SPE DISTINGUISHED LECTURER SERIES

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Introduction

• Don Whitfill
  – Global Technical Advisor
  – Wellbore Pressure Containment
  – Baroid

• Background
  – 8 years with Baroid in technology applications
  – 30 years technology development with a major operator
  – Society of Petroleum Engineers Distinguished Lecturer
    • 2004-2005
    • 1986-1987
Wellbore Pressure Containment

Donald L. Whitfill
Baroid product service line
Halliburton Energy Services
1920 Ford Model T

Gets you where you want to go.

But Slow
Tokyo Bullet Train

Gets you where you want to go – IN A HURRY!!

Fast – 300 km/hr
Reduces commuting time
Has an engineer
What if you had a vehicle like the bullet train in your business?

Reduce drilling non-productive time
- Employed in a fully engineered system
- Provide unique LCM and systems
- Provide the same answer for each set of circumstances.
Wellbore Pressure Containment

Maintain Wellbore Stability

• Prevent lost circulation
  – Block vugular/seepage losses
  – Seal depleted sands
  – Prevent wellbore fracture initiation
  – Stop wellbore fracture propagation
  – Mitigate wellbore breathing
  – Recover from lost returns
An Engineered Process

• Drilling Fluid Strategy
  – Proper fluid selection
  – ECD modeling
  – Geomechanical modeling

• Lost Circulation Strategy
  – Preventive
  – Corrective
Derivation of our Strategy

• Drilling Engineering Association (DEA) 13
  – Joint Industry Project in the 1980’s
  – New product and field experience

• Global Petroleum Research Institute (GPRI) 2000
  – Joint Industry Project conducted 2000-2002
  – Additional insight
  – Revised products and systems
Wellbore Pressure Containment

DEA 13

- Large Sample
  - 30- in cube
- High Cost
  - $25-30 K
Fractures could be -
- initiated
- stopped
- reopened
Fundamental Question - Is the fracture initiation pressure different for water and oil base fluids?

Answer - No, but the propagation pressure (extension) is lower for oil base fluids.

Result – More difficult to stop lost circulation with oil base fluid.

Theory - Fracture tip screen-out is the assumed mechanism.
Fracture Tip Screen Out

\[ P_w \]
Fundamental Question - Is the fracture initiation pressure different for water and oil base fluids?

Answer - No, but the propagation pressure (extension) is lower for oil base fluids.

Result – More difficult to stop lost circulation with oil base fluid. Fracture tip screen-out is the assumed mechanism.

Strategy – Prevention is better than remediation.
Cornerstone of Wellbore Pressure Containment – Resilient Graphitic Carbon (RGC) Lost Circulation Material

- A resilient, angular dual composition carbon
  - No detrimental effects on the rheology and ECD
  - Particles under pressure expand or compress without being dislodged or collapsing
  - Pills up to 100 ppb pumped through mud motors.
- Manufactured by a patented process
Measurement of Resiliency (R)

\[ R = \left( \frac{h_2}{h_1} \right) \times 100 \]
Wellbore Pressure Containment

Resilient Graphitic Carbon

**Carbon Types**
1-Crystalline Vein
2-Flake
3-Amorphous
4-Petroleum Coke
5-Synthetic Graphite
6-Resilient Graphitic Carbon

![Graph showing resiliency of graphitic carbons]
How is RGC different?

GPRI 2000 – Minimizing Lost Circulation in Synthetic Fluids

- Small Sample – 4-in core
- Fractures completely
- No Frac tip screen-out
- Reopening Pressure Only
Carbonate, Graphite, Peanut Shells

- Carbonate 600
- Peanut Shells
- Carbonate 150
- RGC

Scale: 0.5 mm
Test Results - 10 ppb RGC in Red Sand Stone

Fracture Sealing Observed
Test Results - 30 ppb calcium carbonate particles in Red Sand Stone

No fracture sealing capacity observed

Injection Rate = 0.5 cc/sec
Phase 3 Results (cont.)

- 3C - 1:2 Weight ratio RGC:Carbonate in RedSS: 
  *Effective fracture sealing observed.*

30 ppb = 10/20 ppb RGC/carbonate
Test Results - 20 ppb Shell Fiber in Red Sandstone

No effective fracture sealing, but some limited fracture conductivity impairment
Ineffective Single Materials

- Sized calcium carbonate
- Peanut hull fiber
- Gilsonite
- Ground rubber tires
- Acid soluble mineral fiber
- Ground battery casing
Reopening Pressure Increase - RGC

- Only effective single material
- Effective in both low perm shale and high perm sandstone (1-2 D)
- Reopening pressure less shale
- Effective with sized calcium carbonate
To Build a Strong Building – Start with a Good Cornerstone
RGC – The Cornerstone of Wellbore Pressure Containment

Bricks and mortar must be added to make a building

Sized particulates
Sized fibers
Engineered Combinations

One Sack Solutions

**EC-D** A blend of fine RGC and other sized LCM (d50 = 80 microns) in a pellet form used for seepage losses and drilling depleted sands.

**EC-S** A blend of larger RGC and other sized LCM (d50 = 950 microns) in a pellet form used as a treating pill for severe lost circulation incidences.
Wellbore Pressure Containment

To get where you want to go – you may need a bridge

Chemical Treatment Systems
Chemical Treating Systems

HCT – **Dual acting** - sized particulate material plus a crystalline polymer that **hydrates** to form a pliable treatment

FCT – **Flexible** and deformable viscous combination forming a cohesive plug within the fracture
Fractures/Fissures occurring or encountered while drilling
Fractures/Fissures occurring or encountered while drilling – HCT Treatment

HCT Placed in Fractures
Flexible Chemical Treatment

Pump Down Drill Pipe
Spacer
Spot Treating System
Pump Down Annulus

Pump down drill pipe and annulus. Apply pressure and squeeze.

Reacted Product
Open Hole

Resume Drilling
Flexible Chemical Treatment

Viscous – Deformable - Cohesive
Compression generated where wedge forces aside formation

Potential weaknesses where fractures may grow
A Physical Model for Stress Cages

... and here

Compression also partly felt here ...
A Physical Model for Stress Cages

Knock in a few other wedges ......

...... generating a hoop of compression or “stress cage” around hole.
Wellbore Pressure Containment

The Tool Box

• Chemical Treating Systems
• Engineered Combinations
• Resilient Graphitic Carbon
Which do you prefer?


SPE 90493; Alberty, A Physical Model for Stress Cages; 2004

SPE 84319; Whitfill and Hemphill; All Lost Circulation Materials and Systems are Not Created Equal; 2003.
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