Fluid dynamics & casing design induces limitations for P&A operations

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Operating envelope within:

- True Vertical Depth (TVD) / Pressure requirement
- Measured depth / Length of well (MD)
- Casing size’s & depts.
- String ID and OD
- Fluid system
- String RPM
- Total Flow area (TFA)
- Flow rate
- Pump pressure (SPP)
- DP pressure drop (typical 70 % of SPP)
- Pressure drop over down hole tools/nozzle’s
- Equivalent circulating density (ECD)

Geology - Fixed

Early choices – changeable “fixed”

Variable parameters

Output values
Fluid dynamics – prediction with use of Virtual Hydraulics™

To predict and simulate how all the different variables interact with each other Schlumberger use the proprietary software Virtual Hydraulics™.

Virtual Hydraulics™ calculates the effect of fluid dynamics in the wellbore taking into account multiple variables as different casing size, drill pipe and nozzle sizes. In addition to this the viscosity profiles and fluids physical appearance seen across the entire well bore with temperature and pressure.

With the use of Virtual Hydraulics™ an optimum solution for drill pipe selection, pressures and ECD for both drilling and P&A can be predicted.
Today’s operations

Plugging back wells that have manageable challenges;

- Casing design and setting depths
- Drill pipe selection
- Fracture gradient (ECD) & Pore pressure – ok window
- Pump pressure
- Pressure drop over DP & down hole tools/nozzle’s
What are the changes in coming P&A operations?

The ECD requirements and pressures during an P&A can be very different compared to drilling the section years before.

And very different from P&A operations today; the long complex wells drilled today will be a challenge.

So, for Tomorrow’s P&A operations do we have the equipment and operating window to do a safe and efficient P&A operation?
Tomorrow’s P&A operations

Plugging back wells that have limiting factors as;

✓ Extended reach casing design
✓ Drill pipe size and length
✓ ECD limitations - Losses
✓ High pump pressures - Pump pressure limitations
Virtual Hydraulics™ Comparison

**Todays P&A**

- **MD/TVD (ft):** 13,625
- **Csg OD/ID (in):** 5.508
- **Drilling Fluid:** Water-Based Mud
  - **Mud Weight:** 14.5 lb/gal
  - **Test Temp:** 122 °F
  - **PV (@122°F):** 31 cP
  - **YP:** 81 lb/100ft²
  - **LSYP:** 17 lb/100ft²
- **Flow Rate:** 380 gal/min
- **Penetration Rate:** 0 ft/hr
- **Rotary Speed:** 80 rpm
- **Weight on Bit:** 0 1000 lbf
- **Bit Nozzles:** 6-6-6-6-6
- **Pressure Losses:**
  - **Drill String:** 4181 psi
- **System Data:**
  - **System Pressure:** 2147 psi

**Tomorrows P&A**

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  - **Drill String:** 5446 psi
- **System Data:**
  - **System Pressure:** 5446 psi
Thoughts for change..

- Include P&A mindset in drilling design!
- Build & Design of P&A tools for the future
- Deeper casing setting depths
  - Pressure requirements
- Liner substitute casings
  - Require different casing type/spec
- Change in DP configuration
  - Larger pipe → lower SPP but higher ECD
- Topside equipment – pump capacity
- Low ECD P&A fluids
Fluid systems – a variety of choices

- Conventional WBM
- Milling WBM
- Brine based WBM

- Conventional OBM
- Milling OBM
- Specialty OBM
  - Low ECD, Low sag,

Fluid systems optimized per section/well – based on ECD requirements
we have the fluids – do you have the tools?