Exploring Mechanisms of Plug Job Failures & Their Fixes

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Neat Cement Via Pump Truck

Current Plugging Solution

Current Plugging Operations

- Standards
  - Cement Service Companies From Approved Lists
  - Cement Pump Truck, maybe a Batch Mixer
  - Bulk Equipment
    - Can be done with Dump Bailers on Wireline, but not very common

- Familiar, Safe, & Easy

Current Plugging Product & Regulations

- Current Product:
  - API & Construction Grade Portland Cements

- Current Regulations:
  - Vary Depending on Municipality, State, or Federal Lands
  - Various Specifications:
    - Grades or Types of Cement
    - Density
    - Compressive Strength
      - But, This Property Isn't the Whole Story

- Familiar, Safe, & Easy

Make It Grey and Pump it Away!

Mechanisms of Plug Job Failures

- Incomplete Mud Removal / Slurry Contamination
- Lost Circulation / Short TOC

Friends

- Poor Bond / Micro Annulus
- Gas Migration
- Slurry Stability

Support

- Chemical Degradation
- Aqueous / Hydrocarbon Invasion
- Mechanical Damage

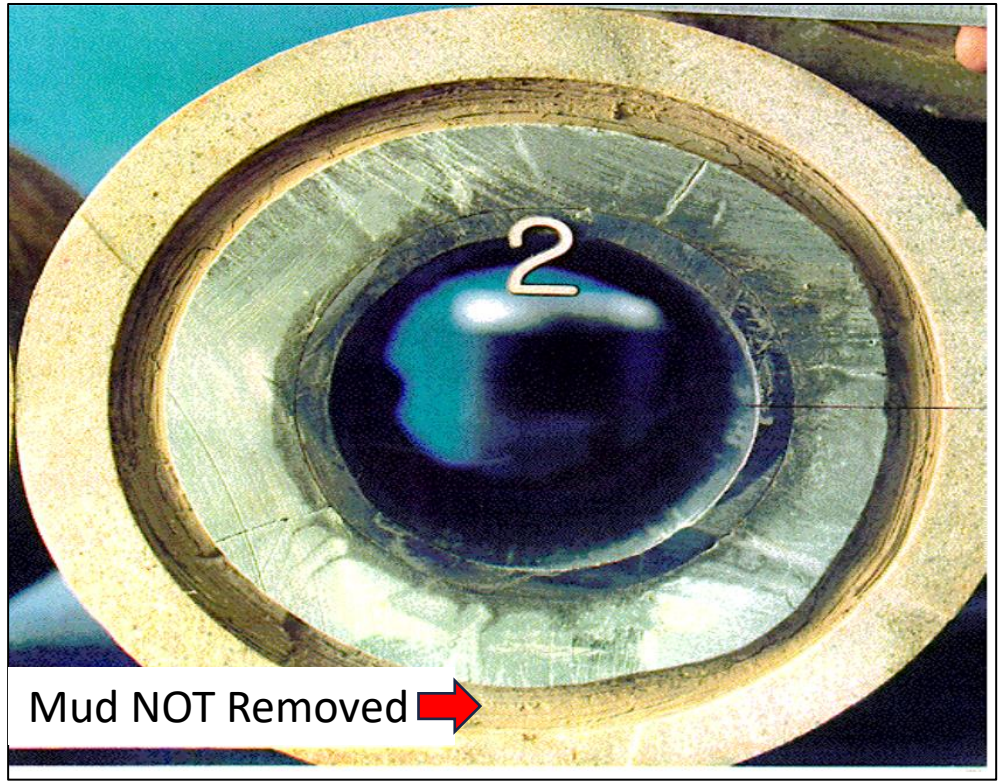
Protectors

Prev Slide - None Related to Compressive Strengths!

Fixing Failures with “Friends” (1)

Failure: Incomplete Mud Removal / Slurry Contamination

- Need Competent Spacer System with Enough Volume:
  - Volume in Primary Cementing: 1000’ of fill or 10 min contact time, whichever is greater
- Candidates:
  - Freshwater: No Yield Point
  - Chemical Wash: Most, No Yield Point
  - Conventional Viscous Spacer: Gels or HEC Spacers - Have a YP!
  - Reactive Spacers like Sodium Silicate - Not Recommended for Plugging



Fixing Failures with “Friends” (2)

Failure: Lost Circulation (Open Perforations) / Short TOC

- Sealing Spacer
  - Def: Viscous Spacer W/Mechanical Pieces that Strengthen Formations & Resist Exiting Wellbore
  - From Prim Cmtg: Curing Prtl/Total Losses, Replacing DV Tools[1], Replaces Cnvntl/Reactive Spacers

Sand Bed Tests Showcasing Sealing Spacer
A: Neat Cement, NO Sealing Spacer
B: Same Neat Cement, W/ Sealing Spacer
C: Birdseye View of B

Fixing Failures with “Friends” (3)

Failure: Lost Circulation (Open Perforations) / Short TOC

- LCM’s: Singular Products
  - Walnut Shells, KolSeal, Gilsonite, PhenoSeal, or **Fibers**[1]



- LCM’s: Eng Combo Products
  - Multiple LCM’s strategically combined into one bag

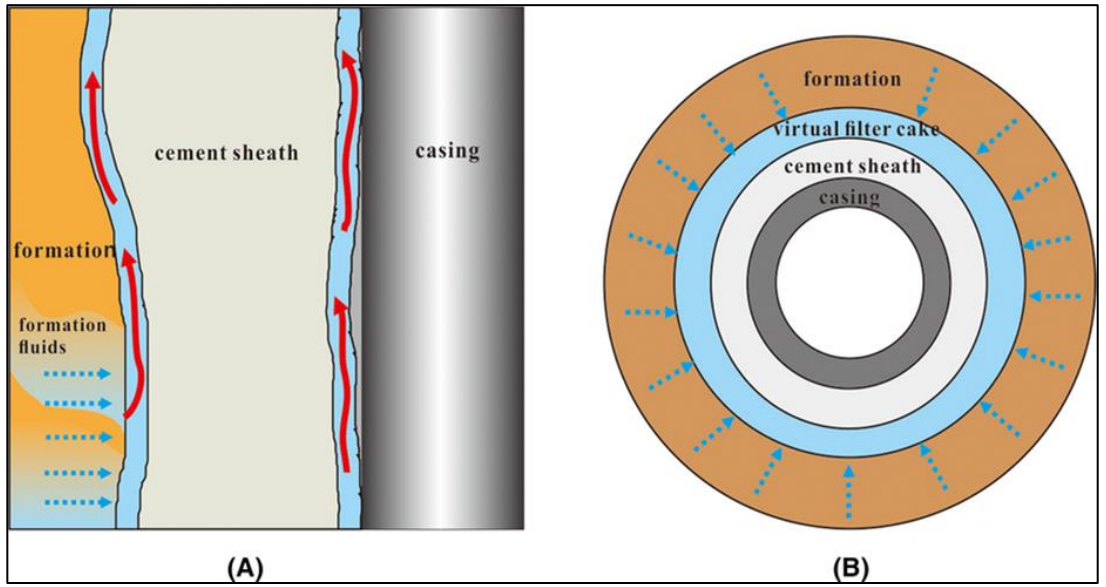

Fixing Failures with “Friends”: Downhole Scenarios

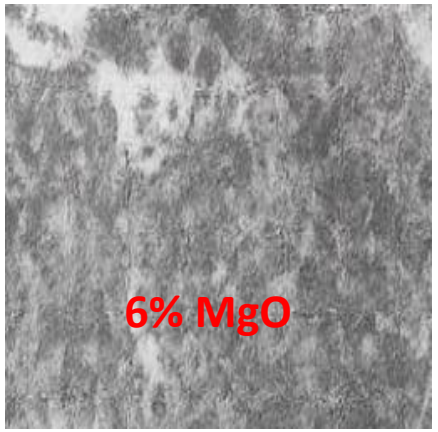
- **Thought Exercises:**
  - Setting a plug inside a clean stable pipe with integrity:
    - Freshwater spacer & Neat Cement is probably fine, just make sure you have enough
  - Setting a plug in open hole that is stable formation:
    - Use a spacer with a YP and enough volume
  - Anything outside the above scenarios – (IE: Perfs, Losses, Prev OBM in hole, Swiss Cheese Pipe, etc..)
    - Use Commercially Available Tools – IE LCM’s, Sealing Spacers, Surfactants, etc…

Fixing Failures with “Support” (1)

Failure: Poor Bond/ Micro Annulus

- Previous slides definitely apply!
- Two Types of Additives:
  - Gas Generating
    - Aluminum Powders
      - HSE Concerns
  - Volumetric Expanders
    - MgO or CaO
      - Cost Effective and Easy to Use!

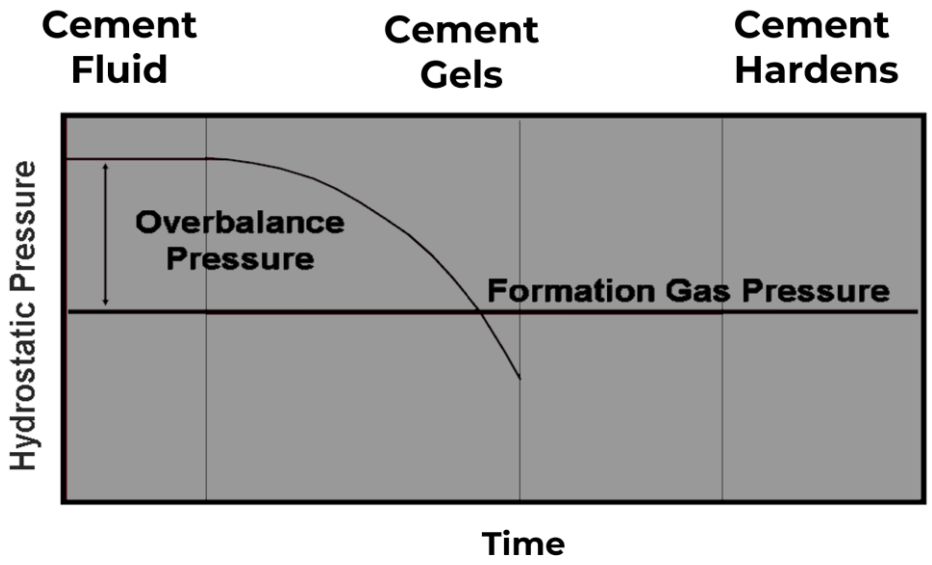


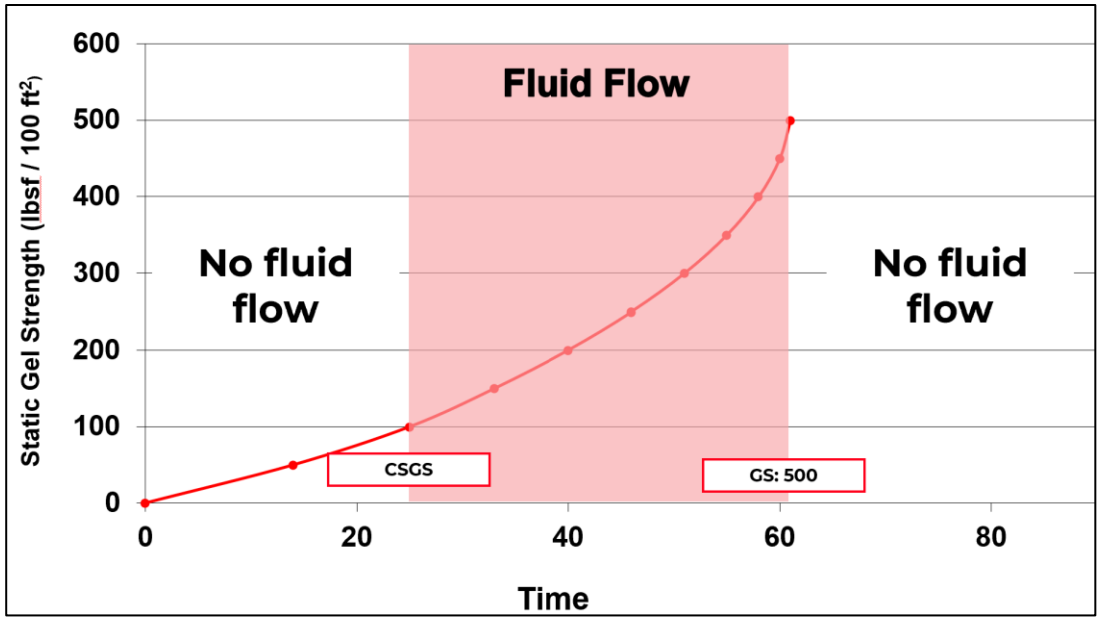


Fixing Failures with "Support" (2)

Failure: Gas Migration

- FFP Equation[3] that are fairly easy to use, but we don't have time to discuss!
  - Two main points from equation:
    - Control pressure loss, due to volume loss (Shrinkage, Free Fluid)
    - Shorten Static Gel Strength Transition Times





Fixing Failures with “Support” (3)

Failure: Gas Migration (Continued)

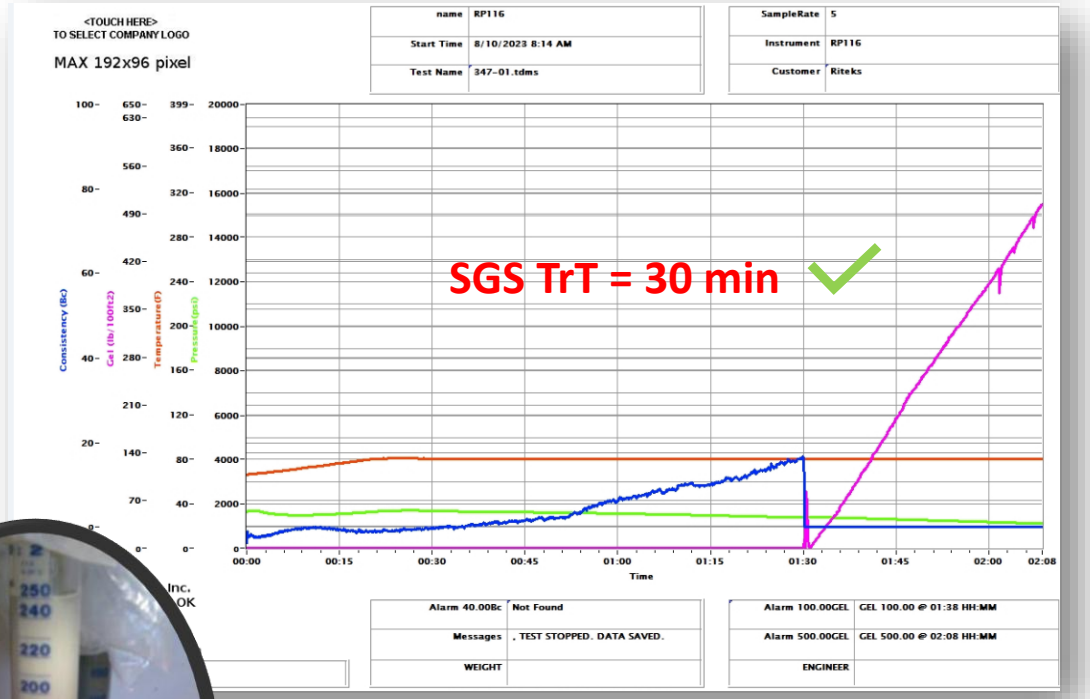
- Applicable GM Control Methods:
  - Raise Density of Cement
    - Use less H2O or Hematite
      - Shortens Thickening Time
  - Use Thixotropic Additives
    - Gypsum, Sodium Aluminate, Sodium Metasilicate, or Multipurpose Combo Adds
      - Have been witnessed to impede waterflows[2]
      - But, multi-purpose additives can remove several additives and simplify design

Photo Credit: Kirk Harris via LinkedIn

Fixing Failures with “Support” (4)

Failure: Slurry Stability

- Use Gas Migration Fluid Loss Adds
  - Helps Stabilize, Shorten SGS TrT & provides low fluid loss (<50 cc/30 min)
  - Might Lengthen TT
- Use Gels, Gums, or Free Water Control Adds
  - Helps “Soak Up” FF
  - Might slow Compress Strengths



Mechanical SGS TrT Chart

Failed Free Fluid Test

Fixing Failures with “Support”: Downhole Scenarios

- **Thought Exercises:**
  - Setting an open hole plug that is stable in Vertical formation:
    - At minimum, do expansion adds anything necessary to make the slurry stable!
  - Outside the above scenario – (IE: Known Gassy Area, Deviated/Horizontal, etc..)
    - Use Commercially Available Tools – IE Thixotropic, GMFL, Expansion, FWCA’s, etc…

Fixing Failures with “Protectors” (1)

Failure: Chemical Degradation

- Via Acids, Brines, H2S, CO2:
  - Old School Fix – Permeability Reducing FL Adds like latex
    - CO2 Studies being conducted currently
  - New Thinking – Reduce or remove Portland Cement
    - Less Portland to be attacked
  - Or Instead of Cement – Geopolymers & Resins

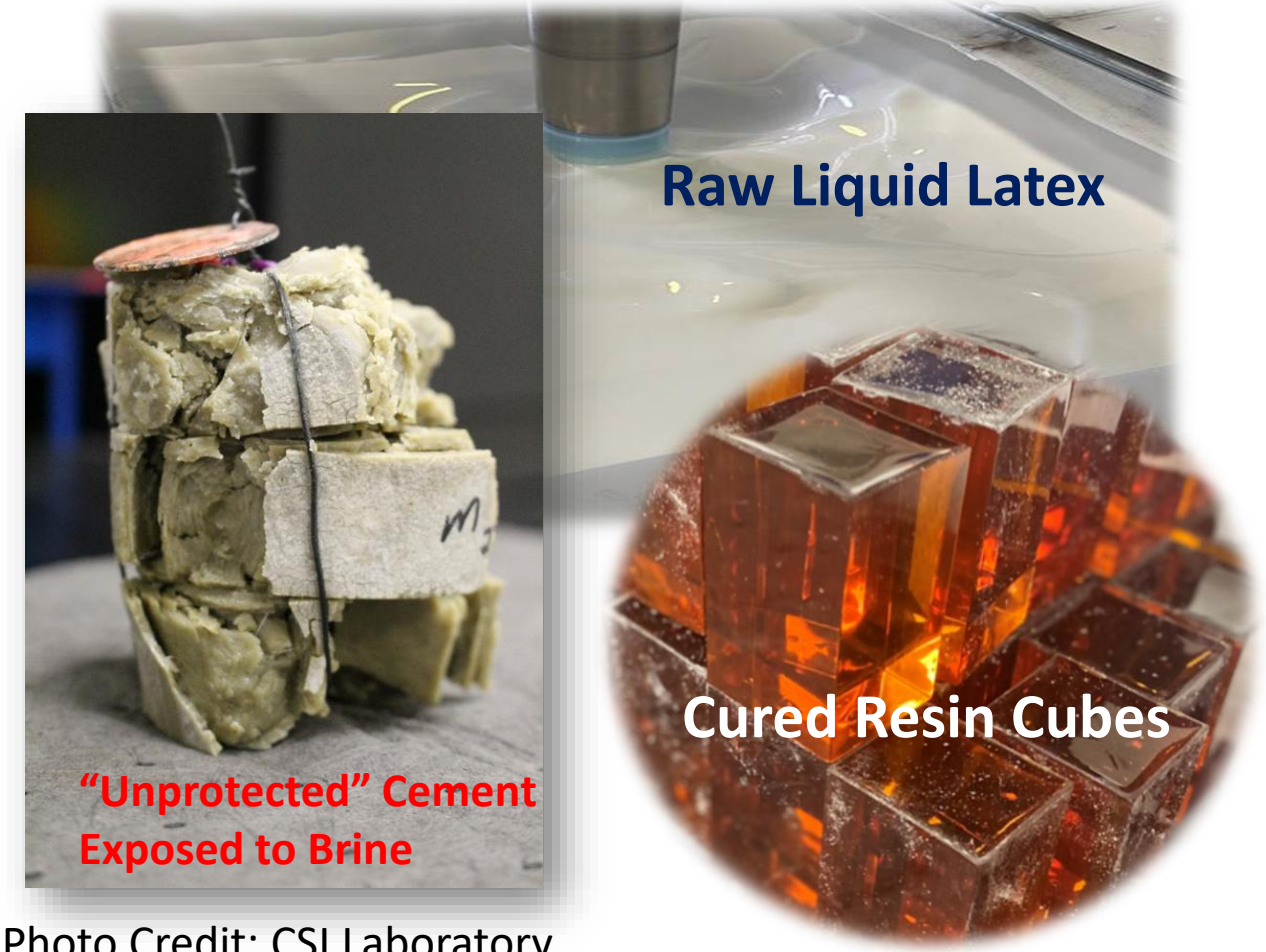


Photo Credit: CSI Laboratory

Fixing Failures with “Protectors” (2)

- **Failure: Chemical Degradation (Continued)**
  - Geopolymers
    - Potentially Viable, but more testing needed
      - Describe “Non-Portland Cements” thought processes
      - Field Lab tested needed for chemical efficacy
      - More studies needed in acid, H2S, CO2 environments
  - Resins
    - Commercially available & not permeable
    - Oilfield grade glue & In use today
    - Many publications on when/where to use resins[4],

    Its chemical resistance[5], effectiveness against annular gas flows[6]
    - Materials much more cost effective than 5 years ago!

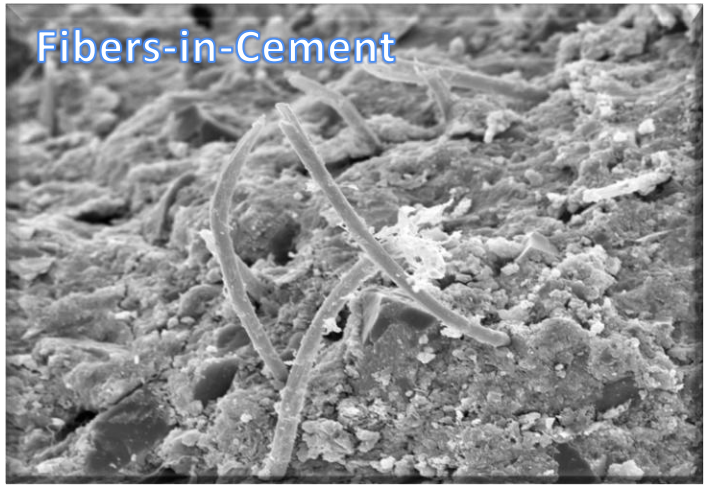
Fixing Failures with “Protectors” (3)

Failure: Mechanical Damage

- Forms of Mechanical Damage
  - Tectonically Active Areas
  - Salt Creep Areas
  - Disposal / Injection Zones
- Reinforcements
  - Foams (N2 & CO2)
  - Fibers[7]
  - Resin-in-Cement

Concepts that “Reinforcements” Bring

- Lower Young’s Modulus
- Increase Poisson’s Ratio
- Increase Flexibility / Toughness



Final Thoughts on Fixing Failures in Plugging

- Most everything we have discussed today is being used in Primary Cementing daily!
- Ask for Alternative Solutions from the Service Company! They might include items from “Friends, Support, or Protectors”.
- The answer may NOT Be Familiar, Safe, or Easy, but it could be the best available answer….

Works Cited (1)

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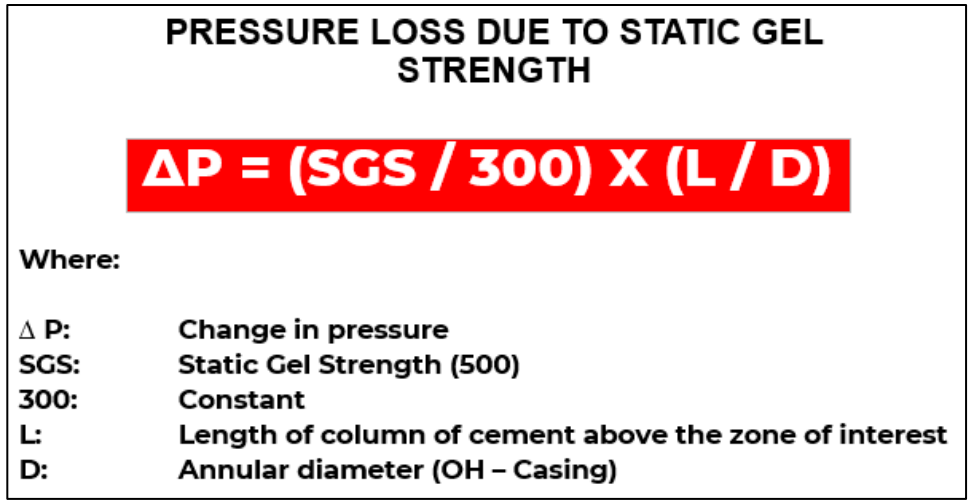
2. AADE-23-NTCE-038 - Novel Cement Composition Eliminates Water Flows on Intermediate Strings in Midland and Delaware Basins
3. 

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4. AADE-22-FTCE-020 - Implementing Manufacturing-Style Workflow to Resin Sealant Squeeze
5. SPE 204374 - Epoxy Resin Exhibits Long-Term Durability and Chemical Stability as a Well Sealant
6. AADE-24-FTCE-088 (Resin Sealant Remediates Annular Gas Flow to Surface Allowing Completion of Four Colorado Wells)
7. SPE-174483-MS Enhanced Thermal Well Integrity Through The Use Of A New Cement Tensile Strength-enhancing Fiber

Questions?

Thanks for your Time!