Challenge: Place barriers to isolate formations from each other and from the surface

- Appropriate selection of materials and elements to form the barrier(s)
  - 30 CFR part 250 – pg 263-264 describes cement
  - UK Oil & Gas describes alternative materials
  - Individual operator requirements generally more stringent

- Key parameters
  - Permeability
  - Fluid interaction
  - Dimensional stability
  - Mechanical properties
  - Other (material dependent)
Solution: Resin (WellLock® Resin) and Resin/Cement Composites (LockCem™ Cement)

- WellLock® Resin usage in abandonment operations
- LockCem™ Cement usage in abandonment operations
Halliburton Resin Usage Recommendation for Plugging

- Job designs using the lowest volume of resin to achieve maximum results is recommended to be employed.

- The length of the resin portion of the plug is recommended to be no more than 20% of the total plug length, while the remaining 80% of the total plug length is recommended to be a Portland-based cement, composite cement (LockCem™ Cement) or equivalent.

- If a leak is located, it is recommended to contact the leak pathway with the resin and to squeeze the resin into the leak pathway as part of the job procedure.
Microfluidic Flow of Epoxy Sealant

Mass collected = 0.18 gm
Collection time = 4:41 (h:mm)
Fluid velocity = 9.89 m/hr
Volumetric flow rate = 0.035 mL/hr

\[
\nu = \frac{\Delta P \times D^2}{32 \times \mu \times \Delta L}
\]

\[
Q = \nu \times A
\]

\(\nu\) = fluid velocity
\(\Delta P\) = pressure drop = 7 bar
\(D\) = diameter = 67 µm
\(\mu\) = fluid viscosity (70F) = 549 cP
\(\Delta L\) = length = 20 cm
\(Q\) = volumetric flow rate

<table>
<thead>
<tr>
<th></th>
<th>Calculated</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\nu) (m/hr)</td>
<td>3.22</td>
<td>9.89</td>
</tr>
<tr>
<td>(Q) (mL/hr)</td>
<td>0.011</td>
<td>0.035</td>
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</table>
Resin Applications in P&A

- Squeezes for annular fluid flow
- Shut-off gas source
- Squeeze a previously leaking plug
LockCem™ Cement

- Oil well cement containing resin
- Regulatory approval under 30 CFR part 250
- Increase bonding
- Reduce stiffness
- Maintain strength
- Reduce density
- Non-shrinking formulations
LockCem™ Cement

Maintain compressive strength while reducing Young’s modulus

- Reduced Permeability
- Increased Shear Bond

![Graphs showing Young's Modulus, Compressive Strength, Shear Bond, and Permeability vs. Volume Fraction of Resin.]
WellLock® Resin and LockCem™ – 400+ Case Histories

PERCENTAGES BASED ON FIRST 100 JOBS
Resin Cement Composite Case Study

**Challenge**

- Rig less abandonment, no cementing equipment, only wireline
- Small slurry volumes (2.5 to 5 bbls total)
- Abandon bottom part of well and perforate new intervals in close proximity

**Solution**

- Dump bailer run on wireline used to place slurry on top of mechanical base
- Small volumes mixed using hand mixer
- Resin cement composite system (20% resin and 80% cement by volume)

**Results**

- Dump bailer minimized contamination of small volume in specialized applications
- Increased shear bond of LockCem™ Cement allowed shorter plugs
- Plug length ranged from 100 to 200 feet
- 100% success rate on all wells
Publications


- P.J. Jones, J.D. Karcher, D. Bolado, Halliburton, “OFFSHORE PLUG AND ABANDONMENT USING SYNTHETIC RESIN TECHNOLOGY”, delivered at RAO/CIS Russia (2013)


THANK YOU