Loss of Circulation

- Loss of circulation
  - The reduced or total absence of fluid returning up the annulus when fluid is pumped down through the drill string.

- Consequences
  - NPT
  - Increased well control safety risks
  - Wellbore stability issues
  - Stuck pipe
  - Formation damage
  - Sidetrack or complete well loss
Lost Circulation – Treatments

• LCM materials to apply
  • Fibres
  • Flakes
  • Granules
  • Cross-linking polymers
  • **BAKER-SQUEEZ™**
  • Cements

• Special Case Treatments
  • Reservoir Protection [ acid solubility ]
  • Stress ‘cage’ and ‘Bridging’ solids

Rapid Fluid Loss Formulations
### Objectives

An LCM pill, for massive losses capable of being spotted at the loss zone or above and be squeezed into the formation.

### Results

2. A pre-cement pill or squeeze to eliminate cement losses and aid in achieving cement-to-surface.

Easy to prepare with limited rig resources.

Laboratory scale testing indicates exceptional ease of blending

Pill/Plug to develop compressive strength with a minimum of 200 psi (1380 kPa)

When mixed in water, compressive strengths as high as 1176 psi (8111 kPa) have been observed.

Minimum Temperature limitation of 250°F (120°C).

Temperature stable up to 400°F (204°C).
BAKER-SQUEEZ™ - Testing

Dewatering LCM slurry to form cake
BAKER-SQUEEZ™ - Testing

• Post-test cake showing no internal filtrate/mud invasion

The cell containing the cake and drilling fluid was kept at 100 psi for 10 minutes and was observed for passage of filtrate or mud through the cake. After the 10 minute test was complete, the cake was removed and examined for filtrate or mud invasion into the interior of the cake. All samples showed no filtrate or mud invasion into the cake interior.
BAKER-SQUEEZ™ - Diesel

12 lb/gal Diesel
BAKER-SQUEEZ™ – LTMO
Well Successfully Drilled to TD after Lost Circulation Zones are Sealed

Baker Hughes 17.6 ppg BAKER-SQUEEZ™ pill seals multiple lost circulation zones

**Results**
- Well successfully drilled to TD after two lost circulation zones were sealed
- Reduced NPT (cementing and sidetracking were not required)
- Optimized mixing with single-sack solution

**Background and Challenges**
- 8 ½” hole was drilled with 17.6 ppg TERRA-MAX water-based fluid in difficult Vicksburg sands
- Loss rate of 50 bbls/hour for 6 hours was detected
- Two lost circulation zones were identified
- Traditional lost circulation pills failed

**The Solution: 17.6 ppg BAKER-SQUEEZ Pill**
- BAKER-SQUEEZ pill developed compressive strength
- Pumped and squeezed a 79 bbl 17.6 ppg pill over lower lost circulation zone
- Pumped and squeezed a 50 bbl 17.6 ppg pill into upper lost circulation zone – held for 4 hours at 600 psi

<table>
<thead>
<tr>
<th>Time</th>
<th>Strokes Pumped</th>
<th>Pressure (psi)</th>
<th>Pressure - After bleed off (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hour 1</td>
<td>18</td>
<td>125</td>
<td>60</td>
</tr>
<tr>
<td>Hour 2</td>
<td>25</td>
<td>70</td>
<td>0</td>
</tr>
<tr>
<td>Hour 3</td>
<td>25</td>
<td>150</td>
<td>100</td>
</tr>
<tr>
<td>Hour 4</td>
<td>5</td>
<td>170</td>
<td>90</td>
</tr>
<tr>
<td>Hour 5</td>
<td>3</td>
<td>200</td>
<td>150</td>
</tr>
<tr>
<td>Hour 6</td>
<td>1</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Hour 7</td>
<td>0</td>
<td>200</td>
<td>200</td>
</tr>
</tbody>
</table>

Pressure track after pumped and squeezed 17.6 ppg BAKER-SQUEEZ pill

BAKER-SQUEEZ post-test cake showing no internal filtrate/mud invasion
Zero Fluid Losses in High Mud Weight Application with Multi-Purpose Baker-Squeez™ Pill

Baker Hughes Squeeze pill completely seals problematic sand

Results
- Well was successfully drilled to TD with zero fluid losses and increases in mud weight as required

Background and Challenges
- 8-1/2” hole was drilled with 16.4 water-based mud in difficult Yegua sands
- Loss of 1150 bbl in 24 hours was detected
- Two traditional lost circulation pills failed

The Solution: Field-Proven BAKER-SQUEEZ Pill
- BAKER-SQUEEZ pill was designed according to water-based and high mud weight guidelines
  - Pumped only 53 bbl weighted pill
  - Squeezed in 25 psi increments to 200 psi
  - Held 200 psi for 4 hours
  - Bled off pressure, tripped bottom, regained circulation and continued drilling to TD with zero fluid losses
  - Logged, ran and cemented production liner with no mud losses

<table>
<thead>
<tr>
<th>EVENT</th>
<th>MW (psi)</th>
<th>Stand Pipe (ppg)</th>
<th>F.I.T. (ppg)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.8</td>
<td>528</td>
<td>11.8</td>
<td>Test Casing Shoe</td>
</tr>
<tr>
<td>2</td>
<td>10.8</td>
<td>2113</td>
<td>14.8</td>
<td>Squeeze 40 bbls Cement</td>
</tr>
<tr>
<td>3</td>
<td>10.8</td>
<td>2166</td>
<td>14.9</td>
<td>Squeeze 50 bbls Cement</td>
</tr>
<tr>
<td>4</td>
<td>10.8</td>
<td>2800</td>
<td>16.1</td>
<td>Squeeze DFE-917 78 bbls</td>
</tr>
<tr>
<td>5</td>
<td>10.8</td>
<td>2642</td>
<td>15.8</td>
<td>Final F.I.T.</td>
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</tbody>
</table>

Formation Integrity Test tracking. DFE 917 guaranteed required F.I.T. to finalize drilling operations.
BAKER-SQUEEZE solves critical operational problem and saves the well

BAKER-SQUEEZE increases formation integrity at the shoe

Results
- Application enabled customer to achieve sufficient Formation Integrity Test (F.I.T.) in under 40 full turns.
- Perforation didn’t have to cement and re-drill the well, avoiding reaming unit.
- BAKER-SQUEEZE field prevents solution for additional cementing at casing shoe.

Well Background and Challenges
- 7” Intermediate casing stack and cemented 7 5/8” drill tail.
- Production well was 17,100 ft. An E.I. of 17.1 ppg would be required to avoid total collapse the production zone.
- Cements, squeeze failure to achieve required F.I.T.

Baker Hughes Solution
- BAKER-SQUEEZE™ was designed to meet operational requirements.
- Made a regular synergistic combination of strength in fracture and fracture tip.
- Well was successfully drilled to total depth with increases in mud weight as required.

Challenge
- Normal progress was experienced while drilling an 8 3/4 inch, Intermediate section to total depth in Hock County, Texas. While running the 7” Intermediate casing string, the casing became stuck and was eventually cemented 7480 feet above the total depth. The successful drilling of the production zone and the economic success of the project was put at risk with the casing shoe cemented significantly above the planned casing depth. Formation Integrity Tests (F.I.T.’s) would be required to ensure that the casing shoe would tolerate the significant increase in density that would be needed to drill the production zone to the planned total depth.

The initial F.I.T. results were disappointing, being less than required for the drilling of the production zone. Two cement squeeze procedures followed, but these were not successful in increasing the formation integrity as required to allow safe and successful drilling to the planned total depth.

Solutions
- Based on extensive lab testing, the Baker Hughes Research and Development Team, proposed to the customer the use of BAKER-SQUEEZE as a solution for the Formation Integrity results required by the actual well status.

BAKER-SQUEEZE is a versatile, multi-purpose tool with all required features such as squeeze and highly permeable formations. It provides the ability to drill through the fracture and fracture tip.

BAKER-SQUEEZE works by rapidly developing, resulting in a solid plug. The plug develops compressive strength and is effective in stabilizing all types of fractures and high permeable formations and forms a rigid bridge inside the fracture and fracture tip.

BAKER-SQUEEZE was blended and pumped as a squeeze in a successful attempt to achieve an F.I.T. that would allow drilling ahead to planned total depth. During the squeeze procedure on the fracturing tool, innovative fracturing solution was subjected to squeeze pressures exceeding 9,600 psi.

Results
- Drilling progress on the well had come to 94 ft/pending a satisfactory leak-off test. As the NPT cost began to mount, BAKER-SQUEEZE held up the squeeze pressures and a successful F.I.T. was achieved.
- Following the BAKER-SQUEEZE application and a successful F.I.T. the operator resumed drilling to total depth with increases in mud weight as required.
BAKER-SQUEEZ LCM Stopped Lost Circulation of Heavy Oil-Based Mud

Baker Hughes lost-circulation squeeze allowed well to be drilled to TD in challenging Haynesville Shale

**Benefits**
- Eliminated lost circulation
- Drilled ahead to planned total depth
- Minimized seepage losses

**Background and challenges**
- Haynesville Shale
  - Drill a 6 1/2-in. hole with 17.2 ppg oil-based mud in challenging shale
  - Losses from 11,722 ft after drilling out of 7 1/4-in. casing at 11,098 ft
  - Total losses over 10,000 bbl down to 12,108 ft
  - Traditional lost-circulation pills proved unsuccessful

**Baker Hughes solution and results**
- BAKER-SQUEEZ LCM
  - Pumped 200 bbl weighted pill
  - Stopped lost circulation
  - Well was drilled to TD with only minor seepage losses

An operator drilling a well in the Haynesville Shale was experiencing increasing mud losses as mud weight was increased to control gas kicks. By the time the well was drilled to 14,469 ft and mud weight increased to 17.2 ppg to counter gas invasion, lost circulation of the expensive oil-based mud had reached more than 10,000 bbl total.

During the drilling of this hole section, a wide range of lost-circulation materials was used—in large quantities—without success. After losses reached more than 200 bbl/hr, the operator decided to try BAKER-SQUEEZ LCM (Lost-Circulation Material) to achieve the Formation Integrity Test (FIT) results required by the operator to drill to TD.

BAKER-SQUEEZ is a versatile, multipurpose lost-circulation material that works by rapidly de-watering, resulting in a solid plug of lost-circulation material. The plug develops compressive strength and is effective in sealing all types of fractures and highly permeable formations. It forms a rigid bridge inside the fracture and fracture tip.

BAKER-SQUEEZ LCM was blended and pumped as a squeeze and successfully achieved a FIT that would allow drilling ahead to planned total depth. During the squeeze procedure on the well, this innovative lost-circulation solution was subjected to squeeze pressures exceeding 2,800 psi. The operator was able to finish drilling the well with only minor seepage losses after pumping BAKER-SQUEEZ LCM.

### Event Log

<table>
<thead>
<tr>
<th>Event</th>
<th>MW</th>
<th>Stand Pipe, psi</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17.2</td>
<td>350</td>
<td>Bed off at 210 psi in one hour</td>
</tr>
<tr>
<td>2</td>
<td>17.2</td>
<td>450</td>
<td>250 psi after 1 hour</td>
</tr>
<tr>
<td>3</td>
<td>17.2</td>
<td>350</td>
<td>250 psi after 1 hour</td>
</tr>
<tr>
<td>4</td>
<td>17.2</td>
<td>250</td>
<td>Stabilized at 250 psi</td>
</tr>
</tbody>
</table>

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BAKER-SQUEEZ™ - Features and Benefits

- Single sack system
- BAKER-SQUEEZ™ plug develops compressive strength, un-weighted dewatered plug has a compressive strength of $> 952$ PSI and a weighted plug greater than 12.0 ppg has a compressive strength of $> 1350$ PSI
- Easy mixing and pumping
- No spacer required
- No setting time required
- Broad PSD range for effective sealing or bridging of micro-fractures and larger openings, once into the formation the discharged fluid will bond with any clay or gumbo shale to form a cement-like bridge
- Can be blended in all types of drilling fluids
- Tolerant of most drilling fluids contaminants
- Effective in both weighted and low-solids muds and over a wide pH range
- Compatible with a wide range of water-base fluid additives.
- Environmentally friendly
- Can be applied through downhole tools.
Thank You for Your Participation

• Any Questions?