Spud To Reservoir With CWD / PDC Drill-Out Technology Using an Automated Drilling Rig

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Agenda

- Technologies
  - The rig
  - Casing while Drilling (CwD) bit
  - PDC drill-out bit
- The project
  - 2 Exploration wells
  - Drilling/casing plan
- Results
  - Nieuwendijk-1
  - Tiendeveen-1
- Conclusions
- Lessons
- See SPE 128219
Semi-Automated Drilling Rig

- Straight ‘out of the box’
- Containerised
- Small footprint
- Semi-automated pipe handler
- Singles rig
  - Horizontal set-back
- Touch screen driller’s console
  - Computerised auto-driller
- Casing drive tool
Casing while Drilling Bit

- Casing sub
- Rupture port
- Drillable steel alloy crown
- Nozzle
- PDC cutting structure
- Engineered internal profile for drill-out
PDC Drill-Out Bit

• Specialised PDC bit
• Two functions:
  – Drills out the CwD bit
  – Drills ahead
• Two sets of cutters
  – Tungsten carbide (TC)
    • Overexposed during drill-out
    • Drill out the CwD shoe
    • Protect the standard PDC cutters
    • Wear away in formation
  – PDC cutters
    • Exposed when TC cutters worn down after drill-out
    • Engages and drills new formation

8 1/2-in. Drill-out bit  6-in. Drill-out bit
The Project
Application

- 12-1/4" x 13-5/8" CwD bit
  - 4 blades, 13mm cutters
  - 4 x 14/32" nozzles
  - 780m to 2,075m (1,295m)

- 8-1/2" PDC drill-out bit
  - 6 blades, 16mm TC & PDC
  - 8-1/2" x 7" CwD bit
  - 4 blades, 13mm cutters
  - 4 x 14/32" nozzles
  - 2,075m to 2,500m (343m)

- 6" PDC drill-out bit
  - 4 blades, 16mm cutters
  - 4 x 14/32" nozzles
  - 0 to 780m (780m)
Spudding Nieuwendijk-1: 12 ¼-in. x 9 5/8-in. CwD Run
Results: 12-1/4 section – drilled with casing

- 12 1/4-in. hole drilled and cased simultaneously from surface to 780 m
  - 11 m/hr
- Planned v actual: 2.6 days v 4.4 days
  - 8 hr NPT
  - Bit balling
  - Slow connection times
- Auto-driller used to identify balling threshold
- The hole inclination at section TD was 0.63°
- Casing cemented through the nozzles successfully

12 1/4-in. x 9-5/8-in. CwD bit
Results: Drilling 8-1/2” section

- Drill-out bit run on a motor
- 12 1/4-in. CwD bit drilled out in 1.5 hr
- Drilled from 780 to section TD at 2075 m
  - 1295 m section length
  - ROP 7.4 m/hr
  - Offset required six bits: combined ROP of 7.0 m/hr
- Balling prevalent thru run
  - Auto-driller used to identify balling threshold
- Bit graded 1-1-WT-A-X-I-TD
- No damage to PDC cutters
Results: Running 7” casing

• After calling section TD the 7-in. casing run in hole
• Casing stood up at 1924 m – 151 m high
  – Depth coincided with a fault
  – Casing drive tool engaged
  – Casing reamed to bottom
    • 60 RPM, 0 to 20 klbs WOB, 800 lpm
• Casing cemented without issue
• There was a degree of geological uncertainty
  – The 8 1/2-in. CwD bit meant there was the capability to drill ahead
  – Option was not implemented

8 1/2 x 7-in. CwD bit
Results: Drilling 6” section

- Drilled out 8 1/2-in CwD bit in 13 min
- Drilled from 2075 to 2418 m
- Pulled early for a motor failure
- The bit was graded 1-2-WT-A-X-I-CT-DTF
  - The cutting structure was in excellent condition
  - Without the DTF, bit would have drilled to TD
- The well was completed with a standard PDC to 2677 m
Results: Well #2 (Tiendeveen-1)

- 17 1/2-in. x 13 3/8-in. CwD drilled from surface
  - 0 to 492 m
  - 33 hrs at 15 m/hr
- 12 1/4-in. PDC/drill-out bit
  - Drilled out the 17 1/2-in. x 13 3/8-in. CwD bit
  - Drilled from 492 to section TD at 2254 m
  - 1762 m section length
- 9 5/8-in. casing run on 12 1/4-in. CwD bit
- The 8 1/2-in. PDC/drill-out bit drilled out the 12 1/4-in. x 9 5/8-in. CwD bit
  - Drilled from 2254 to 2951 m
  - 697 m section length
  - Pulled for DTF
- Cumulative drilling length for CwD and PDC drill-outs was 2951 m
  - Longest achieved with this technology worldwide
Conclusion - General

• Nieuwendijk-1 was successfully drilled
  – Newly commissioned semi-automated drilling rig
  – CwD and PDC drill-out technology
  – 90% of the well drilled with this technology
• Completed & suspended inside AFE
• Included first CwD run in The Netherlands
• Motor failure stopped the entire well being drilled with CwD / PDC drill-out bits
• Total cumulate footage on two wells 5369 m
Conclusions - CwD

• Nieuwendijk-1 12 1/4-in. CwD run longest in the Europe using this system – 780 m
• The time taken to complete the 12 1/4-in. section with CwD was comparable using the same rig and conventional drilling techniques
• The 8 1/2-in. CwD bit ensured the 7-in. casing was set at depth saving 4.5 days NPT
• The 8 1/2-in. hole may still have been deepened even after casing had been run
• CwD enabled reduced tool/pipe handling and tripping events
Conclusions - Rig

• The automated pipe handling system and CwD BHA enabled a safe start to the well
• Less demanding than conventional drilling
  – Lower flow rates
  – Lower SPP
• Wells drilled using rigs with no set-back facility lend themselves to CwD techniques
  – The picking up and lying down of singles
  – Making up/breaking down of a conventional BHA
  – All add additional time to the operation
    • 2.1 days for a round trip using conventional drilling BHA
Conclusions – Drill-out PDC

• On both wells CwD bits were drilled out with drill-out PDC bits without incident
  – 5 drill-outs over the two wells
  – Less than an hour (average)
• The drill-out feature protected the primary cutting structure during drill-out
  – No damage to blades or PDC cutters
• Outperformed conventional bits
  – The best offset well required six bits to complete a comparable 8 1/2-in. section
  – The combined ROP over these six bits was 7.0 m/hr
  – 7.4 m/hr achieved in one PDC/drill-out run
Lessons

- Computerized auto-driller
  - Identified balling threshold
  - Enabled optimised ROP
  - Allowed precise ROP staging-up
- CwD bit design recommendations:
  - Three-bladed configuration
  - Interchangeable nozzles
  - Relocate the burst disk
  - Increasing cutter size (13 to 16mm)
- Centralizer design recommendations
  - Reduced blade count
  - Smoother transition to blade OD
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