The Dual Gradient Drilling System

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Riser at Seawater Gives Full DGD Effect

Seafloor

Depth

Pressure

Seawater Hydrostatic

Fracture Pressure

Pore Pressure

Dual Gradient Density at TD

TD

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Chevron Prefers Positive Displacement Pumps

- **Seawater Hydraulically Powered**
  - Power generated on surface - minimal electrical power below surface

- **Riser Margin**
  - System has riser margin (most of the time), so well is dead

- **Positive Displacement Pumps**
  - Improved overall well control capabilities
  - Due to design of pumps, the pump can’t suck on well – well must flow for pump to function
  - With PD pumps, gal in = gal out: therefore -- extremely fine kick detection
  - Pump prevents fluid “backflow” into well so well is isolated from return line
  - Pump measures flow out to the nearest pint
  - Basic design results in multiple levels of redundancy

- **Highly Versatile / Rapid Pressure Control**
  - Add mud weight
  - Add backpressure
  - Change the fluid level in the riser
DGD Subsea Component Stack-Up
(Not to Scale)

- Subsea Rotating Device (SRD)
- Solids Processing Unit (SPU)
- MudLift Pump (MLP)
- Subsea Manifold
- Standard BOP Stack
Normal Drilling – The U-tube Is Balanced

- **Sea Level**
- **Mud Line**
- **Drillstring**
- **Annulus**
- **Bottom Hole**
- **Bit**
DGD Drilling – The U-tube Is Unbalanced

- Sea Level
- Drillstring
- Annulus
- Mud Line
- Bit
- Bottom Hole
The Drill String Valve Arrests the Natural U-Tube

- Variable Opening Valve in BHA
- 3 Sizes
- Evaluating two Major Companies’ Designs
- Is be Tested in Top-hole Operations

(JIP Design, 1998)
About the Drill String or Flow Stop Valve

- Not “essential”
- Makes operations appear more normal
- Arrests the U-tube
  - Faster connections
  - Makes Kick Detection Simpler
  - Easier to manage the MLP
  - Helpful in flow rate management
  - Helpful in well control pressure reading
- Run above the BHA, you can’t wireline below it
- Mechanism of operation, not intuitive
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(Not to Scale)

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Surface Changes

- Six rig pumps
  - Three for power fluid and Three for mud
  - One back-up for each fluid stream
- Additional trip tank (riser fluid)
- More piping for handing up to 3 fluids at once
- Pits divided for multiple fluids
The Drilling Riser is Modified

- MudLift Pump is Seawater-Powered, so Riser Modifications are Needed
- Two Six inch Lines
  - Seawater Power
  - Mud Return
- No Boost Line
- 3.5MM lb Flange rating
- Standard 15K C&K lines
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Subsea Rotating Device Separates Mud from Riser Fluid

- Located above the Solids Processing Unit in the DGD System
- The “Active” guts: seals and bearings are retrievable
- Seals pressure from both below and above, typically 50 psi, up to 1000 psi WP
- Maintains the gradient “interface”
- Allows for rapid Managed Pressure Drilling type operations
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(Not to Scale)

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The Solids Processing Unit (SPU)

Part of a riser specialty joint
Provides feed of mud to MLP
Sizes solids to 1-1/2” or smaller
Controlled and powered by the MLP control system
Choke and Kill lines pass through it
Tears Everything to Pumpable Sizes

- Sits in Riser below SRD
- Two separate feed paths
- Can be flushed in multiple ways
DGD Subsea Component Stack-Up
(Not to Scale)

- Subsea Rotating Device (SRD)
- Solids Processing Unit (SPU)
- MudLift Pump (MLP)
- Subsea Manifold
- Standard BOP Stack
The Heart: MudLift Pump

- (2) Triplex modules
- 80 gallon chambers
- 1800 gpm max rate
- 10,000’ WD rating
- 18.5 ppg mud
- Contains Subsea Manifold
DGD Subsea Component Stack-Up
(Not to Scale)

- Subsea Rotating Device (SRD)
- Solids Processing Unit (SPU)
- MudLift Pump (MLP)
- Subsea Manifold
- Standard BOP Stack
Subsea Stack

- The BOP Stack is unchanged
- One extra valve placed in the Choke line for improved operations
- Still have complete “conventional” Well Control available.
Questions?