Advanced Applications of Wireline Cased-Hole Formation Testers

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Agenda

Introduction to Cased Hole Formation tester

Tool specifications

Applications

Zonal Isolation examples
- Cement Integrity
- Formation Integrity
- Annulus investigation

Conclusions
Cased Hole Dynamics Tester (CHDT)

Designed to drill:
- through casing
- through cement
- into the formation

To measure:
- reservoir pressure
- take fluid samples
- downhole fluid properties

And to plug the hole:
- 10Kpsi bi-directional seal
Specifications

- Casing 5 1/2” to 9-5/8” (tool OD = 4 1/4”).
- Up to 6 holes drilled & plugged
- Hole diameter = 0.28”, penetration = 6”
- Max. temp. 175 degC / pressure 1375 bar.
- Plug pressure rating = 700 bar bi-directional
- Overbalanced or underbalanced operation (275 bar)
- Pretest volume = 100cc (re-cyclable)
- Low-shock PVT sampling*
- Downhole realtime fluid properties*
Advanced design

Plug in Casing
- 375 bar bi-directional metal-metal seal
- Radial expansion of cup as pin is inserted

Revolver
- 6 holes per run
- Max. 2 modules*

Packer
- Packers to cover casing range (5 1/2” to 9 5/8” OD)
- Consists of several layers of spring wire wound around a central mandrel
- Highly flexible in bending - torsionally stiff
- Small diameter: 3/16”
- Tungsten carbide bit
Applications

Conventional applications

- Bypassed hydrocarbons
- Multi-Layer reservoir pressure monitoring
- New wells with difficult conditions

Advanced applications

- Zonal isolation studies
- Stress testing
- Annulus pressure investigation
Case 1 – Testing isolation between zones

- Seawater injected to support production
- Tripling current injection rate will eliminate need for additional injection wells or workovers
- Poor cement coverage across injected formation and high permeability neighboring formation
- Several attempts to squeeze proppant and gel into the annulus unsuccessful
- Increase injection feared propagate and frac the cap rock

Tool conveyed with Tractor (62 deg)
Results

- CHDT showed communication between formations
- Maximum safely achievable injection-rate was estimated
- Injection rate tripling not possible
Case 2 — Testing communication between zones

- Deviated reservoir section completed with 7 inch liner
- Injection through A - formation
- Unknown connectivity between B and overlying A formation
- B formation potentially pressurized
- Future drilling plans through the B formation planned with equipment of limited pressure rating
- Max. deviation 81 deg, 45 deg at B formation. Tool conveyed with tractor
- Good cement identified through ultrasonic log
Case 2 - Testing lower B formation

Objectives

- Identify communication between reservoir under injection and lower intervals.
- Determine representative reservoir pressures

Lower B formation operational sequence

- A hole was drilled though the casing, cement and formation
- CHDT pressures monitored in real-time to allow injection sequences optimization
- Formation pressure observed after the drill bit penetrated casing, cement & formation
- Pretest taken to confirm the formation pressure of 291 bars
- Seawater injected at four different rates into the upper A formation
- Drilled hole was plugged and tested to 170 bar differential pressure
Case 2 - Testing lower B formation

No pressure response observed on the CHDT during injection, indicating that the lower B formation was not in communication with the A formation.

CHDT P = 303 bar

BHP cal = 309 bar

Max tubing BHP 535 bar, constant 291 bar at CHDT

CHDT P = 291 bar

After drilling

230 m³/hr Injection rate

Injection rate

Elapsed time (sec)
Case 2 - Testing upper B formation

Upper B formation operational sequence

- After drilling casing, cement and formation the pressure stabilized quickly at 317.5 bars, then slowly decreased.
- The same pressure fall-off was observed on the surface gauge.

- Two hours of injection into the upper A formation followed.
- The CHDT gauges reacted directly and consistently to the injection.

- Drilled hole successfully plugged off and tested.
- Upper B formation definitively in pressure communication with A formation.
Case 2 – Testing upper B formation

- CHDT P = 323 bar
- BHP cal = 324 bar
- Quartz gauge swapped to measure inside wellbore
- Match with BHP cal
- Fall off inside wellbore and CHDT
- Start injection, immediately pressure response
- After drilling, CHDT P = 317.5 bar
- BHP cal = 320 bar
- 2 hr Injection test @ 48 m³/hr
Case 2 - Testing communication between zones

- Maximum formation pressure in both upper and Lower B formation measured
- Barriers between lower B, Upper B and A formation redefined
Case 3, CHDT shale integrity testing

- Poor isolation due to bad cement job could result in plugging back and side tracking of this well.

- Overburden shales are relatively weak and prone to collapse in this field.

- If the weak overburden shale had collapsed around the casing and if it could be tested for integrity then it may be classified as a well integrity barrier, saving a sidetrack.

- Isolation Scanner used to identify collapsed shale. Then shale was “stress tested” with use of CHDT tool, confirming shale integrity and it’s average stress.
Case 3, CHDT Shale Integrity Testing
Case 3, CHDT Shale Integrity Testing

Pressure propagation

CHDT Gauge pressure

Volume

Flowline resistivity

Time (sec)
Case 3, CHDT Shale Integrity Testing

CHDT Stress Testing. Leak-off (Shut-in) Analysis

- Linear fit
- Fracture closes

Pressure, bar vs. SQR Delta Time, sec
Case 3, CHDT Shale Integrity Testing

The stress-testing results, confirmed over two cycles, suggested that:

- there is no communication through the annulus
- the collapsed shale provided zonal isolation. The results of the job satisfied the annular barrier regulations.

The operator did not have to side track the well.
Example 4 - Problem

Problem

- Wellbore annulus pressurized due to leaky cement
- Annulus production rate 2.7 l/min crude oil
- Unknown pressure behind 9 5/8" casing
  - Possibly too high for casing milling
  - Annulus fluid type unknown without pressure
  - Origin of the leak required fluid type
  - Bottoms up circulation, required for accurate fluid identification, would require over 1 year.

Solution

- CHDT on TLC to measure annulus pressure
- From depth & Pressure, the annulus fluid type and origin can be determined
Example 4 - CHDT station data

Seal test  
Formation penetration  
Drilling  

CHDT Probe Pressure, 0 - 300 bar  
CHDT Bit penetration, 0 - 2 inch  
CHDT Bit Force, 0 - 50 Kg
Example 4 - zoomed CHDT data

Stable annulus pressure, 269.3 bar

Pressure communication to surface established

Start Bleeding annulus pressure at surface

Annulus fluid was determined to be crude oil from the Brent reservoir
Conclusions

Cased hole formation testers have been successfully used for many formation testing and sampling applications.

The following Zonal Isolation examples were discussed:

- Cement Integrity
- Formation Integrity
- Annulus investigation