Rigless Well Abandonment

OISD Workshop 28th & 29th Dec 2016, Noida
Outline

- Permanent Well Abandonment - Overview
- Global P&A Standards - Comparative Analysis
- Rigless P&A
  - Outline procedure
  - Compliance with standards
  - Advantages and Limitations
- Case Study
Permanent Well Abandonment - Overview

Why?

- Prevent hydrocarbon leak on surface
- Isolate permeable zones to prevent crossflow
- Prevent contamination of freshwater aquifers
- Enable removal of mechanical installation below surface / seabed
- Regulatory requirement for site restoration

Applicable

- Exploration or Appraisal Well
- End of economic life
- Not operated / required for the purpose
Permanent Well Abandonment - Overview

- Critical Requirement Prior to P&A
  - Cement top cover the previous casing shoe
  - Good cement bond at least 100 m above and below porous zone
  - Multiple permeable zones have good cement above and below
  - Surface casing is cemented upto surface
Permanent Well Abandonment - Overview

- **P&A Requirements - Open Hole**
  - Cement plug across hydrocarbon zone
  - Cement plug across casing shoe OR Bridge plug 15-30 m above casing shoe
  - Squeeze cement across casing failure
  - Perforate Prod & Intermediate Casing to place 50m of cement in both annuli
  - Recover casings
  - Surface plug of 60m below GL / MLS
  - Pressure test and Weight test the cement plugs. Fill up the well with drilling fluid
Permanent Well Abandonment - Overview

- P&A Requirements - Cased Hole
  - Cement plug across hydrocarbon zone
  - Spot cement above completion packer
  - Isolate liner lap with cement plug across the top of liner and inside
  - Perforate Prod & Intermediate Casing to place 50m of cement in both annuli
  - Recover casings and conductor
  - Surface plug of 60m below GL / MLS
  - Pressure test and Weight test the cement plugs. Fill up the well with drilling fluid
Global P&A Standards

USA

- Bureau of Safety & Environmental Enforcement (BSEE) - Decommissioning Guidance

UK

- Oil & Gas UK - Guidelines for suspension and abandonment of wells

Norway

- NORSOK standard D-010 - Plugging, abandonment and suspension

India

- Oil Industry Safety Directorate (OISD) STD-175 - Well Abandonment
Global P&A Standards - Verification of Barriers

**BSEE**
- Weight Test - 15000 lbs
- Pressure Test upto 1000 psi
- Inflow Test

**NORSOK D-10**
- Tag test
- Pressure Test upto 500 psi above LOT
- Inflow Test

**O&G UK**
- Weight Test - 10 to 15000 lbs (Tag test with wireline / CT is acceptable)
- Pressure Test upto 500 psi above LOT
- Inflow Test

**OISD**
- Weight Test 8 MT (17600 lbs)
- Pressure Test 500 PSI or 80% of LOT for Open Hole
- Pressure Test 1000 psi for cased hole

**BSEE** has recognized Weight test is not feasible in Rigless operations.

**OISD** recognizes not doing weight test on case to case basis.
Global P&A Standards - Rigless P & A

**BSEE**

- BSEE recognizes Rigless Abandonment with recommended procedure:
  - Circulate and Squeeze cement plug across permeable zones
  - Place balanced plug inside tubing and annulus by circulation into annulus
  - Cut and retrieve tubing from 150-300m
  - Place balanced plug across annuli to facilitate casing cutting and retrieval

**O&G UK**

- O&G UK recognizes Rigless Abandonment with following risk assessment:
  - Slumping of Cement due to deviation / eccentricity / radial clearances
  - Reliable verification of cement plugs inside tubing and annulus
  - Inconclusive wireline tag due to contaminated cement debris in tubing
Global P&A Standards - Rigless P & A

NORSOK D-10

- Indirect reference to Rig-less P & A - Removal of downhole equipment is not required if barrier requirement is met
- Recommends that methods should be established to install and verify position of plugs

OISD STD 175

- Consideration is given to rigless abandonment after proper risk assessment based on the proposal
Rigless P&A - Outline Procedure

- Establish injectivity into formation
- Pump calculated volume to cement to squeeze into formation
- Set bridge plug below packer depth
- Perforate above packer
- Circulate and place cement plug on top of packer
- Set bridge plug to appropriately place surface plug
- Perforate tubing and casing
- Circulate and pump surface plug
Rigless P&A - Outline Procedure

- Cut tubing and casing above surface plug
- Recover the Surface equipment X-Mas Tree, Wellhead etc
- Recover the tubing and casing with simple lifting equipment
Rigless P&A - Compliance with Standards

Abandonment Requirement

60 m length

GL or MLS

Drilling Fluid

Isolate packer or liner lap

30 m Above & Below

Surface Csg

Intermediate Csg

Production Csg

Drilling Fluid

Squeeze Plug

Rigless Abandonment
Rigless P&A - Advantages & Limitations

- **Advantages**
  - Extremely Cost Effective - Multifold reduction in cost
  - Applicable to wide range of wells
  - Meets most of the well abandonment requirements
  - Minimum footprint
  - Faster project delivery
Rigless P&A - Advantages & Limitations

- Limitations
  - Not applicable to ALL the wells - Wells with complication, multilaterals, horizontals
  - Weight test is not feasible
  - Limitations with verification of cement plug position specially in the annulus
  - Cement settlement along lower side in high angles wells
  - Cement plug integrity becomes questionable in presence of umbilicals
  - Requires better precision for cement calculations
Rigless P&A - Advantages & Limitations
Rigless Abandonment: Case study of onshore gas well

Well summary and status before permanent abandonment

<table>
<thead>
<tr>
<th>X-mas tree</th>
<th>3-1/8&quot; 5K WOM X-mas tree installed on 7-1/16&quot; x 3-1/8&quot; 5K bonnet assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wellhead</td>
<td>BHEL make conventional wellhead system</td>
</tr>
<tr>
<td></td>
<td>Casing Head Spool: 11&quot; 5k top flange x 9.5/8&quot; Casing (Slip-on weld),</td>
</tr>
<tr>
<td></td>
<td>Tubing Head Spool: 11&quot; 5k bottom flange x 7-1/16&quot; 5k Top Flange</td>
</tr>
<tr>
<td>Tubing Hanger</td>
<td>Tubing Hanger 7-1/16&quot; x 3-1/2&quot; NVAM B with 3&quot; BPV profile</td>
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<tr>
<td>13-3/8&quot; Conductor</td>
<td>13-3/8&quot; K-55 &amp; L-80 68# NSCC @ 114.4 m MDBRT</td>
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<tr>
<td>9 ½&quot; Casing</td>
<td>9.5/8&quot; N-80 47# NSCC @ 484.4 m MDBRT</td>
</tr>
<tr>
<td>7&quot; Casing</td>
<td>7&quot; 26# K-55 NVAM &amp; BTC @ 0-727 m MDBRT</td>
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<tr>
<td>Upper Completion</td>
<td>Single String Single Zone, 2-7/8&quot; 6.5 ppf NVAM tubing</td>
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<tr>
<td>Well Completion Details</td>
<td>7&quot; WH-6 Retrievable Hydraulic Packer(WFD)@ 540.25 m MD</td>
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<tr>
<td></td>
<td>1.87&quot; F Nipple (Weatherford) @ 560.99 m MD</td>
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<tr>
<td></td>
<td>X-over (2-7/8&quot; NVAM B x 2-7/8&quot; EUE P)</td>
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<tr>
<td></td>
<td>Perforated Pup Joint @ 562.46 m MD</td>
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<tr>
<td></td>
<td>1.82&quot; R nipple (Weatherford) @ 564.36 m MD</td>
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<tr>
<td></td>
<td>4-1/2&quot; 5 spf TCP gun (Confirmed failed to release from Auto release sub)</td>
</tr>
<tr>
<td>Shut-in tubing head pressure (THP) is ~640psi</td>
<td></td>
</tr>
<tr>
<td>Pay Zones depths &amp; Properties</td>
<td>Well was open to following pay zones:</td>
</tr>
<tr>
<td></td>
<td>B1c: 592-595 m MDORT, Expected Permeability: 250 md</td>
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<tr>
<td></td>
<td>B1b: 599-608 m MDORT, Expected Permeability: 500 md</td>
</tr>
<tr>
<td></td>
<td>B1a: 615-618 m MDORT, Expected Permeability: 350 md</td>
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<tr>
<td></td>
<td>Virgin reservoir pressure ~ 870 psi</td>
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<tr>
<td></td>
<td>Depleted reservoir pressure ~ 790 psi (recorded survey in Nov’11)</td>
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<tr>
<td></td>
<td>Depleted reservoir pressure ~ 720- 750 psi (basis - extrapolation from current THP) = 7.45 ppg formation pressure.</td>
</tr>
<tr>
<td></td>
<td>Reservoir temperature ~ 60-65°C (last recorded survey)</td>
</tr>
</tbody>
</table>
Rigless Abandonment: Concept selection and regulatory approval

Dispensation from OISD

- Waiver of weight testing requirement of cement plug set inside production casing/tubing
- The bottom most of the two DST zones (909-930m) were not isolated from open hole - 200 m Cement plug was placed from 927 to 727m.
Rigless abandonment: CB-X-1 well site lay out

CB-X-1 well site

List of Chemicals:
1) Cement & additives
2) Sodium formate brine
3) HEC & Xanthan Gum
4) LCM pill

Crossovers
Transfer pumps
Flame proof lights
Non-flame proof lights

12,3,4) CIL provided crossovers
5,6,7,8) Schlumberger provided crossovers
a) CIL provided Wilden pump for water
b) CIL provided Wilden pump for diesel

Emergency gate

Main gate

Security room

Office bunk

Bunk#1

Bunk#2

Bunk#3

40 KVA Generator 1

Diesel

Ambulance with Medic

Mud tank 1 (Brine)

Mud tank 2 (Water)

Cementing unit

Batch Tank

Slickline unit

1,2,3,4

Cellar

Existing pipeline

Waste pit 1

Waste pit 2

Crane
Well Killing and Cementing - Surface line up

Note
- Based on operational requirement to line up cementing unit to B-annulus, Connection to A-annulus was broken and used for B-annulus.
Operations: Well Killing and Plug# 1 placement

- Verified integrity of A-annulus & B-annulus
- Well killing was planned by bullheading
- Attempted to kill the well by pumping kill weight brine multiple times - Observed gas percolation and subsequent THP build up
- Placement of viscous pill across the perforations delayed gas percolation
- Punched tubing above packer to establish communication to cater to any contingency during Plug# 1 placement
- Placed cement plug#1 (squeeze plug) from 528 to 618m
- Verified Plug#1 by pressure test and tag test with slickline
Operations: Placement of Cement Plug# 2 & 3 and final P&A

- Placed cement plug#2 (displacement plug) from 425 to 528m in both tubing and A-annulus
- Verified Plug#2 by pressure test and tag test with slickline
- Perforated 2.7/8” tubing and 7” casing from 173.8m - 179.8m
- Established circulation from tubing side to A-annulus side
- Placed cement plug# 3 from 10m to 180m
- Verified the cement plug#3 by pressure test and tag test with conventional slickline at 10m
- Gas cut windows in casing in 9-5/8" X 7", cut 2 7/8" tubing. N/D X-mas tree and wellhead
- Fill the half cellar with cement and cover with soil
Operations: On site view

Fig: Surface cement plug