HALLIBURTON

Deepwater Displacements Issues and Drivers

October 11, 2006

Deepwater Displacement

What's Different?

- **Large volumes**
- **Planning and logistics**
- **Vessel variable deck load issues**
- **Riser requires high pump rates**
- **Recesses in sub-sea stack / jet riser**
- **Clean-out assembly design**
- **High rig rates**
- **MLT – cold temperature rheologies**

Deepwater Displacement

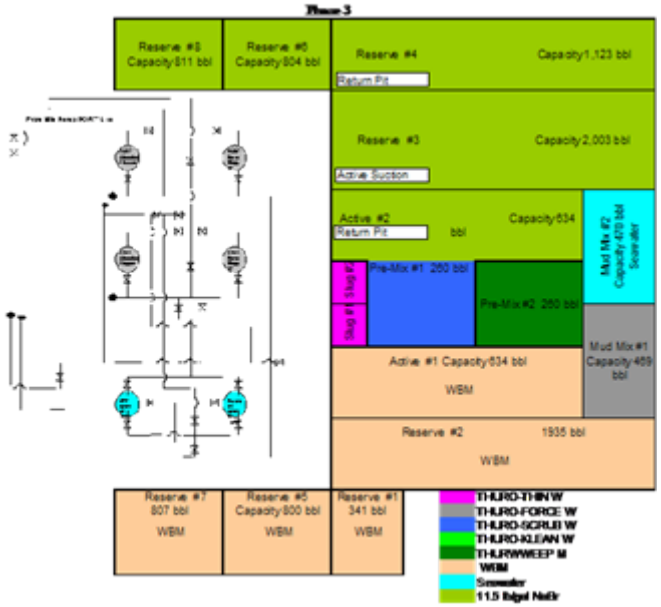
Basic Techniques

- **Single Stage**
  - **Displace entire well – riser & well-bore**
    - **Direct**
    - **Indirect**
- **Two Stage**
  - **Riser and well-bore displaced separately**
  - **Riser typically indirect**
  - **Well-bore can be direct or indirect**
  - **Requires 2 spacer trains (riser and well-bore)**

Deepwater Displacement

For All Techniques

- **Pit Management Plan**
  - **Large volumes - 2,000 to >4,000 bbls**
    - **Both drilling and completion fluid systems**
    - **Pit management plans for each operation**
    - **Some rigs may not have capability to handle both**
  - **Place premium on embedding time**
    - **Surface cleaning**
    - **Spacer preparation**
  - **Transfer rates**
    - **Where will fluids be**
    - **How quickly can be transferred to active system**



Deepwater Displacement

Single Stage Issues - Direct

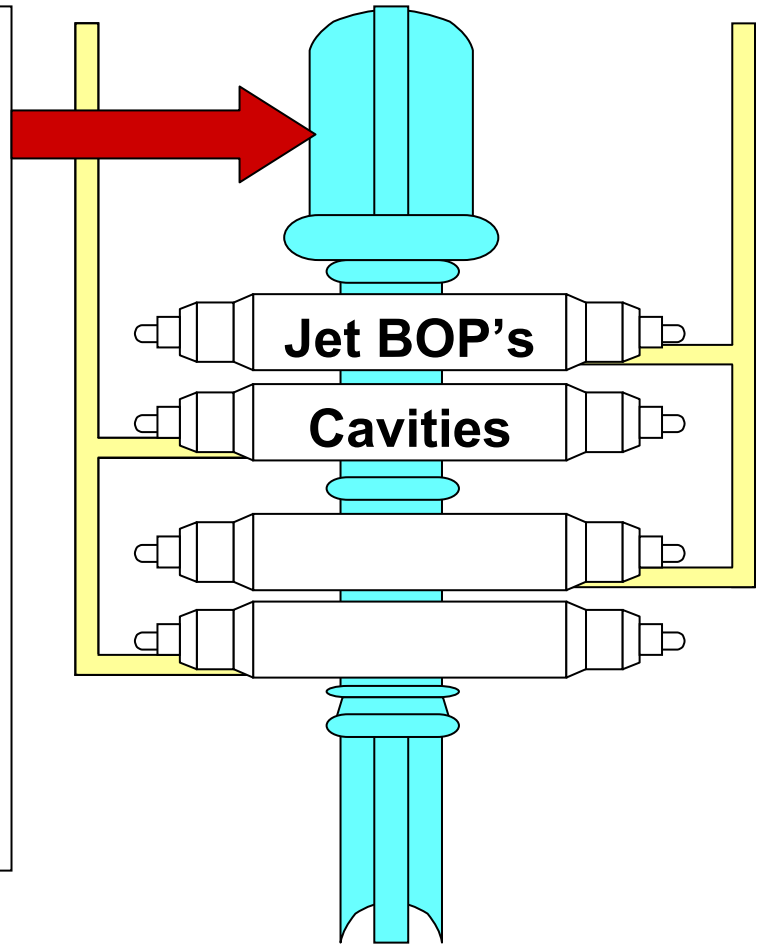
Riser AV's
Typical deepwater riser
5⅞" x 21" = 0.345 bbl/ft

Minimum 100 ft/min AV
Pump Rate = 34.5 bbl/min

Desired 150 ft/min AV
Pump Rate = 51.8 bbl/min

Field scenario @ 45 bbl/min
HHP ~2,100

Designing the spacer train in concert with flow properties is critical

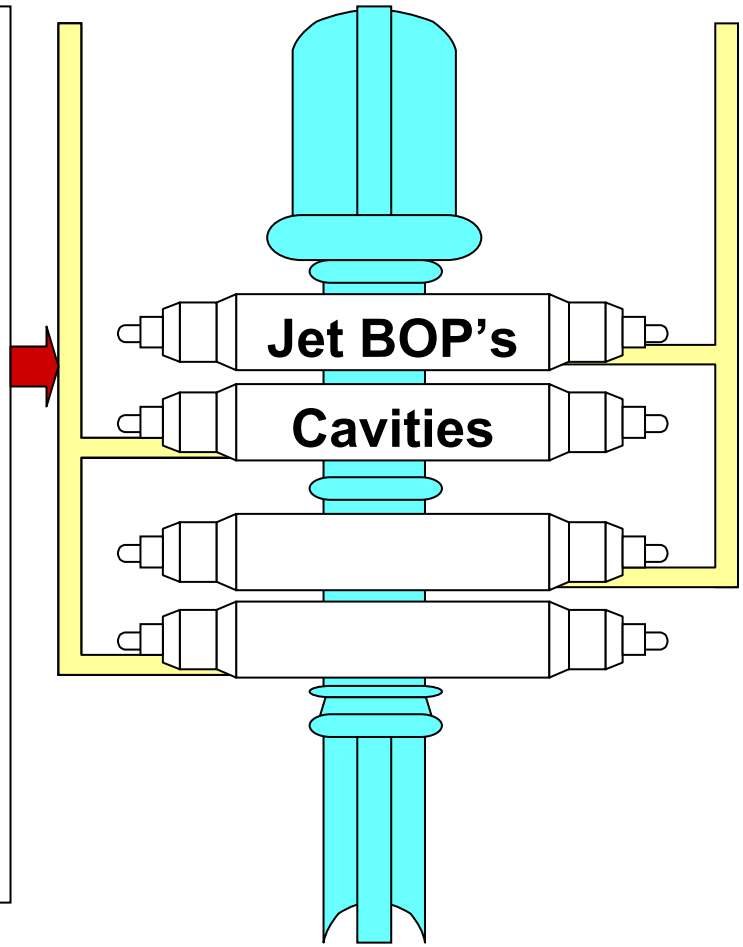


Deepwater Displacement

Single Stage Issues - Direct

Need choke, kill, and boost lines

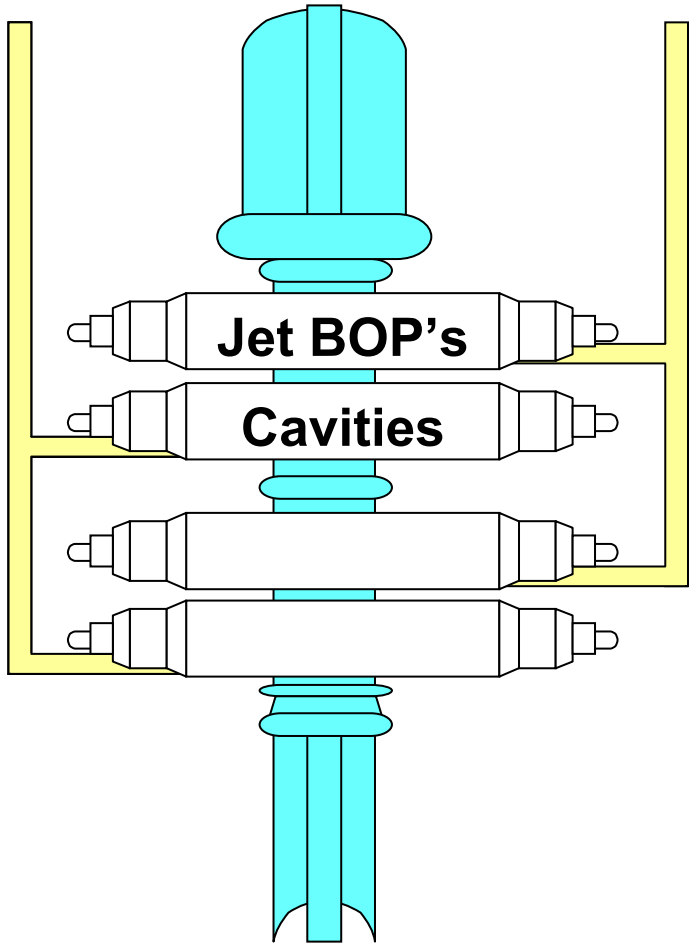
- **Parking spacers – possible issue with solids in valve area**
- **Flush mud thinner into BOP's**
- **Park viscosified spacers in CK&B**
- **Parked spacers pumped into passing spacer train**
- **Compatibility issues**



Deepwater Displacement

Single Stage Issues - Indirect

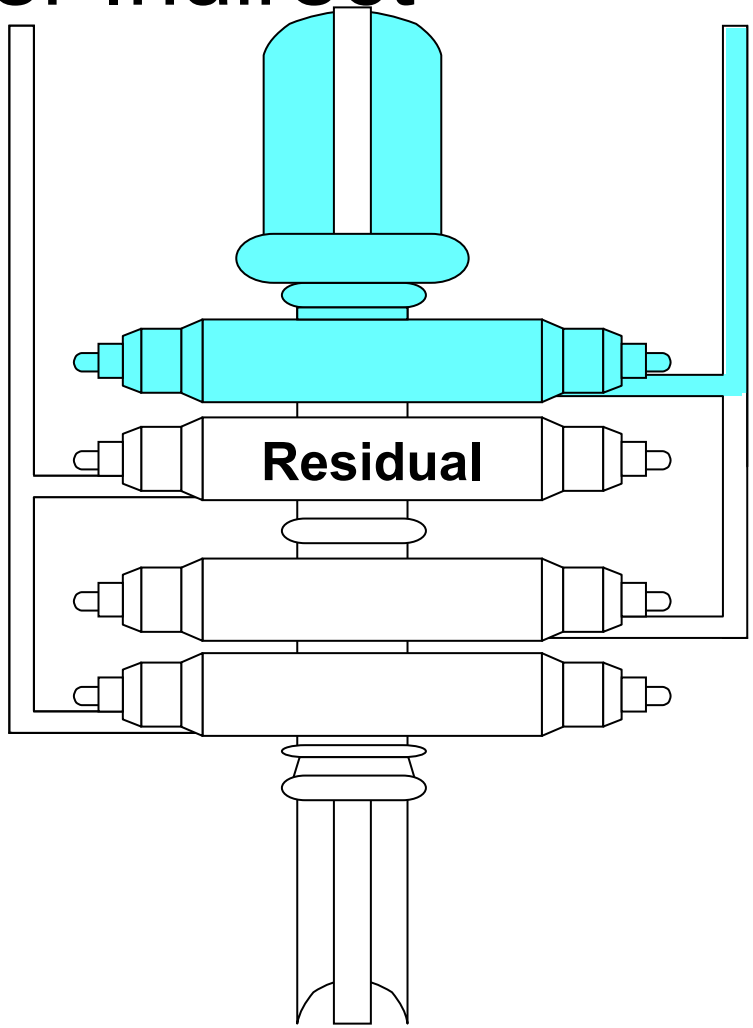
- **Displace to seawater - then to completion fluid**
  - **Underbalance**
  - **In-flow test for liner tops**
  - **Lower risk of failed displacement**
  - **More rig time = cost**
  - **Embed, if possible**
  - **If SBM – O&G limitations on seawater**



Deepwater Displacement

Two Stage – Riser Indirect

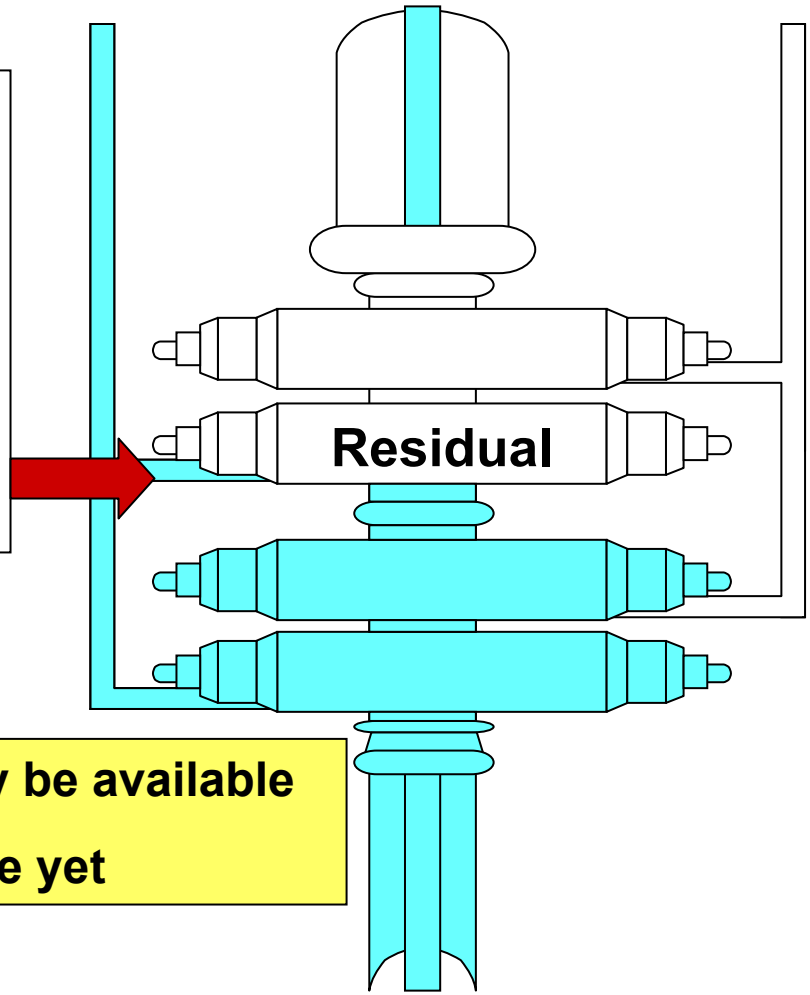
- **Displace to seawater - then to completion fluid**
  - **No under-balance issues**
  - **Can often be embedded**
  - **Residuals in sub-sea stack**
  - **No rotate and reciprocate**
  - **Mud cold temp rheologies**
  - **If SBM – O&G limitations on seawater**



Deepwater Displacement

Two Stage – Well-bore Direct

- No rotation and reciprocation of DP
  - Problem for deviated wells
- Once riser and well are displaced open BOP's and jet riser
- Upper/lower C&K jumpers



R&R tool may be available

No field usage yet

Deepwater Displacement

Rig Capabilities

- **Can often drive displacement design**
  - **Can rig handle both fluid systems**
  - **Is enough HHP available**
  - **Pit management and fluid systems management are critical**
  - **Personnel experience and rig familiarity**
  - **Filtration capabilities and management**
  - **Deck space management**

Deepwater Displacement

Other Factors

- **Safety**
- **Environmental**
- **Weather**
- **Transportation turn-around times**

Objectives

- **Clean well bore in <2 circulations**
- **Data collection**
- **Lessons learned**

Deepwater Displacement

Field Example

- **Drilled with SBM**
- **Displaced to WBM for running tiebacks**
- **Spacers designed to remove SBM residual**
- **Single stage modified-direct displacement**
- **Limited volume of seawater within casing collapse risk**
- **Mud returns, part captured-part overboard**

Deepwater Displacement

Field Example

- **Why single-stage modified-direct**
  - **~4,000 bbl hole volume**
  - **Rig pit capacities ~10,000 bbls**
  - **Total HHP available 4 - 2,200 HHP pumps**
  - **Maximum 6,500 psi pump pressure**
  - **Mud can be discharged**
  - **Rig has capabilities to displace direct**
  - **Time analysis assessment less time versus indirect**