Squeeze Cementing

– Forces cement slurry, under pressure, through perforations or holes in the casing or liner…..
  - Used to permanently block entry of undesirable fluids to the wellbore or to fill channels behind the casing. Water production form watered out zones or leaks are common targets.
  - Also used to set “cement packers” to isolate sections of the annulus.
  - The cement plug must remain an effective seal full temperature, highest pressure and in contact with any fluid from the well.

Repair Cementing

- Squeeze Cementing
  – Shutting off watered-out perforation intervals
  – Filling channels behind the pipe
  – Covering pipe annuli that was never cemented
  – Setting cement packers

Partly copied from Arco Alaska presentation.

Treatment Execution

- Execution of squeeze cementing operations in four basic steps:
  - Wellbore preparation
  - Slurry mixing and pumping
  - Squeeze
  - Removal of excess cement

Squeeze Cementing – channel repair

- Objectives

1. Locate the channel
2. Perforate into the channel
3. Inject cement and fill the channel

Problems

1. locating the channel
2. squeezing into the channel

Channel Detection

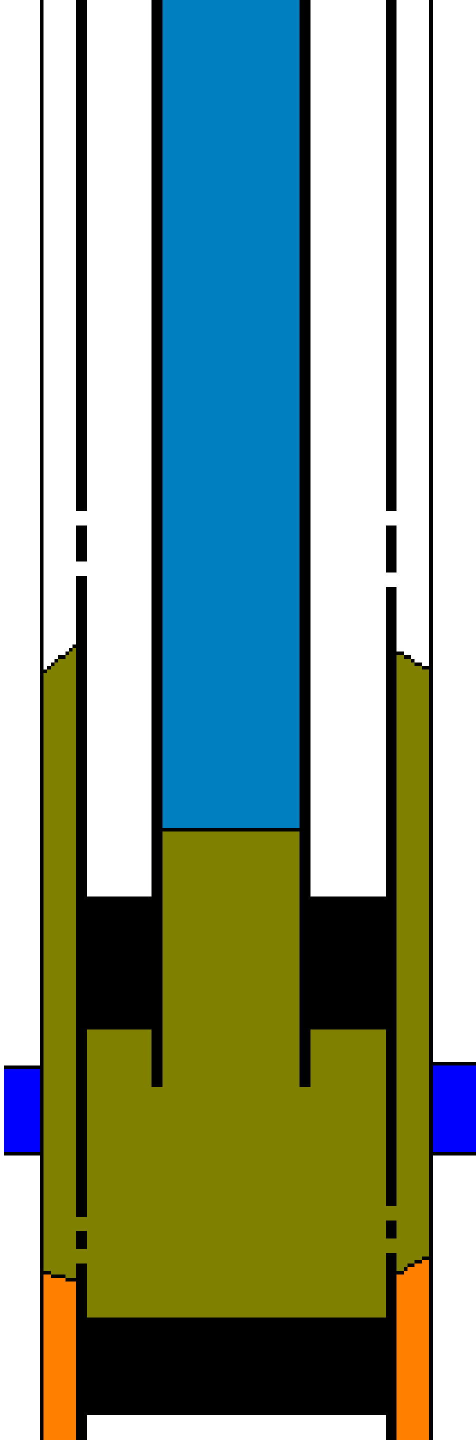
- Cement bond log
- Noise log? - leaks
- Segmented or radial bond log
  – Bond differences
  – Looking for patterns that represent channels
- Block perforate and squeeze techniques

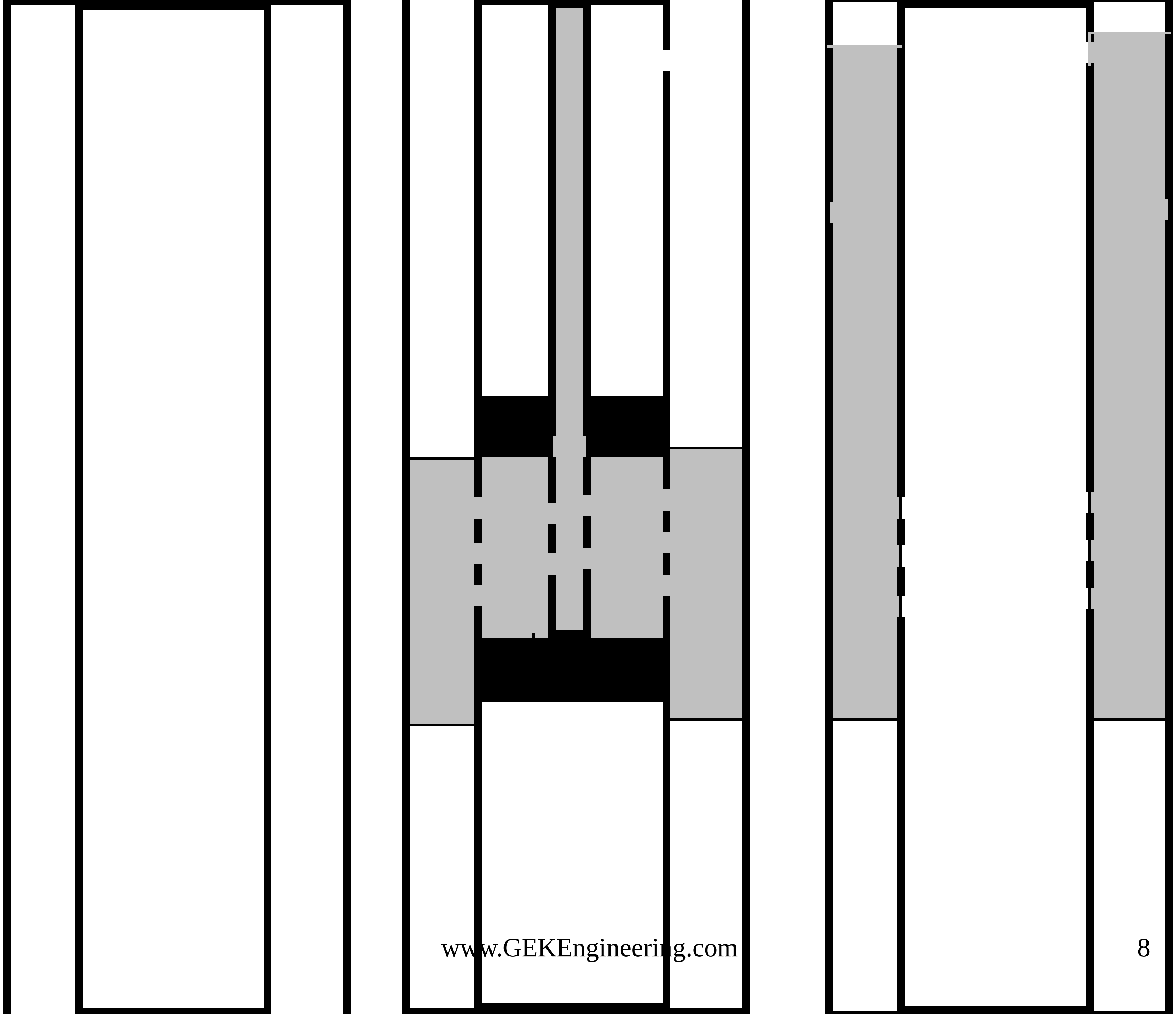
Squeeze Types

- **Hesitation squeeze** – steady application of pressure thought by some to force cement in matrix – may only help build size of dehydrated mass or "node" through fluid loss of liquid from the cement slurry.
- Actually – what may be happening in some cases is that the wellbore is being "restressed" – forming a "stress cage" by solids from mud or cement wedging into and bridging on the formation. This may allow 1 to 5 lb/gal higher fluid gradient weight than initial frac pressure of the formation.

Squeeze Types

- Suicide squeeze – This squeeze perforates two spots – high and low and squeezes from the bottom towards the top. There is a chance, if slurry volumes are too large, of cement spilling out of the upper perforations and sticking the isolation packer or retainer in the well.

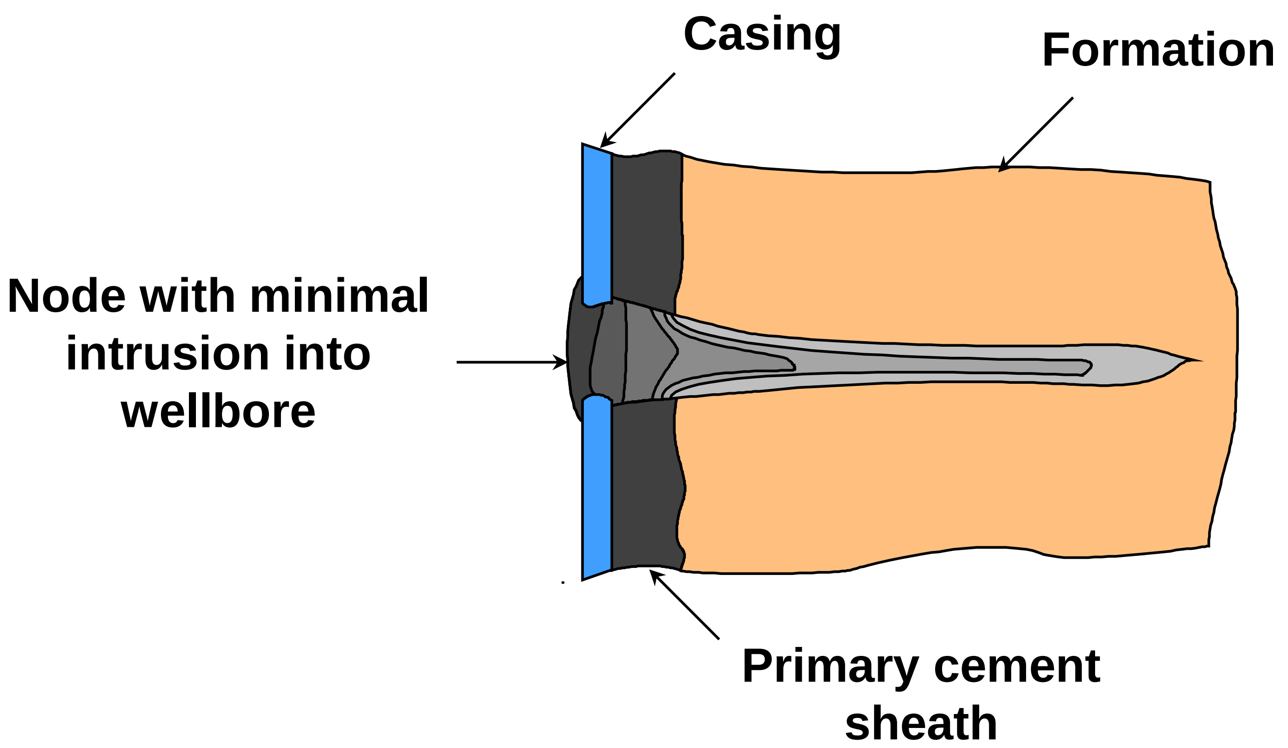




Fluid Loss Control

- Excessive fluid loss in the slurry can result in bridging of tubulars by dehydrated cement.
- Slurries with too little fluid loss can result in insufficient buildup of filter cake on the formation (may also be a function of permeability and pressure).
- Fluid loss additives may be required to control fluid loss.

Cement Node Buildup



Rheology Controls

- Cement slurries have higher viscosity than most workover fluids and this significantly reduces maximum possible pump rate.
- Rheology and stability tests are commonly performed:
  - At surface mixing temperatures, and
  - At bottomhole static temperature BHST (caution – make sure mix water temperature is not higher than bottom hole temp.).
- Slurries must stable to provide good rheology characteristics that are easily reproducible.

Slurry Volume

- Volume of slurry prepared depends on:
  - Length of perforated interval
  - Capacity of liner/casing or channel behind pipe
  - Void areas behind the perforations
  - Force that can be applied to the tubing
  - Configuration of surface mixing / pumping equipment
  - Use of cement plugs, pigs or darts (isolation devices)

- <u>Previous squeeze experience provides best guidelines.</u>

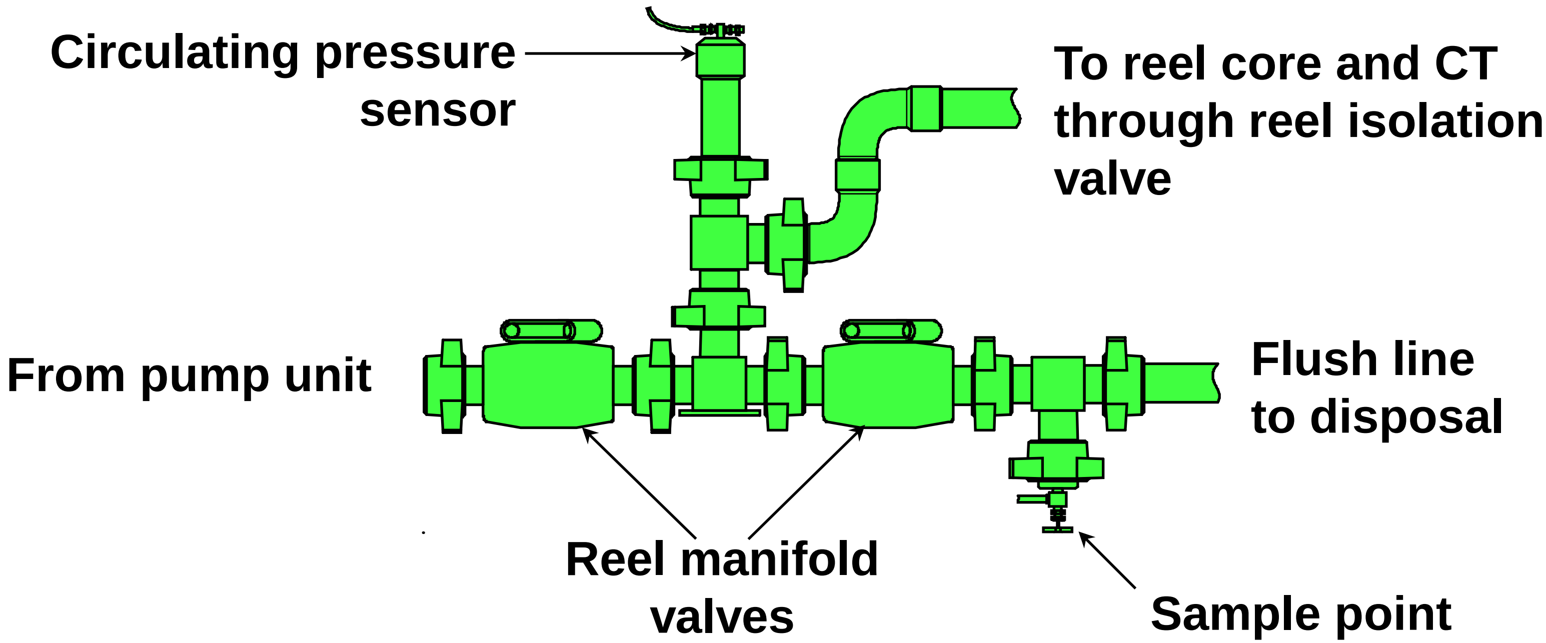
Depth Control – (with CT)

- In cement squeezing, surface equipment not accurate enough to position CT nozzle
- Downhole reference point is generally required
- Methods of setting depth reference
  - Tagging bottom
    - inaccurate in wells with fill, but viable in certain conditions
  - Tagging completion restrictions
    - tubing end locator (TEL) or tubing nipple locators (TNL)
    - commonly used in squeeze cementing

Cement Contamination Problems

- Contamination can result in:
  - Unpredictable slurry characteristics
  - Reduced compressive strength of the set cement
  - Incorrect placement due to change in slurry volume
- To avoid contamination:
  - Spacer fluid should isolate (ahead of/behind cement)
  - Lines should be flushed each time a new fluid is pumped
  - Mechanical separation of cement slurry using CT plugs (darts or pigs)

Reel Manifold Sampling Point and Flush Line



Cement Composition and Vol.

- Low or high fluid loss? Depends on depth
- Volume of cement? – depends on channel size
  - Often try several small squeezes.
  - Pressure?

Squeeze Success?

- Usually about 50% - but conditions make success vary widely.
- Increases when:
  - circulation is possible through the channel,
  - Isolation is used fro cement injection,
  - cement blending is pod mix,
  - the operator is experienced.

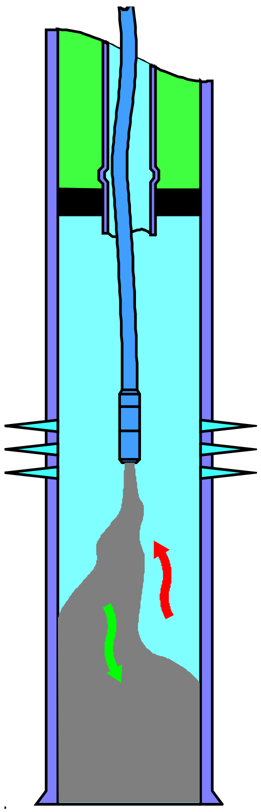
Cement Packer

- Can isolate the annulus
  - Water control
  - Tubing repair or isolation
  - Stabilizing tubing prior to milling window
- Problems and considerations
  - Floating the cement in the annulus – there are ways!
  - How long a cement column? - 50 to 300+ feet.
  - Cement compositions for packers

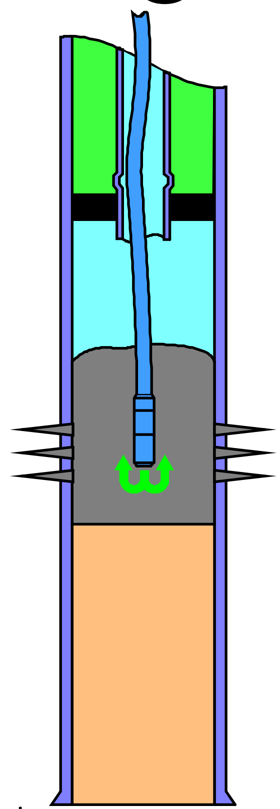
Cement Packer

- Perforated annulus at or below point for packer.
- May need to perforate above top of packer when annulus is liquid filled.
- Displace cement from a straddle packer or packer and plug (or retainer) into the annulus.

Cement Placement With and Without Retaining "Platform"



Cement slurry falls through less dense fluids



Stable cement column placed over the platform

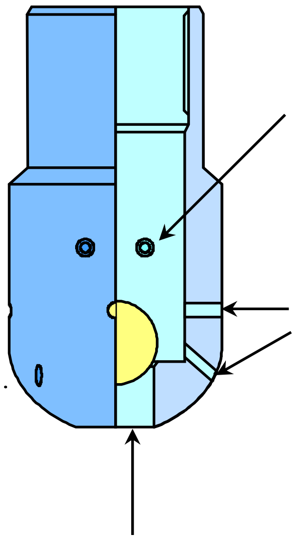
Cement platform

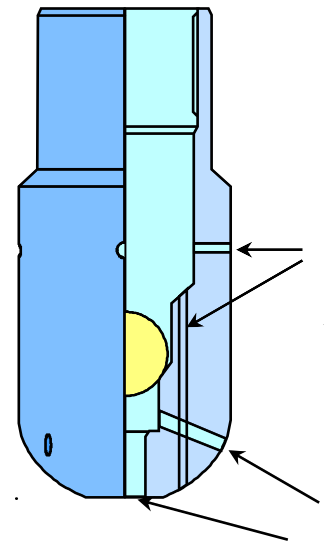
A retainer, mechanical plug, highly gelled mud pill (10 to 20 bbls) or a cement plug may be used as the "platform".

Tool Selection

- Tool strings should generally be kept to a minimum
  - Connector
    - required on all jobs
  - Check valves
    - cannot be used with reverse circulation of excess cement
  - Depth correlation
    - tubing end or nipple locators are commonly used
  - Plug catcher
    - catch and retrieve plugs ahead/behind cement slurry
  - Nozzles
    - developed to improve the slurry placement

Cementing Nozzle Features

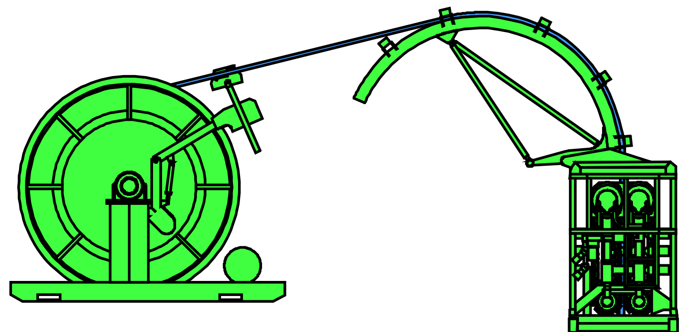




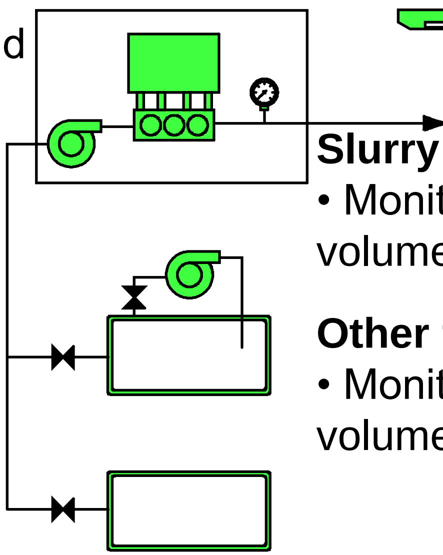
Arco

Monitoring Recording Parameters

Coiled tubing
- Pressure, rate/volume, string weight, depth and tubing OD and tubing cycles.

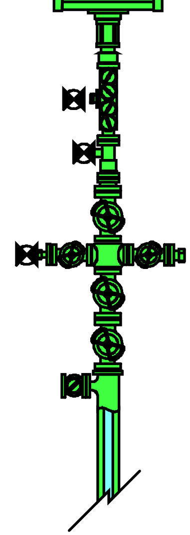


Pump unit
- Pressure, density and pump rate/volume



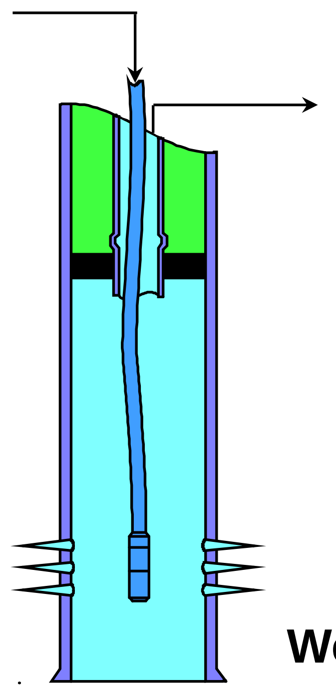
Slurry batch mixer
- Monitor density and volume

Other tankage
- Monitor density and volume

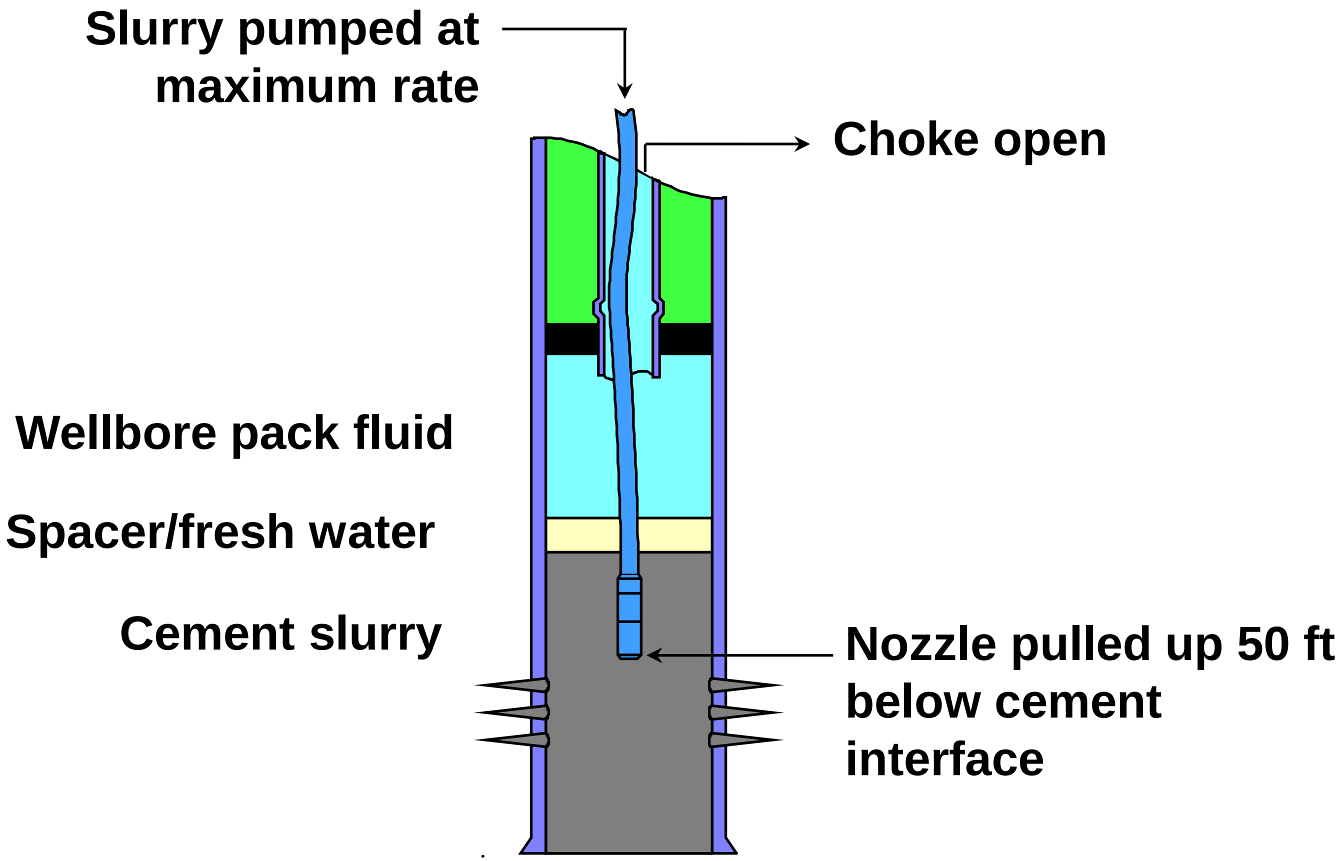


Annulus
- Monitor volume and density of all fluids returned and pumped through the annulus.
- Record pressure.

Wellbore Preparation

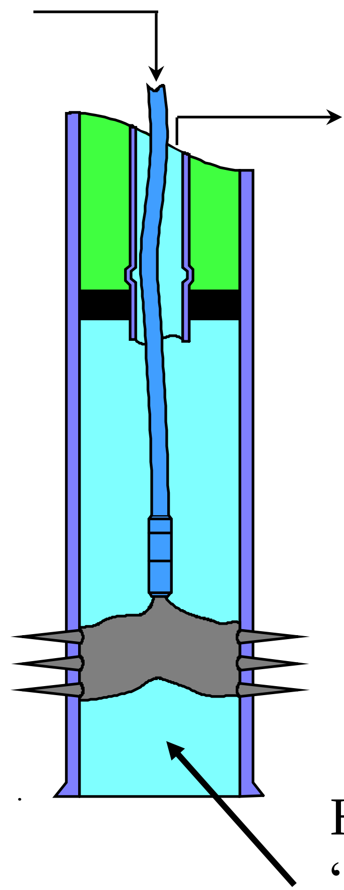


Laying In Cement Slurry



Placing Thixotropic Slurries

Slurry pumped at maximum rate/pressure allowed



Choke closed, if wellbore not fluid packed, pump slowly down annulus to prevent U-tubing

Wellbore pack fluid

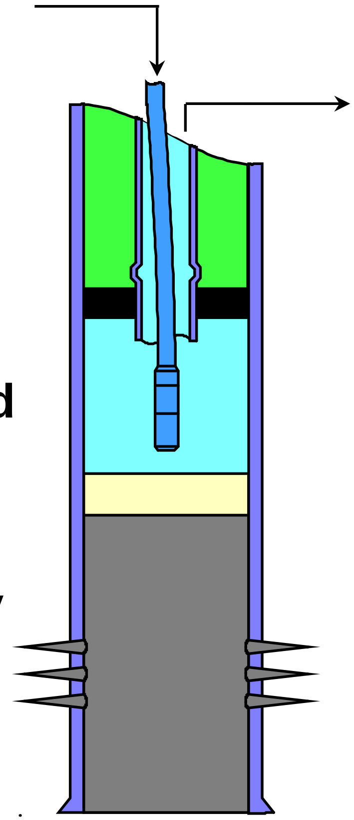
Nozzle placed above thief zone

Cement slurry

Wellbore pack fluid

Highly gelled mud or other "platform" usually needed except in severe fluid loss.

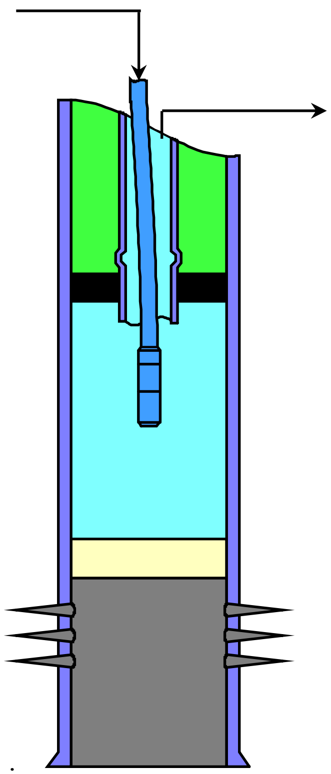
Commencing Squeeze



Completing Squeeze

Displacement fluid pumped at maximum rate/pressure allowed

Choke back returns increasing final squeeze pressure



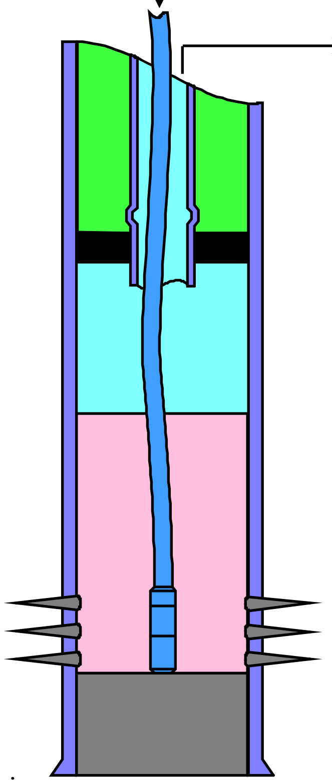
Wellbore pack fluid

Nozzle moved continuously or frequently

Spacer/fresh water

Cement slurry

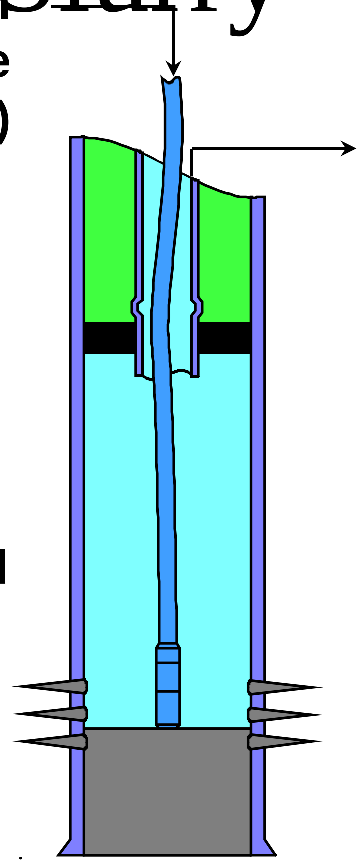
Contaminating Excess Slurry



Reverse Circulating Excess Slurry

Fluid pumped at maximum rate/pressure for allowable differential (1500 psi)

Open returns from CT



Nozzle penetrates contaminated slurry at a rate which provides a 50% mix of contaminated slurry and pack fluid

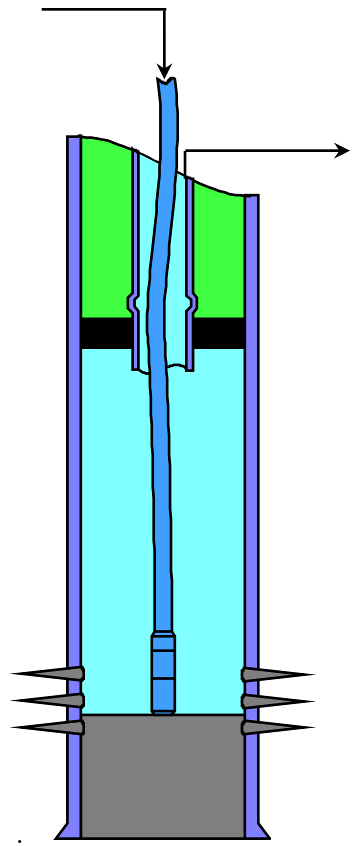
Wellbore pack fluid

Contaminated slurry

Reverse Circulating Live Slurry

Fluid pumped at maximum rate/pressure for allowable differential (1500 psi)

Open returns from CT



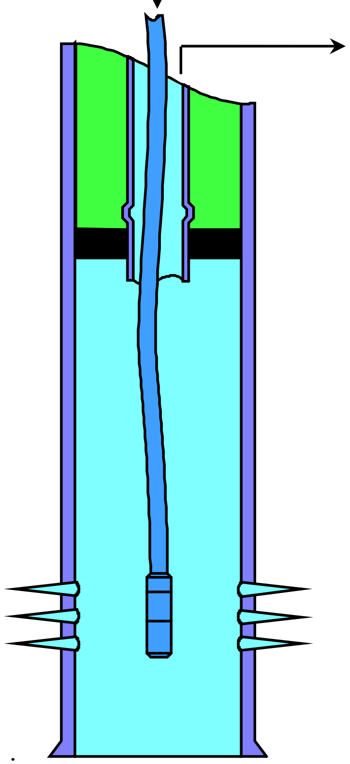
Wellbore pack fluid

Nozzle penetrates slurry at a rate which provides a 50% mix

Cement slurry

Wellbore Circulated Clean

Fluid pumped at maximum rate/pressure



Returns choked to maintain pressure on squeezed zone

Wellbore pack fluid

Nozzle reciprocated through treatment zone to TD

Differential pressure maintained against squeezed zone

Wellbore Preparation

- Wellbore preparation operations include
  - Slick-line work, e.g. fitting dummy gas-lift mandrels
  - Pressure test the production tubing annulus
  - Establish hang-up depth or TD using slick line
  - Confirm and correlate depths with CT and flag the tubing
  - Remove fill from rat hole below perforated interval
  - Perform pretreatment perforation wash or acidizing
  - Place a stable platform for cement slurry
  - Ensure wellbore fully loaded with filtered water (or equivalent)

Slurry Mixing and Pumping

- Key points in the slurry mixing and pumping process include
  - Batch mix and shear the slurry
  - Conduct job-site quality control tests
  - Prepare contaminant and spacer fluids as required
  - Confirm CT depth
  - Lay in cement slurry following pumping schedule
- When using thixotropic cements
  - Do not stop pumping while cement is inside the work string
  - Place CT nozzle above thief zone and pump down production tubing/CT annulus while squeezing the cement
  - Overdisplace cement slurries out of the wellbore

Squeeze

- Downhole generation of filter cake aided by performing hesitation type squeezes
  - For example, 10 min at 1000 psi, 15 min at 1500 psi, 20 min at 2000 psi...

- As fracture pressure exceeded
  - Filter cake prevents formation from fracturing

Removal of Excess Cement

- Efficient removal of excess cement
  - Critical to timely completion of job

- Achieved using several methods:
  - Reverse circulation of live cement
  - Circulation of contaminated cement
  - Reverse circulation of contaminated cement

Reverse Circulation of Live Cement

- Reverse circulation of live cement slurry can be performed if
  - Designed slurry thickening time (including safety factor) allows for completion of the reversing phase
  - CT penetration rate controlled to effectively dilute the slurry as it is removed
  - Maximum density of reversed fluid is 10 lb/gal
  - Reversing is continued until clean returns observed at surface

Rev. Circulation of Contaminated Cement

- Contamination of excess cement is often necessary to:
  - Extend slurry thickening time
    - allows cleanout operations to be completed safely
  - Allow cleanout operations to be delayed until cement nodes have increased compressive strength

Typical Cement Slurry Contaminant Composition

•TYPICAL CEMENT SLURRY CONTAMINANT COMPOSITION

- **Borax/Bentonite**
- 10 to 20 lb/bbl Bentonite
- 20 lb/bbl Borax
- 3 gal Cement Retarder
- **Bio-Polymer Gel**
- 1.5 lb/bbl Biozan gel

Circulation of Contaminated Cement

- Conventional circulation used when:
  - Operating conditions cannot safely support reverse circulation of excess slurry

- Example:
  - Operations performed through 1-1/4-in. work strings cannot employ reverse circulation techniques
  - Reason: excessive friction pressure encountered

Evaluation of Squeeze

- Methods used to evaluate depend on treatment objectives
- Initial step in evaluation process
  - Confirm condition of wellbore in the treatment zone
- If wellbore is obstructed
  - Drilling/under-reaming may be required
- Additional check
  - Ensure the rat hole is debris or cement free