An introduction to well intervention

SPE Aberdeen monthly evening meeting
Jim Wright, The Douglas Hotel, 25th January 2011
Industry sector context

Oil

- Oil production continues to grow
  - Western Europe and North America mature basins in production decline
  - Reduction in discovery rates
    - “Easy” giant fields are now mature

- Peak Oil
  - Generally predicted on accessible reserves today.
  - Does not cater for new technology and demand
  - Previously inaccessible deepwater reservoirs shall be tapped

Source: The World Oil Supply Report Douglas Westwood
Industry sector context

Gas

- Gas production continues to grow
  - Eastern Europe & FSU dominate market
  - Potential peak is much later than oil

- Bridge carbon based energy supply to renewable
  - Abundance of natural gas
  - Cleaner energy

2011 UKCS

- Exploration activity fell to lowest level since 1960’s

- Only five new fields came on stream (smallest annual addition in UKCS history)
What is well intervention?

Well intervention

- An operation carried out on an oil or gas well to extend its producing life by improving performance or providing access to stranded or additional hydrocarbon reserves

- Typical interventions services include,
  - Wireline
  - Tractors
  - Coiled Tubing
  - Hydraulic Workover
Wireline

History

- Mechanical slickline was formerly known as measuring line
  - Flat tape with depth increments

- Schlumberger brothers considered the inventors of electric logging in 1927.
## Wireline

### Slickline wire

<table>
<thead>
<tr>
<th>Nominal diameter</th>
<th>Material / Type</th>
<th>Breaking strain</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.108&quot;</td>
<td>UHT Carbon Supa 75</td>
<td>2730 lbs 2100 lbs</td>
<td>Poor corrosive resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sour gas applications</td>
</tr>
<tr>
<td>0.125&quot;</td>
<td>UHT Carbon Supa 75</td>
<td>3665 lbs 2700 lbs</td>
<td>Poor corrosive resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sour gas applications</td>
</tr>
</tbody>
</table>

### Braided wire

<table>
<thead>
<tr>
<th>Nominal diameter</th>
<th>Material / Type</th>
<th>Breaking strain</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/16&quot;</td>
<td>Conventional Dyform</td>
<td>11,000 – 13,490 lbs 13,560 – 17550 lbs</td>
<td>Very high breaking force gives the operator better margins when carrying out fishing operations.</td>
</tr>
</tbody>
</table>

### Electric line wire

<table>
<thead>
<tr>
<th>Nominal diameter</th>
<th>Material / Type</th>
<th>Breaking strain</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/32&quot; Poly cable</td>
<td>Mono conductor cable</td>
<td>Typically 5200 lbs</td>
<td>Cable type will depend of well conditions and operation conducted</td>
</tr>
<tr>
<td></td>
<td>widely used for e-line operations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5/16&quot; Poly Cable</td>
<td>Commonly used for logging and perforating</td>
<td>Typically 11,000 lbs</td>
<td>Cerberus modelling with determine wire selection.</td>
</tr>
</tbody>
</table>
Wireline

Slickline applications

- Gauge Cutter / Centraliser runs. (Establish the well bore is clear from restriction)
- Setting / Pulling plugs
- Setting / Pulling gas lift valves
- Bailing sand and debris
- Bottom hole pressure and temperature surveys. (Memory)
- Shifting sleeves

Braided line applications

- Utilised where additional pulling force is required:
  - Fishing operations
  - Conveying heavy toolstrings
  - Deeper access

Electric line applications

- Provides real time communication from well to surface
- Unparalleled depth control
  - Logging
  - Ballistic operations
  - Zonal isolation
  - Well integrity
Wireline

Unit components - Slickline

Winch Unit

Wireline Mast

Bottom Sheave

Measuring head
Wireline

Primary Well control
- Stuffing Box (Slickline)
- Grease Head (Braided/Electric line)

Secondary Well control
- BOP c/w Dual blind rams
  - Slickline
- BOP c/w inverted dual blind rams
  - Braided/Electric line
  - Grease injection between rams

Tertiary Well control
- BOP c/w Shear Ram
  - In the event tree MV cannot shear wire
Tractors

History

- Deviated or horizontal wells now common place
  - Slickline relies on gravity for well access

- Tractors introduced in 1996
  - Provides driving force at the end of the wire via traction wheels
  - Speed and force dictated by number of drive sections

- Mechanical Services introduced in 2003

- Coiled Tubing Tractors
Tractors

History

Wireline Tractor Introduction

Mechanical Services Introduction

* Images and text courtesy of Statoil
Tractors

Unit components

- Electrics
  - Powered from surface through wire
  - Control for motor & pump

- Motor & Pump
  - Generates hydraulic flow and pressure

- Wheel section
  - Provides axial force at end of wire
  - Typically 500lbs per section

- Compensator
  - Caters for oil pressure increase and keeps pump primed

![Diagram of Tractor Unit Components]
Tractors

Applications

- Well access
- Mechanical applications introduced in 2003
  - Scale milling
  - Brushing and polishing
  - Manipulation tools
  - Debris removal
  - Logging while Tractoring
- Bi-directional Open hole tractor
Coiled tubing

History

- **Pipeline Under The Ocean (PLUTO)**
  - Allied invasion in 1944
  - 3in pipelines, 70km long
  - Supplied fuel to allies in Europe

- **1st oilfield application in 1962**
  - 15,000ft, 1.315in OD
  - Sand bridge cleanouts
Coiled tubing

Applications

- Vertical, deviated and horizontal wells on both land and offshore:
  - Fluid displacement
  - Logging
  - Perforating
  - Stimulation
  - Remedial cementing
  - Setting, retrieving bridge plugs
  - Fishing
  - Mechanical removal of blockages (milling)
  - ........plus much more!!
Coiled tubing

Unit components

- Coiled Tubing
- Control Cabin
- Power Pack
- Ancillary Equip,
- Tubing Reel
Coiled tubing

Coiled tubing string design

- **Continuous length of pipe**
  - 1 1/2” – 3 ½” OD
  - Typically 22,000ft long

- **Tapered ID design**
  - To withstand combination of forces in hole
  - Adequate stiffness “lock-up”
  - Plastic deformation consideration
  - Circulation rates and pressures
  - Logistic considerations
Tubing guide arch & injector head

Function

- To support, straighten and align the tubing into the injector head
- Provides the surface drive force to run and retrieve the tubing

Design Consideration

- Arch radius should be at least 30 times tubing OD (API 5C7)
- Must withstand the loading caused by reel back tension
- Must withstand side loading caused by fleet angle
- 120% of max force expected pull the tubing from the well (API 5C7)
- 120% of max force expected to snub the tubing into the well against wellhead pressure (API 5C7)
Pressure control equipment (PCE)

Function
- Stripper provides dynamic primary seal around the tubing during tripping and a static seal around the CT when there is no movement
- BOP provides secondary wellbore pressure containment and facilitates tubing severance, tubing support and seals around the tubing

Design Consideration
- Rated working pressure must exceed maximum anticipated surface pressure
- Stack-up height. Ram configuration to suit application
- Pipe severance under anticipated conditions
Hydraulic Workover (HWO)

History

- Mr R H.C. Otis Snr. designed and built first unit to run pipe under pressure in 1929
  - Rig “snubbed” pipe in via series of chains and pulleys

- 1st generation HWO unit introduced in the 1960’s.
  - No requirement for rig
  - Typically run pipe in singles

- Rig assist (RA) units returned in late 1990’s to support UBD activity
  - Hydraulic jacks
Hydraulic Workover (HWO)

Applications

- Through tubing intervention – washing, unloading, stimulation etc. etc.
- Milling inside tubing or casing
- Running or pulling production strings
- Through tubing drilling (over or under balanced)
- Abandonment
- Deploying perforating guns under pressure
- Blowout recovery operations
Hydraulic Workover (HWO)

Unit components

- **Ginpole & winch**
  - Facilitates a crane boom
  - Picks up tubing joints to the work basket
  - Not required for Rig Assist Units

- **Travelling Slips**
  - Two sets of slips to cater for pipe heavy and light scenarios
  - Incorporates rotary head

- **Work Basket**
  - Accommodates crew and unit controls
Hydraulic Workover (HWO)

Unit components

- **Hydraulic jack**
  - Provides the appropriate force to run and pull tubing string
  - Typically <600klbs

- **Stationary slips**
  - Holds tubing string when travelling slips are disengaged

- **Annular BOP**
  - Secondary well control when stripping/snubbing pipe

- **Stripper 1 & 2**
  - Primary well control when snubbing/stripping pipe
  - Equalising loop for running upset joints/collars

- **BOP’s**
  - Tertiary well control
  - Pipe/Blind/Pipe
Hydraulic Workover (HWO)

The stripping process:

1. # 2 closed - Lower Tool Joint
2. Close #1
3. Equalize
4. Open # 2
5. Lower Tool Joint
6. Close # 2
7. Bleed Off PSI
8. Open # 1 & Lower Tool Joint
Service positioning

Intervention class

Heavier

Lighter

Intervention cost $

Lower

Higher

Slickline

HD fishing

Coiled tubing

E-line Tractor

RA Unit

HWO
Recent/Future developments

Subsea

Development of service units
- Cat B – heavy intervention rigs
- Cat A – intervention mono hull vessels

Conveyance challenges
- Fatigue management

Real time data
- Digital slickline
- Real time coiled tubing

Product development
- Well integrity/abandonment
- Composite SL and CT
  - Lighter, less friction
- Riserless coiled tubing
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