Well Integrity Evaluation with Wireline Logs

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Plug and Abandonment Workshop
14th June, Stavanger, Norway
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Agenda

- Wireline Technology & Log Examples
  - Cement Bond Log
  - Ultrasonic Measurements
- New Developments
- Other Wireline Technologies
- Summary
- Questions?
NORSOK D-010 definition of Permanent Well Barrier

“...creates a seal that has a permanent/eternal characteristic”

- Impermeable
- Long term integrity
- Non shrinking
- Ductile – (non brittle)
- Resistance to different substances
- Wetting, to ensure bonding to steel
Sonic Measurements

- Cement Bond Log/Variable Density Log (CBL/VDL)
- Evaluation of tubular-solids-formation bonding
  - Benefits
    - Works in wide range of wellbore fluids & densities
    - Less affected by dry micro-annulus (than Ultrasonics)
  - Limitations
    - Affected by wet micro-annulus, settled solids
    - Sensitivity to eccentering
    - Affected by fast formation and concentric casings
    - No azimuthal resolution (unable to identify channels, etc.).
Example Sonic log

- Suppressed casing signal
- Strong formation arrivals
- Low CBL amplitude
Ultrasonic Measurements

- Azimuthal evaluation of internal tubular, thickness & solids bond to casing
  - Benefits
    - Full azimuthal corrosion + annular evaluation (solids settlement, cement, formation swelling)
    - Less affected by wet micro-annulus (than CBL/VDL)
  - Limitations
    - Borehole fluid & wellbore condition limitations
    - Thick casings
    - Evaluation of lightweight & foam cements
Example Ultrasonic log

- Signal amplitude
- Liquid filled channel
- Radius
- Thickness
Ultrasonic Measurements – Flexural attenuation

- Azimuthal evaluation of internal tubular, thickness & solids bond combining pulse echo & flexural measurements

Benefits

- Evaluation of lightweight cements
- TIE (Third Echo Interface) processing to identify borehole shape & casing centralisation
- Works in greater range of borehole conditions & thick casings

Acoustic impedance vs. Increasing contamination

Difficult to diagnose with acoustic impedance or CBL-VDL measurements alone

Gas | Liquid | Cement | Contaminated cement

0 | 2 | 4 | 6 | 8

Increasing contamination
Example 1 - Lightweight Cement

USIT Impedance Measurement

Combined SLG Map

IS Flexural Attenuation Measurement

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Example 2 - TIE
New Developments

- Ultrasonic Measurement-Cement Bond Log/Variable Density- Multifinger Caliper combination
- Ultrasonic evaluation of internal tubular, thickness & solids bond, sonic evaluation of solids, & mechanical radius measurements
- **Benefits**
  - Eliminate need for 2 runs (when both datasets needed), saving rig-time
  - Eliminates effect of dirty borehole fluid/rugose tubular surface on Ultrasonic radius (use Multifinger caliper data)
  - Compare data from 2 totally different measurements for increased confidence
  - Absolute inner radius measurement & qualification of small features
Log Example

Inner wall rugosity

Readings on USIT radius and thickness measurements

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<th>USIT Amplitude</th>
<th>USIT Ave. IR and OR</th>
<th>USIT Min., AVE. &amp; Max. IR</th>
<th>USIT IR Image</th>
<th>PMIT Min., AVE. &amp; Max. IR</th>
<th>PMIT IR Image</th>
<th>USIT Min. AVE. &amp; Max. Thickness</th>
<th>USIT Thickness Image</th>
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Other Wireline Technologies for P&A

Cased Hole Formation Tester
- InSitu Cement Permeability measurement. Schlumberger patented procedure

Mechanical Sidewall Coring
- Cement samples from existing wells
Summary

- Various well integrity tools to address the needs of P&A:
  - CBL/VDL – Evaluate solids. Omni-directional (no azimuthal resolution)
  - Ultrasonic – Tubular & solids evaluation. Wellbore fluid & lightweight cement limitations
    - Ultrasonic-CBL combination in class G cements is normally satisfactory
  - Ultrasonic and Flexural Attenuation – Eliminates limitations imposed by traditional stand alone ultrasonics. Optimum results
    - Particularly useful in lightweight cements, thick casings and where TIE is required (if possible)

- New Technology
  - Ultrasonic-CBL/VDL and Multifinger Caliper combination – Tubular & solids evaluation + accurate mechanical radius data
Recommendations

- Take into account all of the possible leakage pathways that may exist within the well.
- Be cognizant that the best overall estimate of a well’s integrity comes from taking different types of measurements.

![Diagram showing different types of measurements: Multifinger Caliper Ultrasonic, Sonic Ultrasonic Sidewall Coring, Ultrasonic Cased Hole Mobility, Sonic Ultrasonic, Sidewall Coring.]
Questions

Thank you for your attention