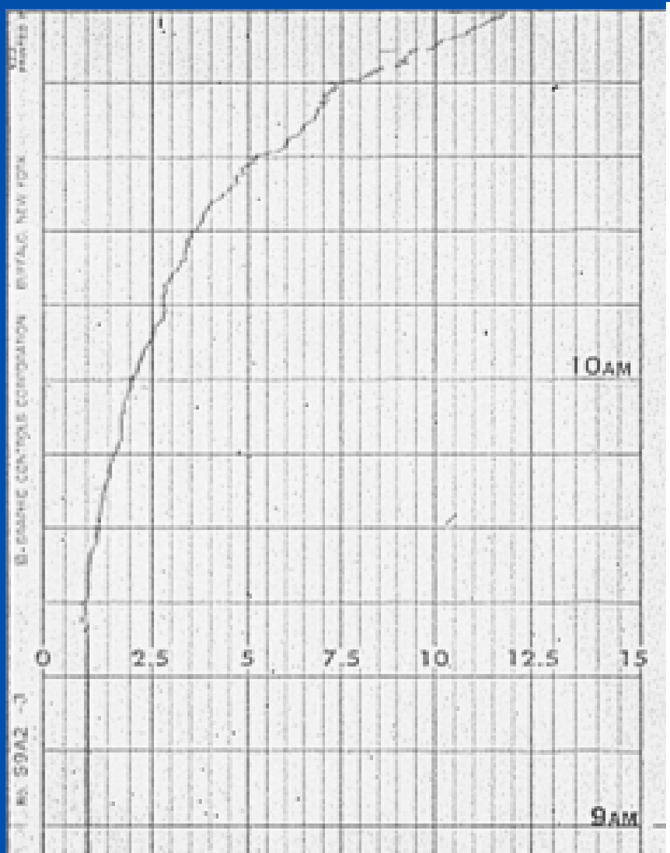
The time available to place a slurry before it becomes too thick to pump

Thickening Time Requirements

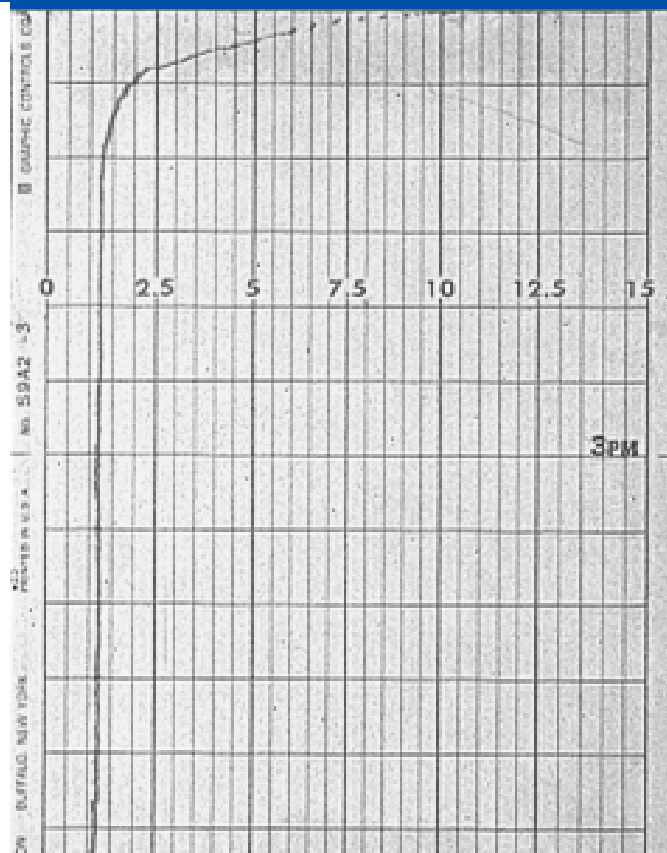
- The thickening time should equal job time (mix, pump, displace) plus a reasonable safety factor such as 1 to 2 hours
- A slurry exhibiting a “right-angle set” rather than a “gel set”, is generally regarded as preferred
  - In actual well, slurry is static when set occurs, not continuously sheared until set as in consistometer.

Gel and Right Angle Set

GEL SET



RIGHT ANGLE SET



Accelerators

- Accelerating a slurry means shortening the thickening time or reducing the time required to gain compressive strength, or both
- In general, an inorganic material will act as an accelerator
  - Salts such as $CaCl_2$, KCl, NaCl

Retarders

- A material that allows sufficient time for slurry placement by delaying the set of the cement is called a retarder
- In general, many organic materials such as simple sugars will retard the set of a cement slurry
  - Lignins from wood pulping process
  - Certain cellulose derivatives
  - Organo-phosphate type synthetics

Fluid Loss Additives

- Reduces the rate at which cement slurry filtrate is lost to a permeable formation
- Works by viscosifying the mix water or by plugging the pore throat in the filter cake with long polymer chains

Dispersants

- Also called friction reducers, these materials make cement slurries easier to mix and pump by making them less viscous
- Act on the surface of cement grains
- Secondary retardation
- Enhances fluid loss control

Extenders

- Additives that reduce slurry density and increase slurry yield are called extenders
  - Most allow the addition of extra water to slurry
- Cement may be lightened to protect weak formations or slurry yield may be increased to reduce cost

Fluid Loss

- The fluid loss of a slurry is a measure of the rate at which filtrate is forced from a cement slurry when the slurry is subjected to differential pressure across a permeable medium
- Fluid Loss rates of less than 50 ml can help with gas migration control through slurry as it sets

Fluid Loss Requirements

- Lead Slurries: 300-500 mls
- Production Casing Slurries: < 100 mls
- Linear Slurries and Anti-Gas: < 50 mls

Free Water and Slurry Stability

- Free water is the fluid that separates from a cement slurry
- Slurry stability is affected and solids sedimentation may occur
- Free Water Requirement
  – The slurry should exhibit zero free water without solids sedimentation or channels @ 45 degree angles
- ***Excessive free water and/ or slurry sedimentation = easy path for formation fluids moving in annulus after ceent sets***

Free Water Test

Slurry Rheololgy

- Rheology is the science that deals with the deformation and flow of fluids
- Correct slurry, spacer, and mud rheological properties are a factor in good mud removal
- Viscosity and Yield Point are one measure of rheology

- ELF stands for “Effective Laminar Flow”
  - Mud must be removed and replaced by competent cement
- One requirement for ELF= Proper Rheological Hierarchy
  - In simple terms, each fluid pumped in well more viscous than fluid in front of it

Compressive Strength

- Obtaining adequate compressive strength is not difficult if overly extended slurries are not used as pay cements
  - We are starting to be able to calculate what “adequate” is
- A slurry must be stabilized against strength retrogression if it is used at high temperature
  - Usually 35% Silica BWOC is added

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Gas Migration Through Setting Cement

- Requirements for slurry to resist gas flow during transition
  - Very low fluid loss: < 50 mls
  - Zero free water @ 45 degree angle
  - Short static gel strength development: Time for 100 to 500 lbf/ 100 sq ft gel strength < 30 min
    - During this time the slurry supports part of it's own weight and well fluids can enter the wellbore. Shorten this time and you are less likely to have annular flow through the cement after cementing
  - While a "right angle" set profile on HTHP consitometer is good, it is not guarantee of gas tight system
  - Certain cement additives can also enhance gas control of slurries: Polymer s, micro-fine particles etc

Gas Flow Potential in a Given Well

- FPF = Flow Potential Factor
- FPF = MPR/OBP
  - MPR = Maximum pressure reduction = 1.67 x L/D

    (L= Length of interval; D= Hydraulic Diameter, in)
  - OBP = Overbalance pressure

FPF < 3 Minor Gas Flow Potential

– Controlled fluid loss and no free water

3<FPF>8 Moderate Gas Flow Potential

– Controlled fluid loss and no free water

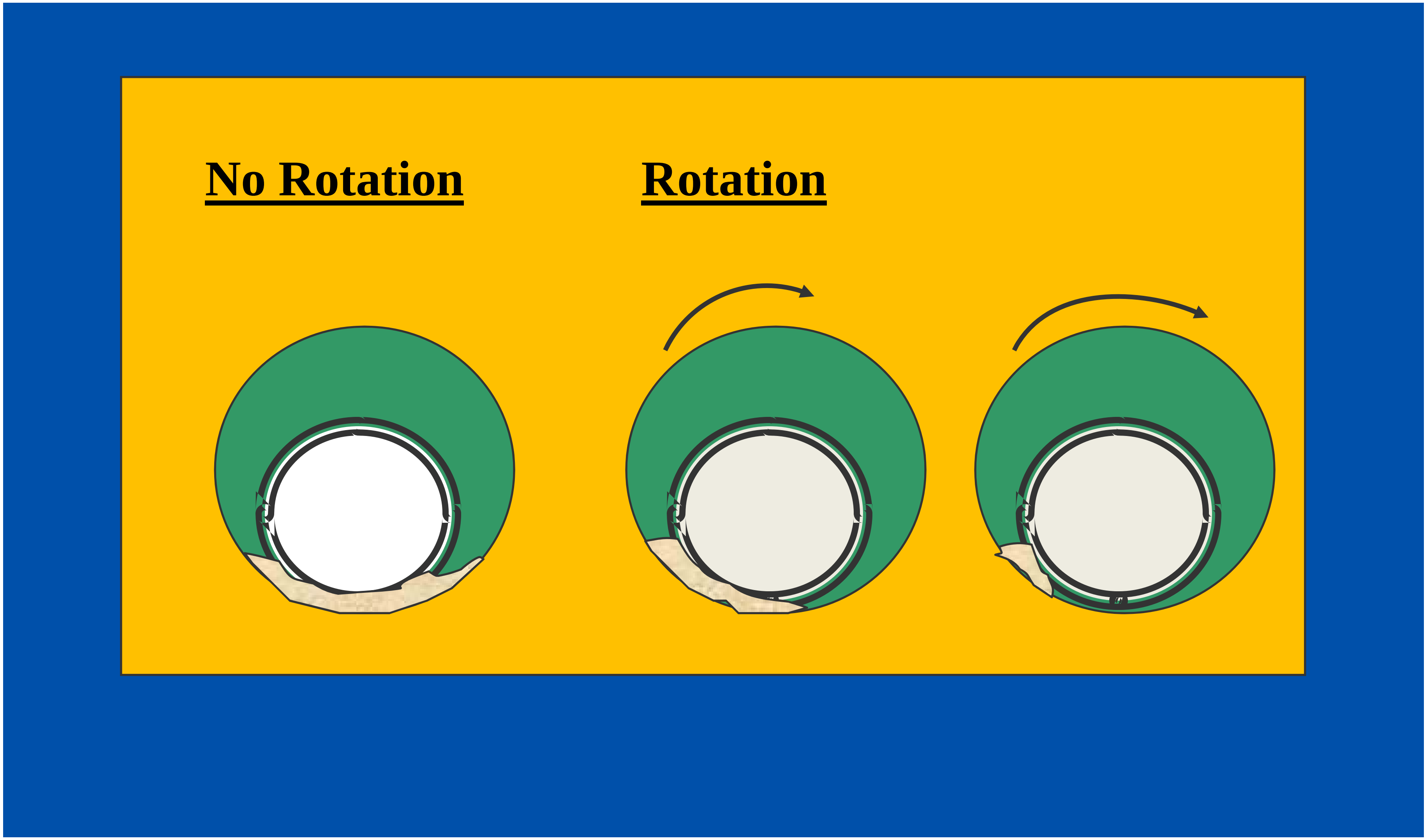
FPF>8 High Gas Flow Potential.

– Slurry Design should have low fluid loss, no free water, and less than 30 minute transition time

Good Cementing Practices

- Casing Movement
- Centralizers
- Scratchers and Wipers
- Casing Wiper Plugs
- Two Floats
- Adequate Shoe Joint

Casing Movement- Rotation



Evaluating the Job

- Temperature Survey
- Leak- off Test
- Bond Logs
  - Sonic Tools: CBL, CBT, SBT, etc
  - Ultrasonic Tools: CET, PET, USIT

Squeeze Definition

The placement of a cement slurry under pressure against a permeable formation causing the slurry to dehydrate and create a cementitious seal across the formation face.

Primary Squeeze Concerns

- Squeeze Purpose
- Reasons for Failure
- Formation Types
- Establishing an Injection Rate
- Method of Squeezing
- Slurry Design
- Laboratory Testing
- Slurry Placement

Plug Cementing Definition

The placement of a cement slurry into the wellbore such that once hydrated, a solid cement mass will occupy that section of the wellbore. This placement may occur in either open-hole sections or inside wellbore tubulars

Purpose of Cementing Plugs

- Lost Circulation
- Whipstock/Kick-Off
- Formation Testing
- Zonal Isolation
- Abandonment

Factors Affecting Plug Instability

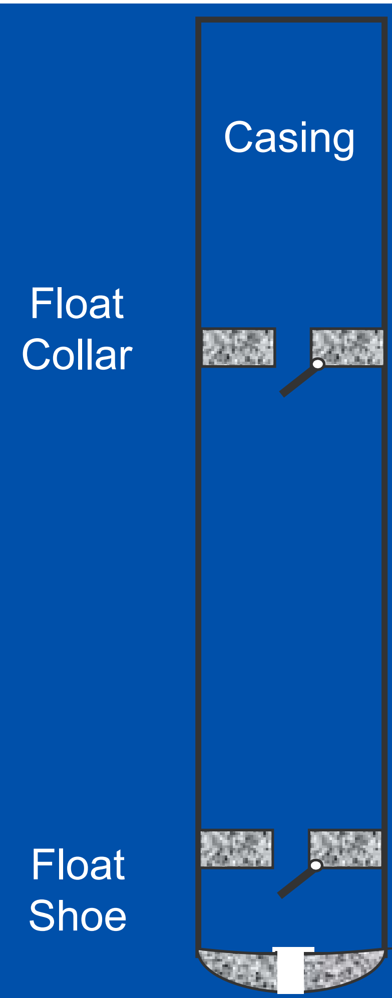
- Fluid Density Difference
- Hole Diameter/ Casing I.D.
- Well Deviation
- Plug Instability During Setting Can Result In:
  - Higher density cement moves down on low side of hole
  - Lower density fluids migrate upward on the high side of the hole
  - *<u>Plug contaminated/ may not seal hole</u>*

Successful Balanced Plug Aids

- Batch Mix Cement
- Use of Diverter Sub
- Use of Stinger On Work String
- Spot Viscous Pill or Mechanical Tool Under Cement Plug Prior To Attempting To Set Balanced Plug
- Use Proper Volume of Compatible Spacer
- Circulate And Condition Wellbore Fluid – Prior To Setting Plug
- Use (Displacement) Plug Catcher Method

Two Floats

- Float failure means pressure must be held on the casing until the cement sets.
  - Can cause micro-annuli
- Use a float shoe and a float collar for redundancy.



Adequate shoe joint

- The length of casing between the float collar and float shoe. Also called the “shoe track”
- The purpose of the shoe joint to to contain contaminated or lightweight cement
- Use at least two joints - more in larger casing

Summary

- Cement has important functions in well control
- Must be specifically designed for each job
- Good cement design and good cement practices are needed to minimize failure
- Evaluate the job

QUESTIONS ?