Overview

• Discuss improvements in cement bond and cement quality
  • Provide an overview of the development
  • Describe the well site process
  • Explain how the technology works
• Review case histories and discuss lowering risk
  • Overview the diversity of “plug and abandonment”
  • Provide studies
  • Discuss benefits of the technology
• Lowering the environmental impact
  • Less exposure to NORMs
  • Less pipe to scrap yards
• Comments and questions
Improvements in cement bond and...

• Provide an overview of the development
  • A major producer in the UK, CoP, requested our involvement on a project. The objective of the project was to review current abandonment philosophies and determine if there were ways to safely and efficiently abandon wells without de-completing them.
  • One of the major challenges being dealt with was cementing. Specifically cementing tubulars when the tubular is static. When cementing in this manner the creation of micro annuls flow paths can compromise the entire abandonment.
Improvements in cement bond and....

• Provide an overview of the development
  • The NOV solution was deployment of an agitator like device installed in the suspended production tubing. Use the movement created by the pulsing of the agitator to eliminate pipe on pipe contact improving cement coverage and eliminating the possibility of a micro annuls occurring.
  • A plan was developed and testing was carried out. These tests were completed in as real life conditions as possible. We deployed in a test well with tubular and casing sizes that match the actual well characteristics that would be commonly encountered.
Improvements in cement bond and….

- Provide an overview of the development
- Test results - mechanical

![Fig 1 Axial and Lateral Acceleration @ Position 1000 ft from Agitator](image)

![Fig 2 Axial and Lateral Acceleration @ Position 2000 ft from Agitator](image)
Improvements in cement bond and....

- Provide an overview of the development
- Test results - mechanical

Flow Rate
~160gpm
~150gpm
~180gpm
~200gpm
~210gpm
~160gpm
~170gpm
~110gpm
Improvements in cement bond and....

• Provide an overview of the development
  • Test results – fluids
    • The Valkyrie ™ was placed into flow loop to confirm that the pulses generated do not negatively affect cement properties
Improvements in cement bond and….

• Describe the process
  • Cut 5-1/2” production tubing below desired plug interval
  • Raise the tubing to create a separation between the two sections
  • Deploy Valkyrie™ System on wireline and set above cut using packer to secure it in place and divert the flow through the tool
  • Cement through Valkyrie™ System to vibrate tubing
  • Laterally displace tubing to improve coverage – majorly beneficial on low side
Improvements in cement bond and....

- Explain how the technology works
  - Power Section + Valve Assembly
  - Varied TFA chokes flow to create pulses
  - Pulses reflect back up the string exciting the column of fluid above

![Diagram of POWER SECTION + VALVE ASSEMBLY](image)

\[ P = \text{pressure drop across valve plates} \]
\[ t = \text{time} \]

1. Valve moves to one extremity
   TFA minimized = pressure peak

2. Valve moves to center
   TFA maximized = pressure trough
Improvements in cement bond and....

- Explain how the technology works
  - The first animation shows how the tool acts on the pipe laying on the low side of the well working to remove any micro annuls flow channels
  - The second animation shows how the improved mixing as well as the vibration of the string acts to compress the cement and improve bond
Improvements in cement bond and....

• Explain how the technology works
Case Histories and lowering risk

• Discuss the diversity of “plug and abandonment”
Case Histories and lowering risk

- Provide studies
  - Micro analysis
  - Work carried out Mar 9th – May 6th, 2015 (58 Days)
- Operation consisted of multiple instances of each of the following intervention activities
Case Histories and lowering risk

• Provide studies
  • June 2015
  • Cost / Time estimate Days
  • Common Rig Rate (2015) USD/day
  • Spread Rate (40%)
  • Total Spread Costs
  • P&A related costs (indirect) USD

≈ $49M USD and 89
≈ $304,000 USD/day
≈ $152,000 USD/day
≈ $40,584,000 USD
≈ $6,996,000 USD
Case Histories and lowering risk

• Provide studies
  • Guidelines on Decommissioning Cost Estimation and Guidelines on Well Abandonment Cost Estimation

• UKCE focused
Case Histories and lowering risk

• Provide studies
  • Field trails / evaluation
    • To date the system had been trialed on 4 well meeting test criteria
    • Cut depth +/- 9000ft
    • Up to 30 deg inclination
    • Volume of cement pumped was increasing from test to test
    • CBL logging was performed each time to verify the results
    • On a last test 2600ft of good cement out of 3100ft volume pumped was confirmed by CBL (objective was to achieve at least 2000ft of good cement)
Case Histories and lowering risk

• Provide studies
  • Commercial installations
    • 5 additional installations since becoming commercially available.
    • On operation specifically this technology was key to shifting from a simple rig based operation to a rigless operation.
Case Histories and lowering risk

• Discuss benefits of the technology
  • Improves cement quality
  • Improves cement bond
  • Enables tubulars to be left in situ
  • Complementary to rigless initiatives
    • Less labor
    • Lower HSE concerns
    • Smaller footprint
Lowering the environmental impact

• Less exposure to NORMs
  • Individuals on the rig site involved in tripping activities, individuals involved in the transportation and cleaning and those associated with the disposal of the waste product itself are less impacted when more pipe is left in the wellbore.

• Less pipe to scrap yards
  • Limiting the amount of pipe that is removed from the wellbore is beneficial to the environment. Currently repurposing these items is difficult due to previously mentioned NORMs

• Less is better
  • Minimizing the amount of pipe that is returned to the shore also reduces fuel cost incurred from transport.
Questions?