



Dual Gradient Drilling Rig Modifications and Technology Deployment

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Agenda

1

What is Dual Gradient Drilling (DGD)?

2

Rig Modifications

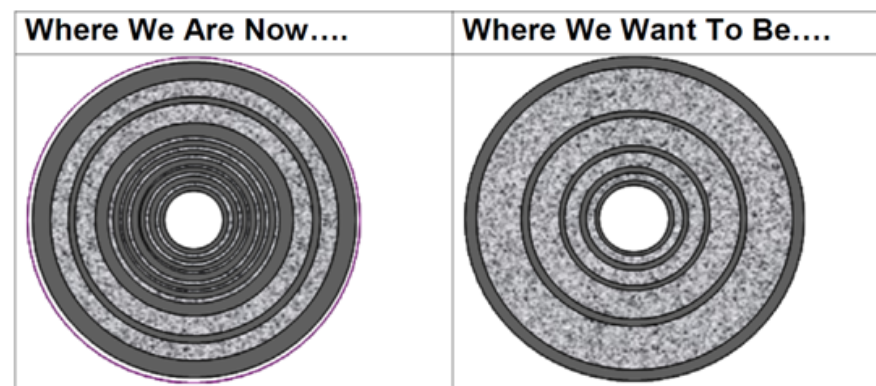
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Technology Deployment

DGD is a Game-Changing Technology

A Proven Well-Construction Advance

- Removes the effect of mud weight in the riser column and provides better pressure control.
- Especially important in deeper water and wellbores (e.g. Gulf of Mexico or pre-salt Brazil).
- Well is fully controlled in the event of riser disconnect; Safer and more efficient.
- Should allow operators to access wells which were previously problematic or inaccessible.

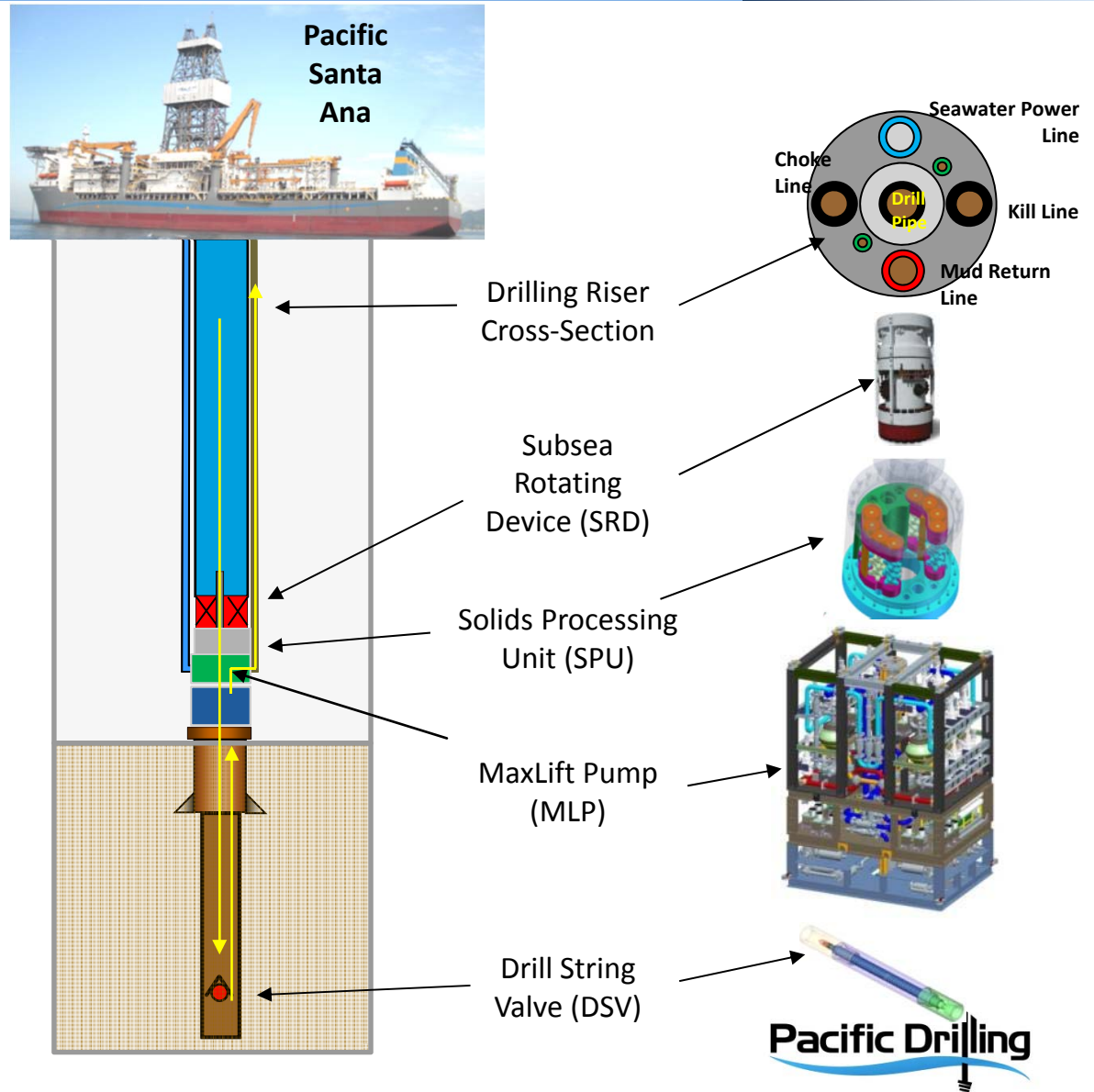


Source: May 2011 BOEMRE Report "Risk Profile of Dual Gradient Drilling"

Rig Modifications Needed to Operate the DGD Subsea Kit

DGD Subsea Kit

- A seawater-driven positive displacement pump (MLP) withdraws the mud from the well and pumps it back up through a 6" line
- A Solids Processing Unit (SPU) crushes the cuttings before pumping
- A Subsea Rotating Device (SRD) can rapidly change the well pressure profile
- The riser is filled with a seawater-density fluid



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DGD Rigs are 7th Generation Rigs

Rig Modifications

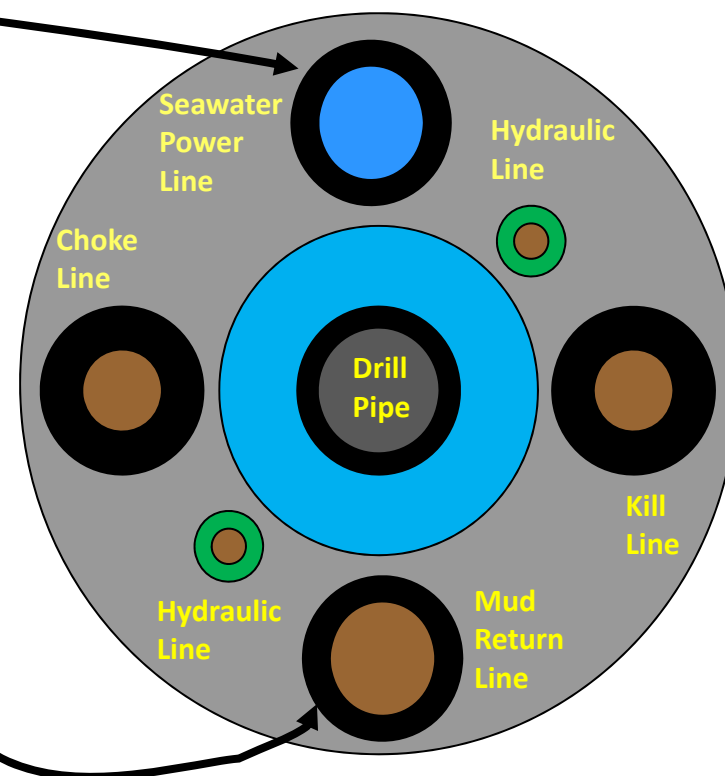
- Pacific Santa Ana, drilling in the GoM since May 2012, was the world's 1st DGD rig
- Pacific Sharav, to be delivered in Q1 2014 will be the 2nd purpose-built DGD rig
- 7th generation characteristics:
 - 12,000ft wd / 40,000ft dd
 - 22,000 MT VDL
 - 7 HP pumps total
 - 29,200 bbls liquid mud
 - 1,250 ST hook load on the main
 - 2 Active Heave Drawworks
 - 2 TDX-1250 Top drives
 - Up to 20" casing racking



A Specific DGD Riser was Built by NOV

Rig Modifications

- FT-H DG riser was designed to accommodate:
 - Two 6" ID diameter lines
 - Seawater Power
 - Mud Return 7.5k
 - 3.5MM lb flange rating
 - Standard 15K C&K lines



New MLP Storage Area and Handling Capabilities

Rig Modifications

- Creation of a MLP setback area
- Addition of second rail for MLP handling and guiding system on Pacific Santa Ana



The Moonpool Dance, New Umbilical Reels and M-PC

Rig Modifications

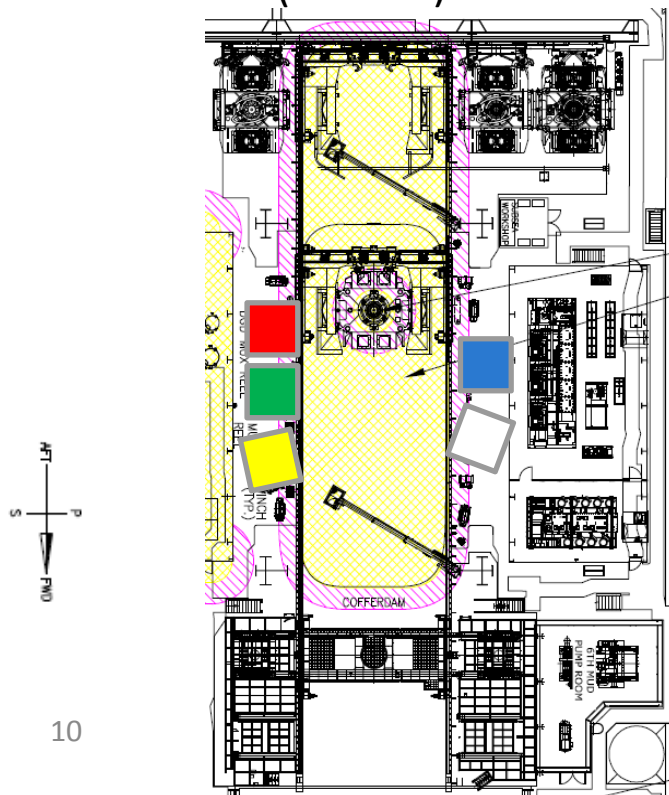
- From 3 to 5 Reels

- Yellow & Blue (LMRP)
- Red & Green (MLP)
- White (Hotline)



- Multi-Purpose Cart (M-PC)

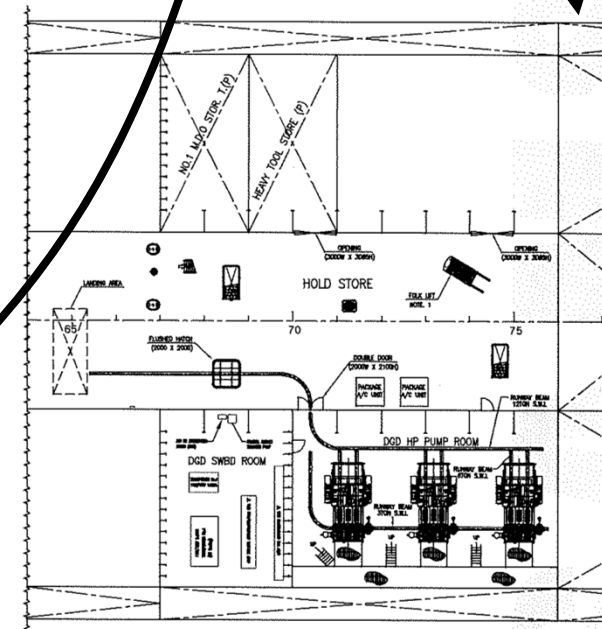
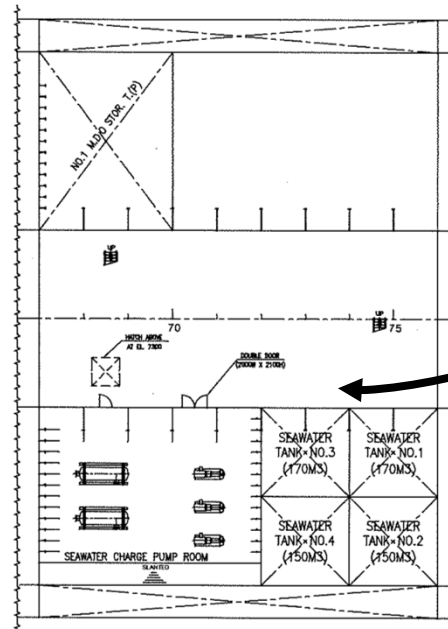
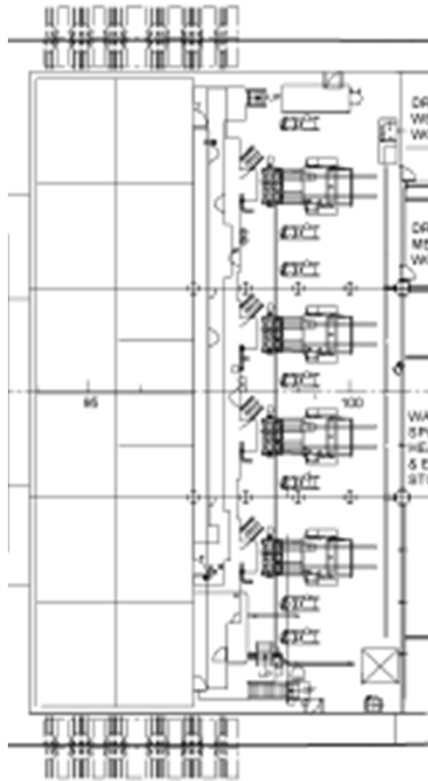
- Lower BOP or MLP Handling
- Riser hang-off
- Christmas tree handling



Creation of a Second HP Pump Room for DGD

Rig Modifications

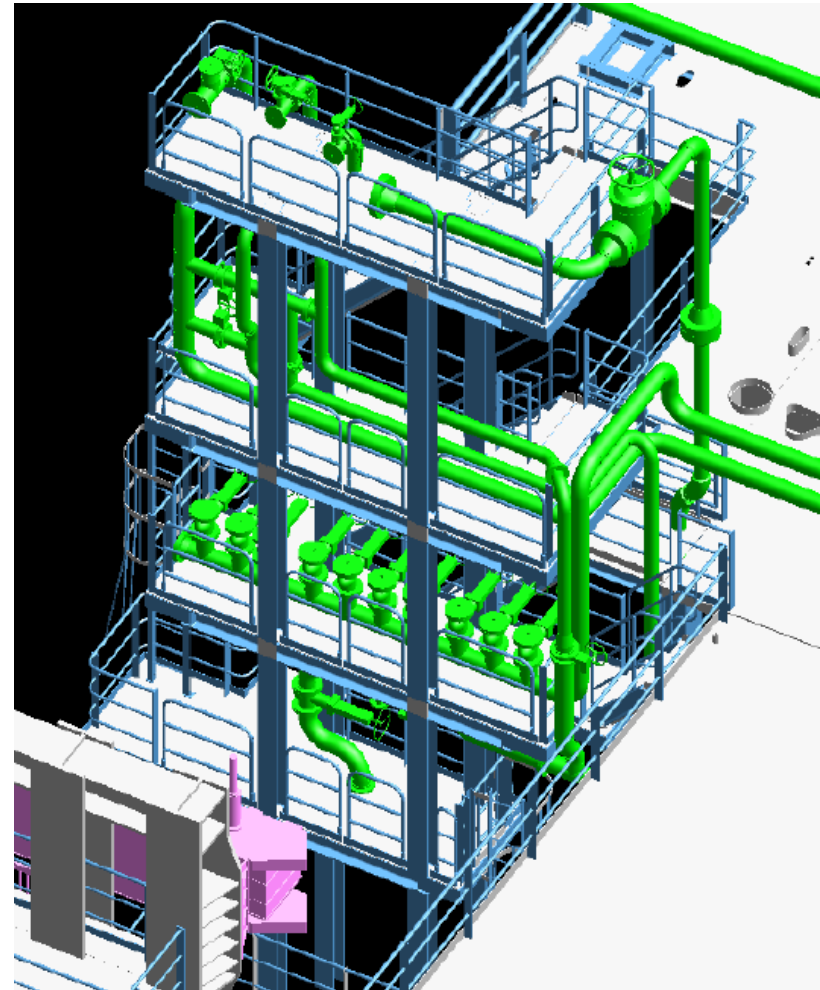
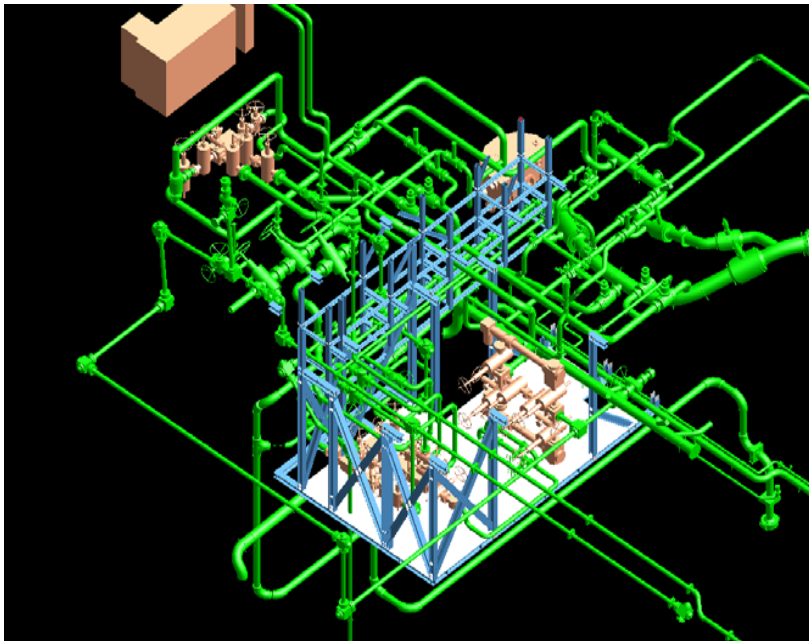
- Pacific Sharav has two HP pump rooms (total 7 HP pumps):
 - Traditional pump room for mud (4 HP pumps)
 - New pump room for Sea Water Power Fluid/Completion fluid (3 HP pumps) located on top of dedicated Seawater pits



New Fluid Management System Handles 3 Fluids Simultaneously

Rig Modifications

- Independent mud / sea water / riser fluid systems
- Multiple manifolds added
- Over 200 valves added
- Revamped Valve Control System



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Technology Deployment

People Preparation is Essential to Deploy a New Technology

Technology Deployment

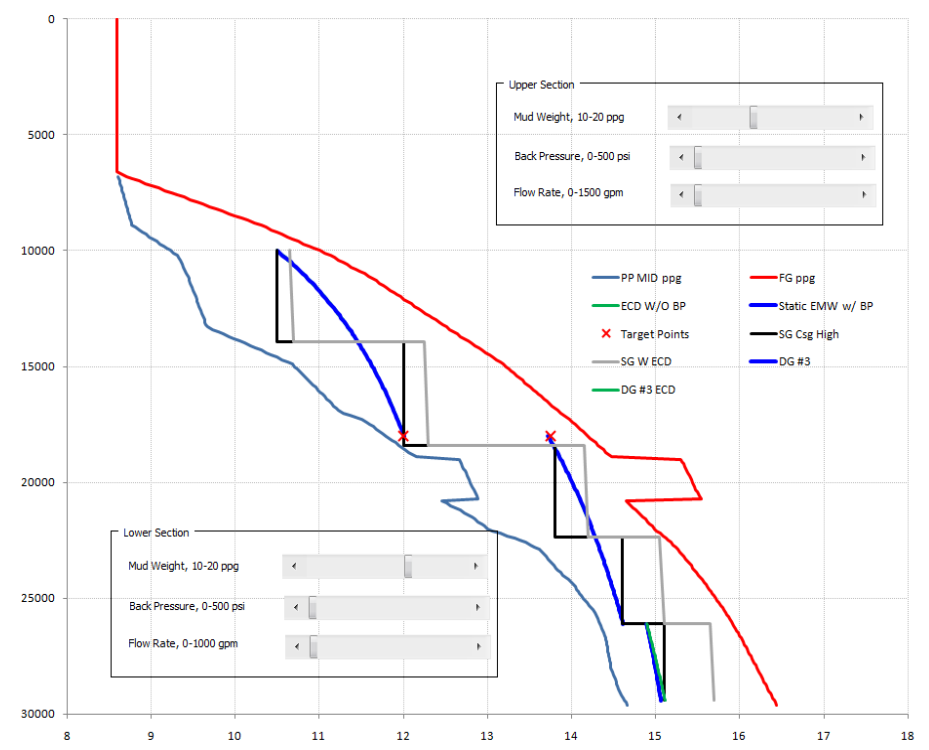
- “One team” workshops and DGD classes
 - Systematic onboarding for all Pacific, Chevron and Business Partners crews
 - Vision, values, expectations
 - DGD Fundamentals (IADC accredited)
 - DGD Well Control (IADC accredited)
- Hands on experience, building ownership of DGD modifications and equipment
 - Factory Acceptance Testing
 - HAZOP participation
 - Commissioning and Acceptance



Training Scope is Deep and Broad

Technology Deployment

- Drilling Engineers: How to design DGD wells
- Drill Site Managers, Field Drilling Engineers and Rig Crews: How to perform DGD Operations (Routine and Well Control)
- Rig Maintenance Personnel: How to maintain, troubleshoot and repair equipment?
- Rig Drilling Personnel: How the procedures have changed, how to think DGD?
- Respective roles of all personnel must be defined and agreed. Who is doing what?



Example of new visual tool designed to help reservoir engineers design DGD wells

DGD is a Team Effort

We are All Very Excited

- We've tried to set an extremely high standard to ensure that everything is very thoroughly thought out with safety in mind, and everyone is fully prepared to do their jobs safely and well
- Tremendous effort in hardware design, fabrication and testing, as well as ensuring that all people are fully prepared in its safe use
- It is just the beginning, though. A very steep learning curve is ahead of us

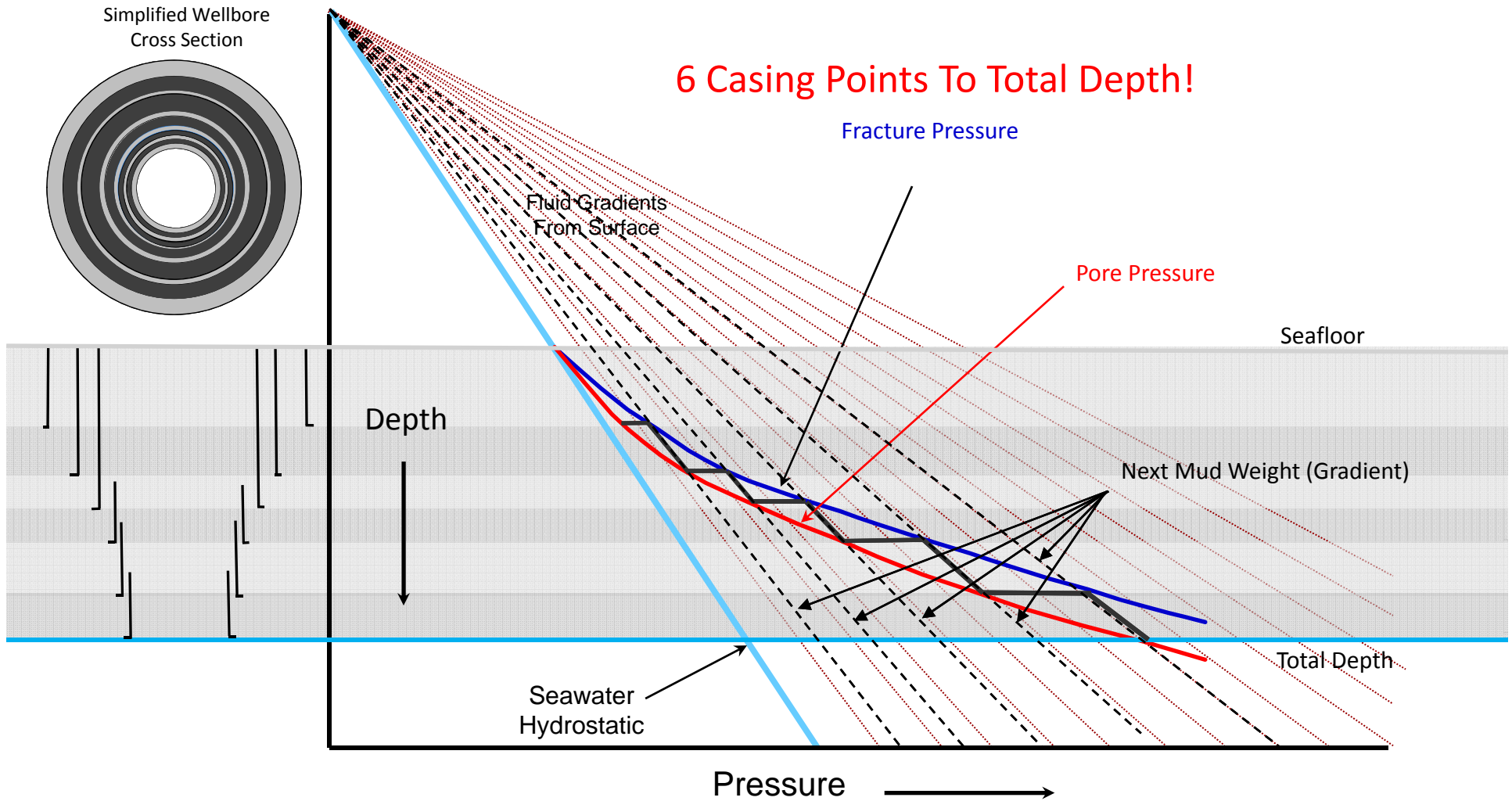


Questions & Answers



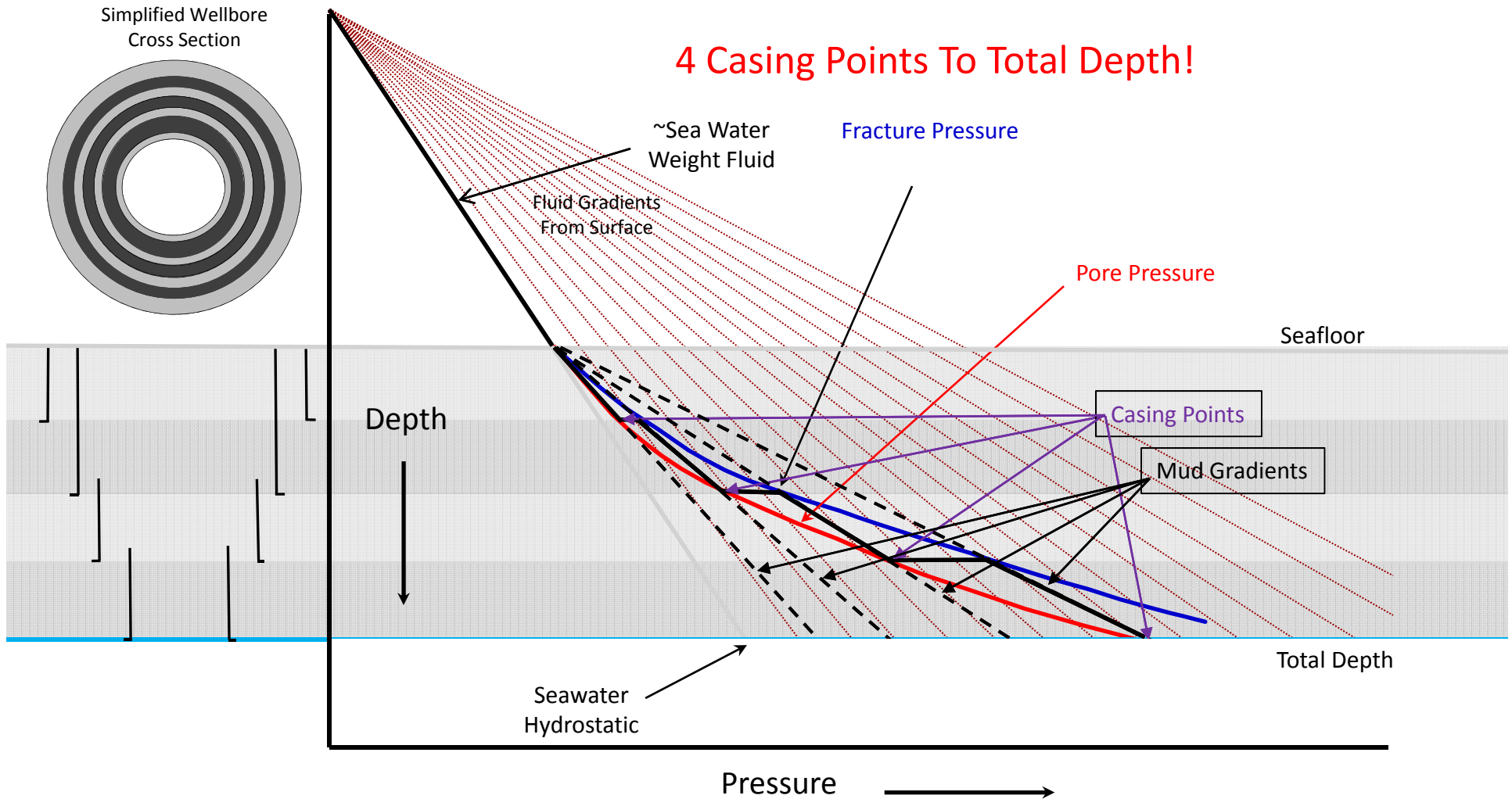
Appendix

Appendix: Single Gradient Drilling...



Note: Single gradient wells use a single fluid gradient from surface for all hole sections

Appendix: ... vs Dual Gradient Drilling



Note: Dual gradient wells use a single light fluid gradient from surface to near the sea floor and higher fluid gradients downward for each hole section

DGD Subsea Kit: the Max Lift Pump (MLP)

Appendix

- Positive Displacement Pump
- Powered by seawater which is returned to sea
- Two interchangeable mirror image Triplex modules
- Pump can be broken into ~ 50 MT lifts for initial lift
- 80 gallon chambers
- Up to 1800 gpm and 18.5 ppg mud
- 10,000' WD rating
- Size - 18' x 18' x 30'
- Weight - 450,000 lbs
- Max Cutting Size - 1.5 in

Triplex
Pump
Modules

HPU's

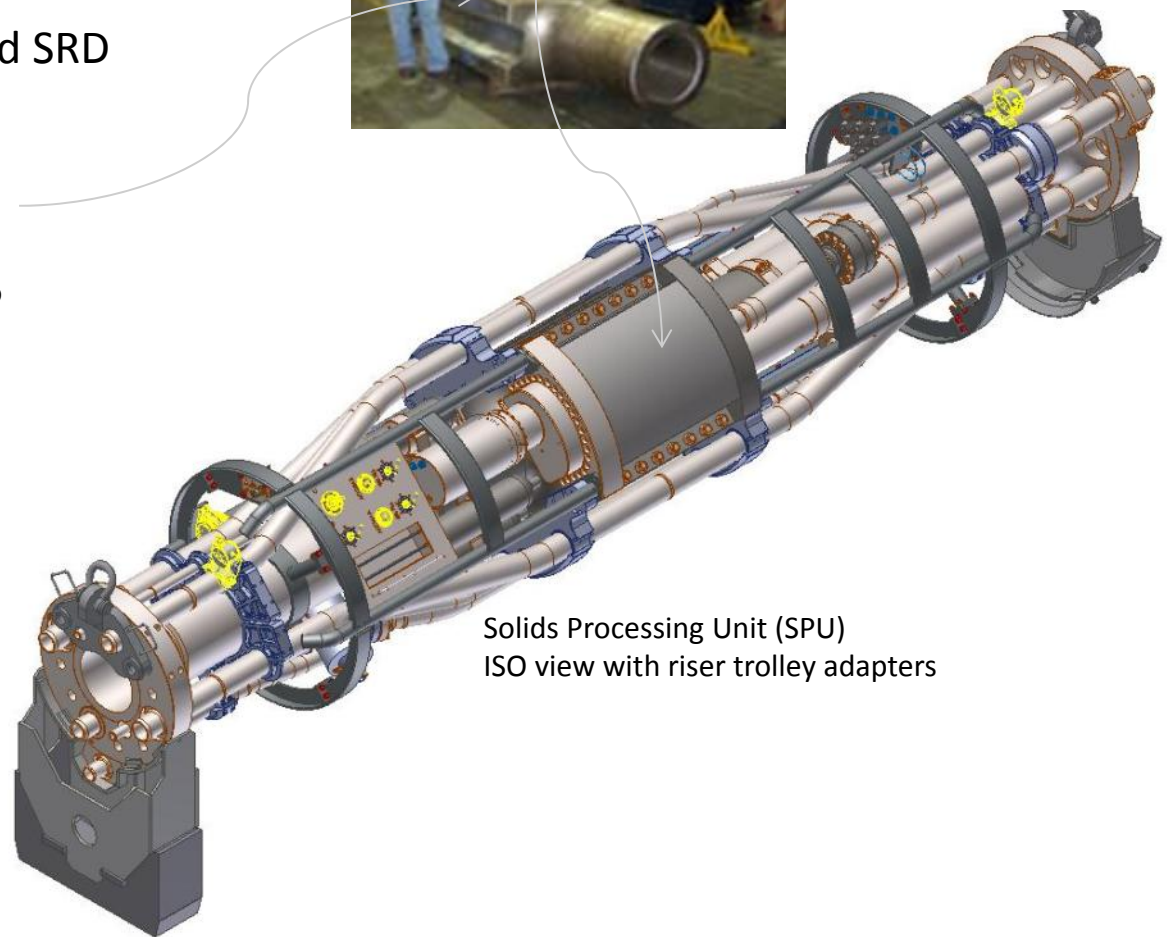
Valve
Manifold



DGD Subsea Kit: the Solids Processing Unit (SPU)

Appendix

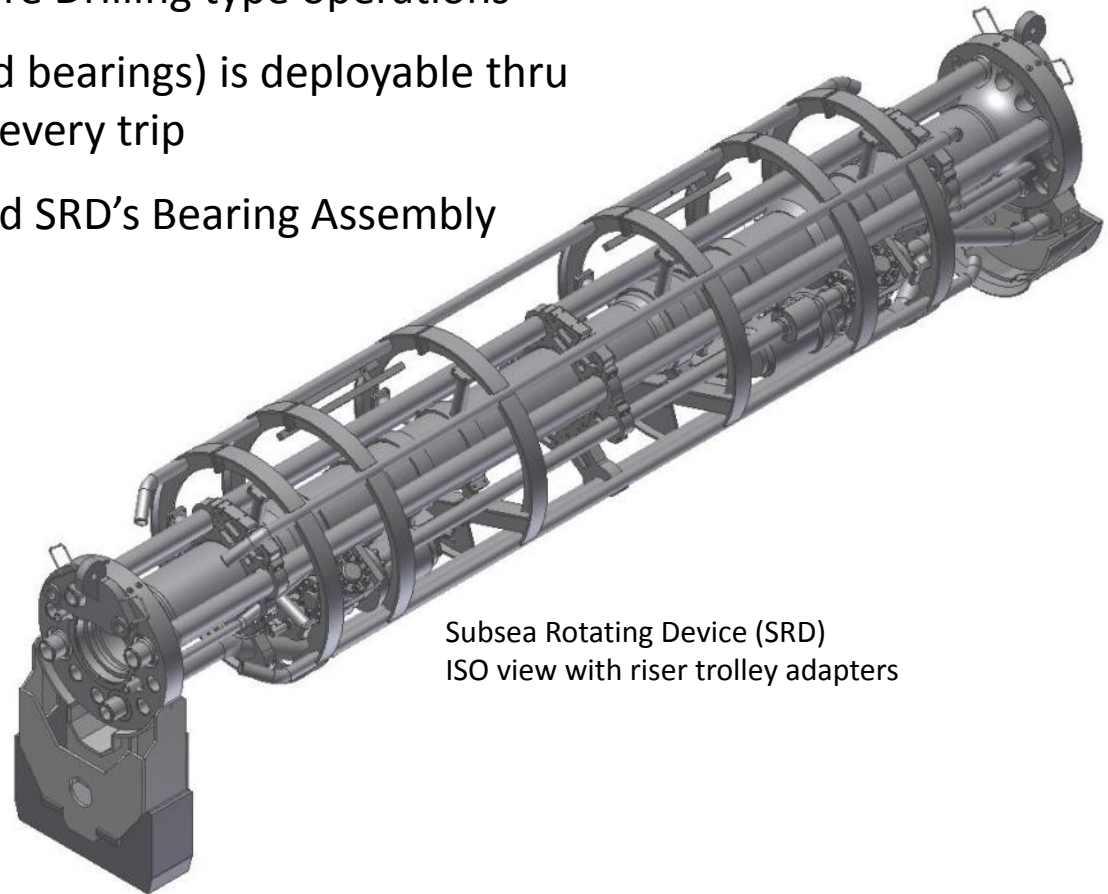
- Reduces everything to pumpable sizes
- Provides mud feed to MLP
- Sits in riser between MLP and SRD
- Two separate feed paths
- Two full capacity cutters
- Power and control from MLP



DGD Subsea Kit: The Subsea Rotating Device (SRD)

Appendix

- Located above the SPU, separates the two fluids
- Seals pressure from either below or above, typically 50 psi, up to 1000 psi WP
- Allows for rapid Managed Pressure Drilling type operations
- Bearing latch assembly (seals and bearings) is deployable thru 19.25 ID riser and it is retrieved every trip
- Bypass lines facilitate flow around SRD's Bearing Assembly
- Mechanical latching profile



Subsea Rotating Device (SRD)
ISO view with riser trolley adapters

DGD Subsea Kit: the Drill String Valve (DSV)

Appendix

- Arrests the U-tube
 - Faster connections
 - Helpful in flow rate management
 - Helpful in well control pressure reading
- Similar to a float, but with a very big spring
- Run above the BHA, but you can't wireline through it
- Opening pressure can be adjusted on rig
- Standard drill pipe connections

