Extended Reach Drilling

- Discussion of the State of the Art, Present Limitations, Completion, Fishing and Workover Tools & Techniques and Critical Safety Issues

Steve Walls

Definitions of ERD

- Throw ratio > 2:1
  - HD/TVD
- ER Projects typically break into four groups:
  - Ultra Long ERD
  - Very Shallow ERD
  - Deepwater ERD
  - Small Rig ERD

General Limitations

- Traditional Challenges have been mostly overcome
- Remaining Ones are Toughest
  - ECD
  - Ultra Deep Casing Runs
  - Practices
    - Design
    - Implementation

ERD Performance

- ERD: Just reaching the objective
- Time & Cost Performance
- New Benchmarks
  - Fit-for-Purpose Solutions
- ERD Solutions: Alternatives
  - Subsea Tiebacks
  - Another Platform
  - Increased Footprint

Ultra-Long ERD Wells

- Where are these wells being drilled?
  - US: GoM, California, ANS
  - West Africa, Canada, North Sea
  - China, Australia, New Zealand
  - SE Asia: Thailand, Malaysia, Indonesia
  - Russia
  - Argentina, Venezuela

Ultra-ERD Characterization

- Throw Ratios up to 6:1
- Build/hold to 80º
- Negative weight: ½ of the HD
- Special techniques: logs, casing
- Nuclear drilling
  - TDS-4 minimum, XT conn
  - 3 or 4 1600-hp pumps
  - 5.5”, 5.875” drill strings

What Does It Take?

- Extensive Planning: 9-12 mo/well
- Lead Times (Drill Pipe 1 year)
- Rig Availability & Modifications
  - HP, HT, space, setback loads
- Training for THAT well
  - Office & Operations teams

Available Technologies

- Casing Flotation
- Downhole Adjustable Stabilizers
- Rotary Steerable Systems
- Walking PDC bits
- Mechanical torque/drag reducers
- Wireline tractors
- Hole condition monitoring systems
- HT top drives and tubulars

ERD Performance

- Case History: Real Learnings
- 1992: 15980' MD
  - Drlg: 400 hrs NPT: 175 hrs
- 1994: 16018' MD
  - Drlg: 250 hrs NPT: 50 hrs
- 1996: 16400' MD
  - Drlg: 260 hrs NPT: <10 hrs

CH 2: Best Performance

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- 1995-1996
  - 16,500' MD: 35 days
  - 20,500' MD: 55 days

Operational Training

- Before Training
  - 14,500' MD: 60 days
  - 16,000' MD: 95 days
  - 17,800' MD: 108 days
- Project-Specific Training
  - 21,000' MD: 110 days
  - 22,000' MD: 108 days
  - 25,000' MD: 140 days
  - 24,000' MD: 93 days

Deepwater ERD

- Same considerations as Shallow
  - ECD is primary limit
- Present wells
  - Comfortably within 2.5:1 ratio
  - 15,000' step-outs, 6000' TVD
  - Primarily from SPARs
- Deepest WD to date: 5400'
- Record: 6000' TVD, 21,000' step-out (WD was 1200')

Small Rig ERD

Typical:	ERD Rig	Small Rig
DW:	2000 hp	<1500 hp
MP:	4000+ hp	2-3000 hp
Circ:	7500psi	4000 psi
TD:	60k ft.lbs	28k ft.lbs
Mud:	>3000 bbl	1000 bbl
Setback:	Plenty	Not Enough

Finesse Drilling

- Offshore California: 1999
- Small "workover" rig
- 5" drill pipe
- Portable top drive
- 2 850-hp mud pumps
- 750-bbl active mud system
- Not enough setback or casing storage

Project Concerns

- Setback Limits
  - Space and fingerboard size
  - Weight on sub and jacket
- Pipe stretch exceeded head room
- Pipe Rack Storage
  - Casing run off the boat
  - Managing multiple strings
  - Simultaneous setback limits

Operational Limits

- Catheads, Iron Roughnecks (HT)
- Rig Power
  - Impossible to backream at TD
  - Max: Pumps, Top drive, Lifting
- Design Limits: Overpulls gone
- Mud systems: shipped whole mud
- Solids handling, small volume
- Circ: Flowrate, pressure limits

Project Results

- Record California Well
- 19,555' MD
- 79º Tangent section, drop @ TD
- 3º/100' build
- 16,000+' HD
- 8,000'+ TVD

Completion Techniques

- Pre-Drilling Consideration
  - Well: designed for the completion AND future interventions
- Tubular logging, perforations
- 8500' slotted horizontal liner
- Wireline, CT tractors
- Intelligent completions, particularly for multiple pay sections

Interventions

- Three Main Technologies
  - **Jointed Tubing**
  - **Live Workovers (Snubbing)**
  - **Coiled Tubing Units**
- Wireline Options typically limited
  - **Wheeled Tools, Tractors**
- Primarily are System Failures
  - **Corrosion, Sand Control, failed packers (Annular pressure)**

Fishing Considerations

- Wellbore friction constraints due to tortuosity, wellbore stability
- Jar placement is of prime importance in ERD wells
- Computer program placement instead of rules of thumb
- Required at the start: Risk Management Analysis
  - **Sidetrack Planning Team**
  - **Are the Take Points Firm?**

Jar Placement

- Longitudinal Stress Wave Theory
  - **Foundation of Jarring Programs**
  - **Impact and Impulse**
- Stress Wave Reflection
- Jars need to be optimized for both down-hits and up-hits, depending on the anticipated problems
- Two-piece jars can be useful

General Fishing Rules

- DLS>15º/100': don't operate jars in this environment due to stresses
- Jars below build/turn section: As much as 50% of the axial load can be lost due to wellbore contact
- Jars above build/turn section: Stress wave reflections are less, resulting in lower impulse.
- Anticipate (experience)

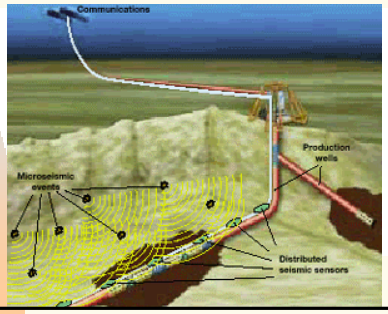
Intelligent Wells

- Fundamental: downhole process control
  - Realtime (or near-RT) surveillance, interpretation and actuation
  - Accomplished through downhole measurement and remotely controlled zones (versus surface)
- "Dumb" wells: provide no data or control except through CT, wireline or jointed tubing interventions

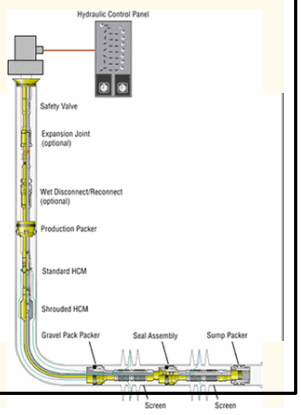
Converging Technology

- Smart wells Just In Time
  - ERD-ML, Horiz Drlg achievements
  - Fewer but larger tubulars
  - Sand control & stim improvements
    - 50 bpm @ 15000 psi frac-pacs
  - Pre-completion of multiple pays
    - Draining multiple reservoirs
  - Co-mingled production

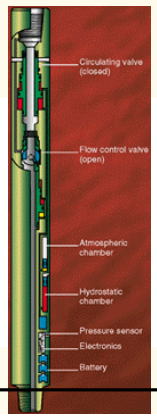
ABB Smart Well Concept

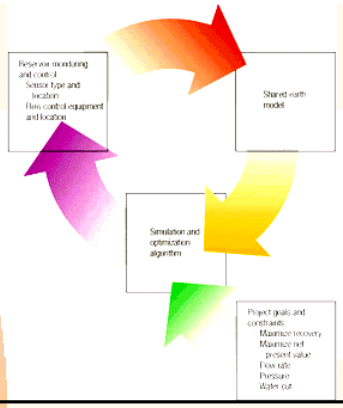


Baker In-Force System



Schlumberger IRIS (Intelligent Remote Implementation System)





Future Intelligence

- ADMARC system being tested

Critical Safety Issues

- Consider the Operations
- HP Circulating Systems
- Multiple handling of Tubulars
- Exposures to exotic fluids
- SBM BMP: compliance systems
- Storm planning, ops disruptions
- Rushed planning implications

Summary

- Viable ERD projects are now being undertaken from small rigs, in deepwater & with very long HDs.
- Current technologies answer most of the limitations of ERD. Those limitations which remain are very significant challenges.
- ERD through specific design and implementation practices is an absolute must.