MAERSK VALIANT

MANAGED PRESSURE DRILLING

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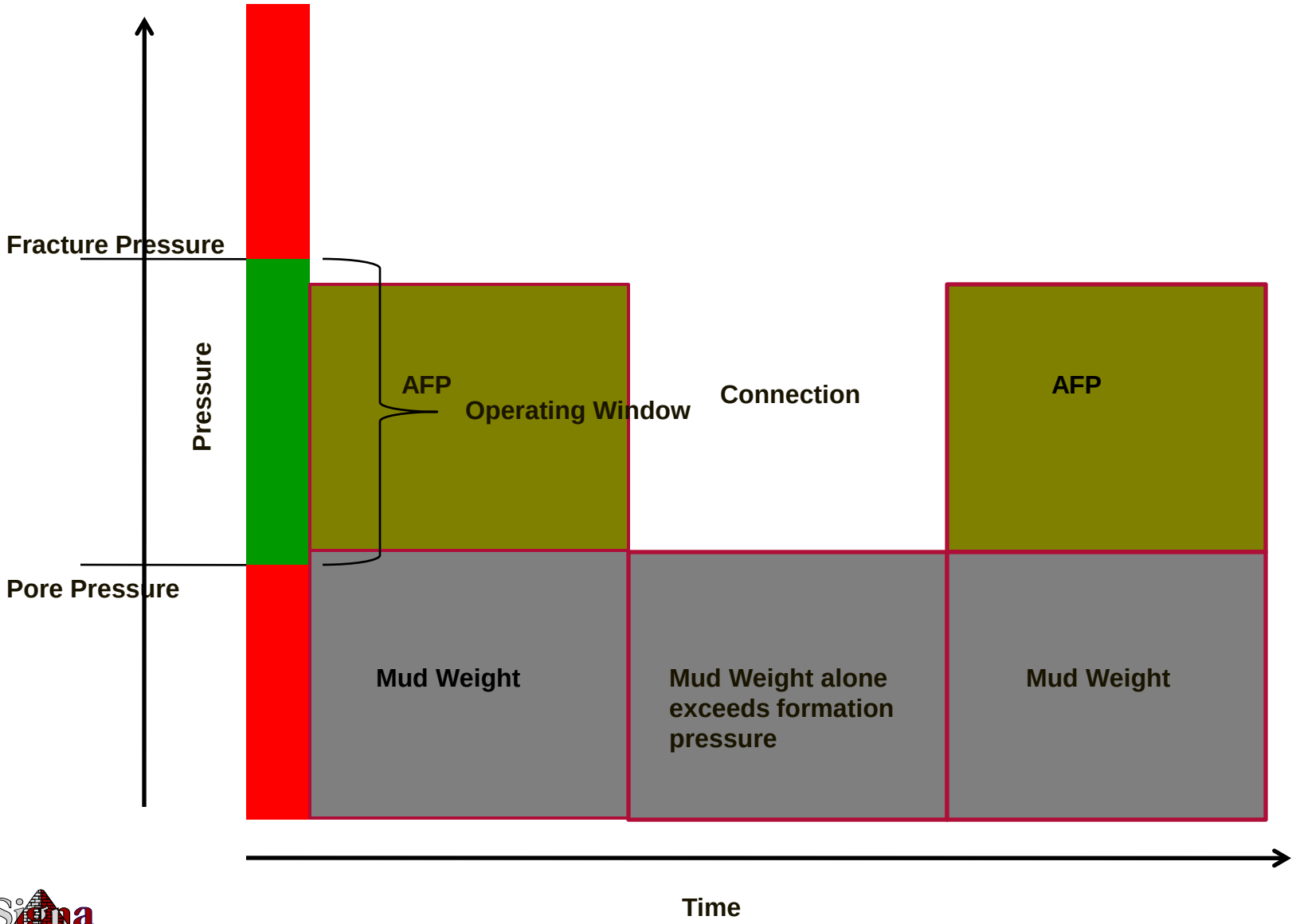
WHAT IS MPD?

- Managed Pressure Drilling (MPD) includes several techniques
- For this presentation, MPD refers to the what is commonly referred to as the Constant BottomHole Pressure (CBHP) method

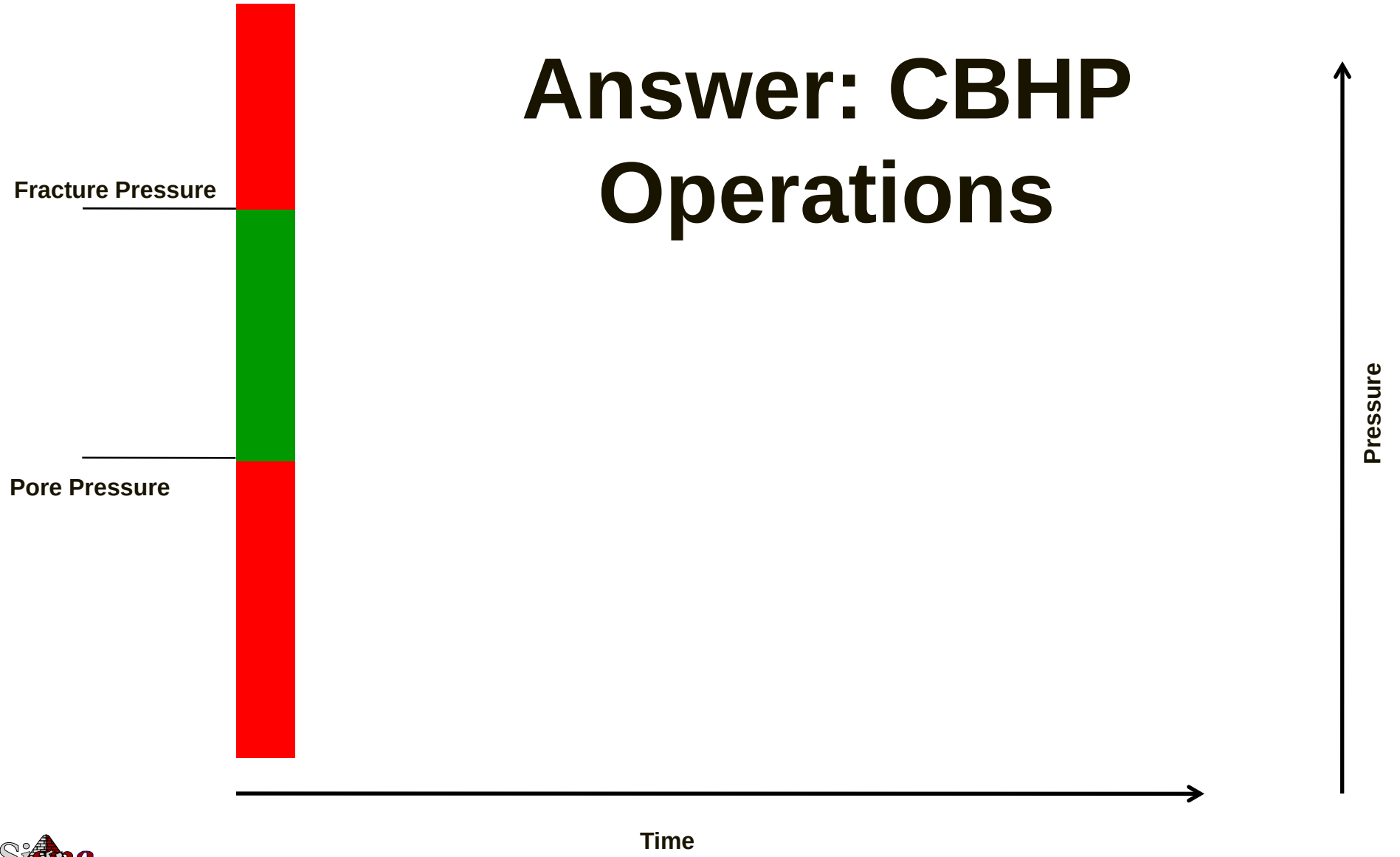
WHAT IS CBHP?

Uses surface back pressure applied to a closed circulating system with a choke to maintain a constant selected pressure at a selected depth

CONVENTIONAL OPERATIONS

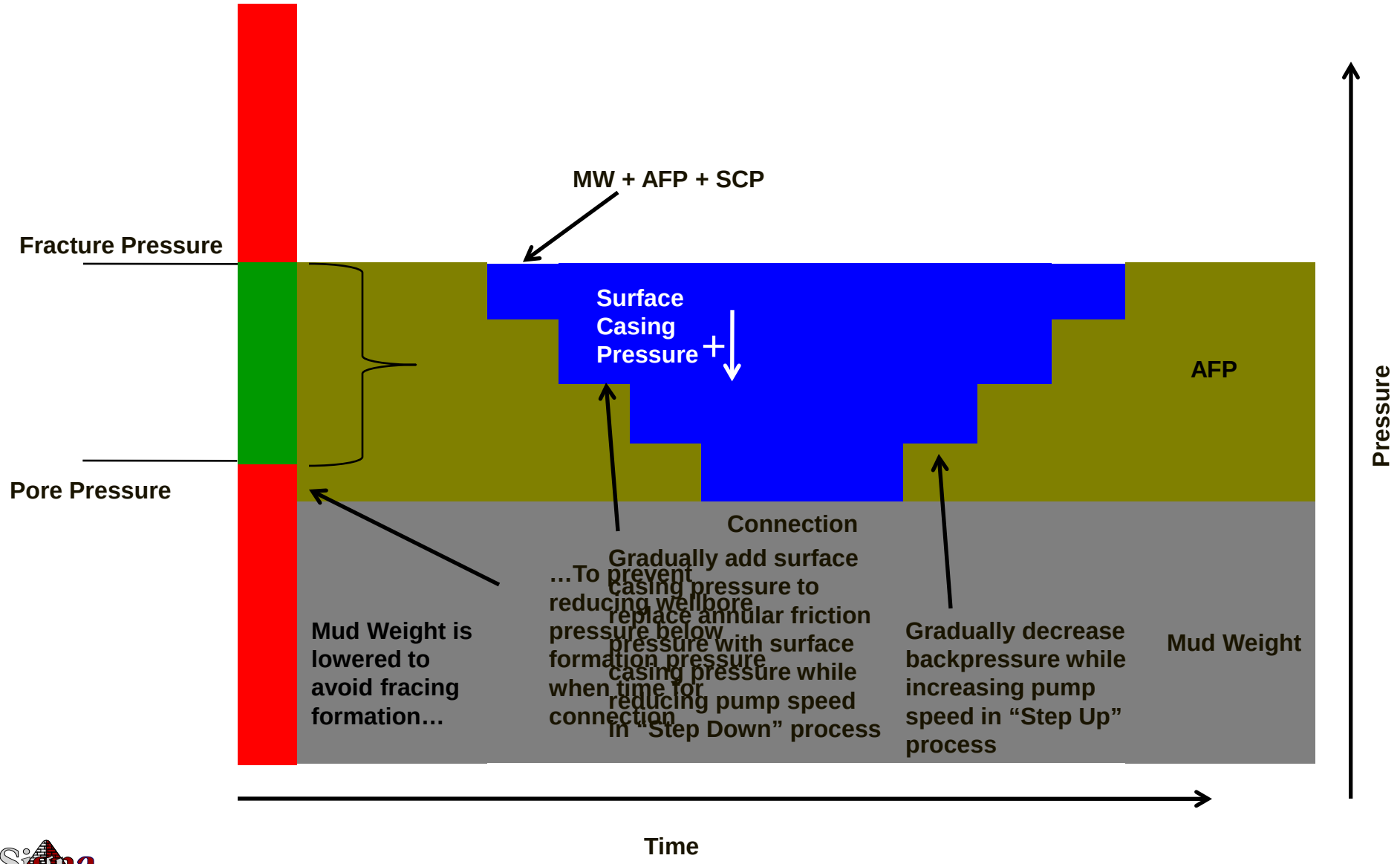


WHAT IF THE OPERATING WINDOW IS SMALLER?

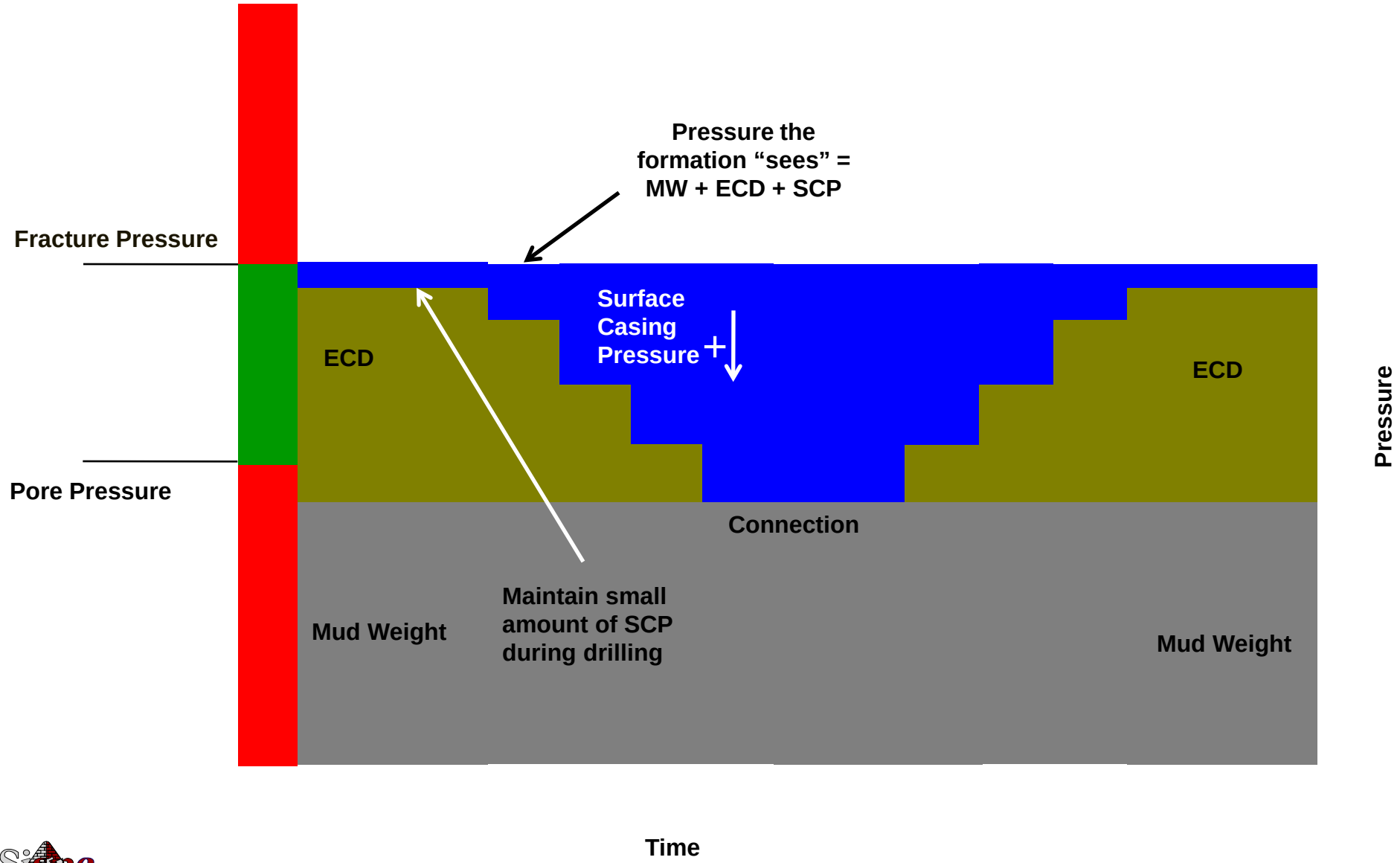


Answer: CBHP Operations

CBHP OPERATIONS (MPD)



OPTIMUM CBHP CASE



PROJECT DESCRIPTION

- Maersk Valiant contracted for three years in Gulf of Mexico
- Rig contract shared with between Marathon and ConocoPhillips
- Benefits of Managed Pressure Drilling (MPD) experienced first hand by both companies under similar arrangement in Indonesia

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CONSIDERATIONS

- Few MPD applications from DP drillships so equipment selection limited
- Functionality of existing systems left something to be desired
- MPD currently only allowed in the GOM with surface BOPs
- No published industry standards for MPD with a subsea stack
- No MOC policies or procedures for MPD

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PLAN FORWARD

- Both companies in favor of equipping rig for MPD
- Agreed to share the cost of doing so
- Also agreed to plan of purchasing the individual components and installing them rather than using a single source provider.
- Maersk agreed to contribute to gain this capability for their rig
- Equipment to be installed while the rig was in operation drilling conventionally

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SURFACE EQUIPMENT SELECTION

- **Existing systems exhibited several shortcomings**
  - Flow control equipment too small
    - High flow rates
    - Large cuttings
    - High cuttings volume
  - RCD
    - Only rental heads available
    - Selection very limited
    - Potential improvements perceived
  - Choke control functionality unsatisfactory

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DESIGN CONSIDERATIONS

- **Be able to drill all hole sections using MPD**
  - Upper hole sections
    - High flow rates
    - Large volume of big cuttings
  - Lower hole sections
    - Lower flow rates
    - Smaller chokes required for precise control
- **Provide maximum feasible redundancy**

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REQUIRED PIPEWORK

- **To minimize friction pressure and erosion, modeling indicated 8” piping and manifolds and 6” chokes needed**
  - No 6” full open chokes available
  - Space limited so compact ball valves required
  - Vendor to design and build 6” chokes and configure manifold to fit in available space selected
- **Return flow meter selected for accurate measurements of flow rates ≤300 - 2000 gpm**
- **Flow meters on all pumps to allow measuring volume (rate) and density of all fluids as the enter the well**
- **PRV protection of riser and pipework required to allow diverting the well in case of an issue with RGH or the BOP’s**

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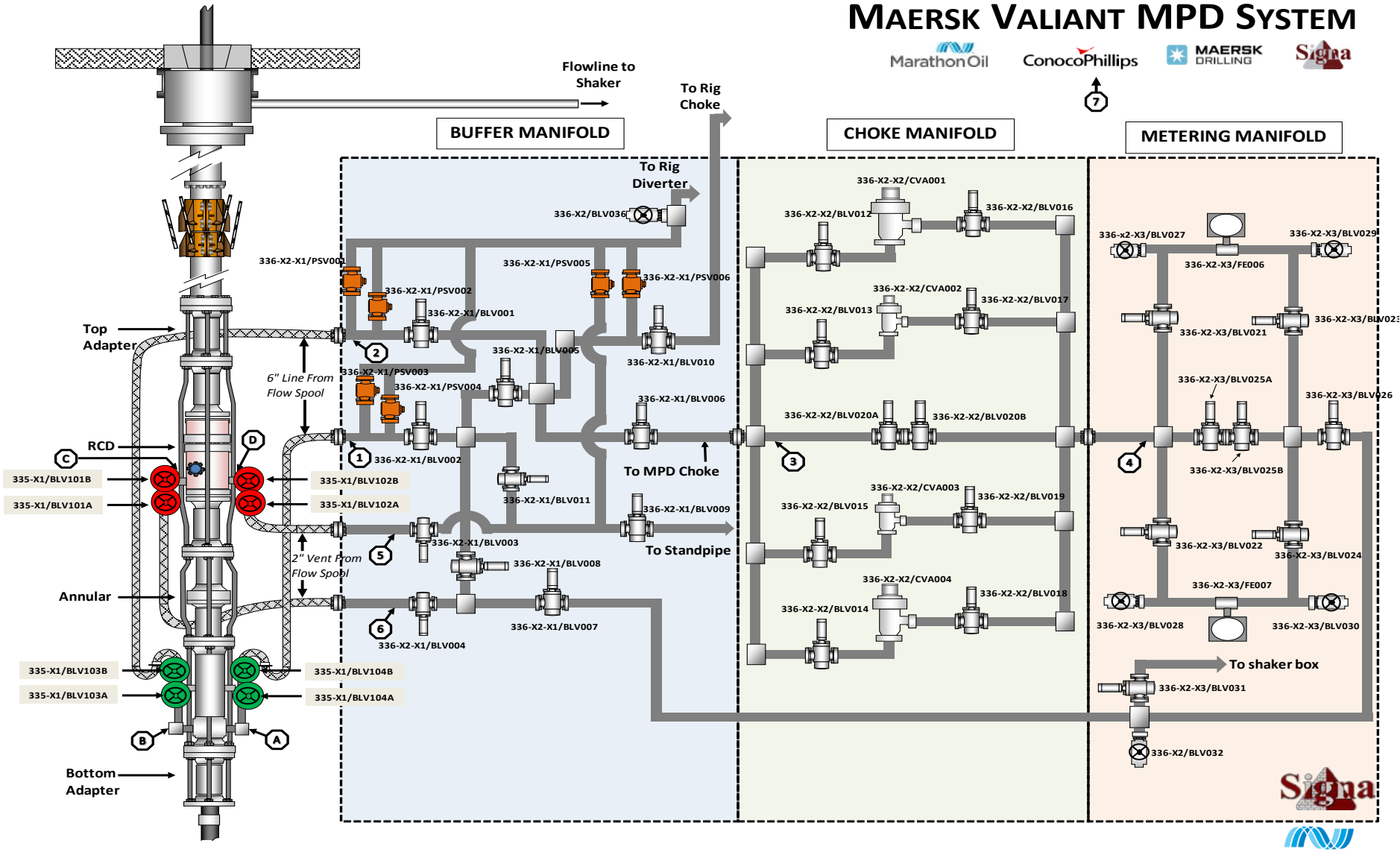
RESULTING SURFACE SYSTEM



MPD RISER JOINT

- Replaces rig's RGH so must perform that function
- Incorporates RCD
- Flow spool directs return flow to buffer manifold
- Lines allow bleeding and equalizing pressure and flushing
- Required getting cooperation between two manufacturers
- Assembled in one piece; one lift

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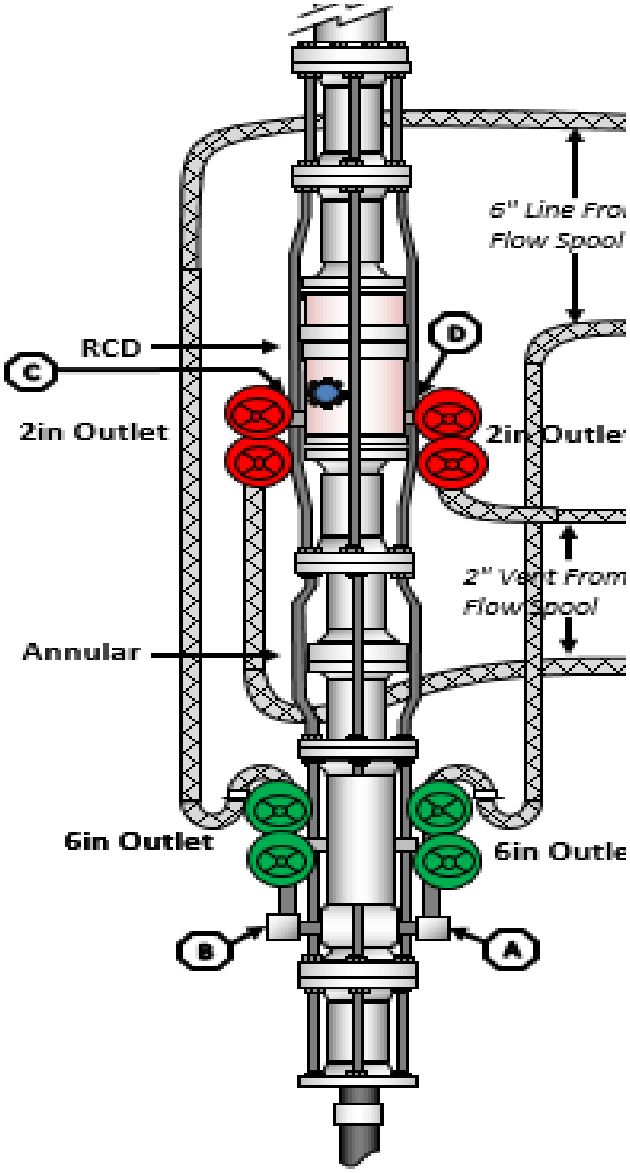
MPD RISER JOINT



MPD RISER JOINT

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BUFFER MANIFOLD

CHOKE MANIFOLD

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METERING MANIFOLD

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CHOKE CONTROL SYSTEM

- **The system uses Intelligent Predictive Control (IPC) logic to control the chokes instead of Proportional Integral Derivative (PID) control as have previous systems**
- **Improved hydraulics model and better control algorithm result in greatly improved performance**
- **Electric servo operated chokes allow for greater accuracy of position control**
- **Allows several operating modes:**
  - Manual
  - Surface Back Pressure (SBP)
  - Pressure At Depth (PAD)
- **Much more responsive and accurate**
  - Automated modes reliably control surface pressures within 10 psi
  - Input from inflow meters allows system to accurately correct for changes in rate, pump efficiency and mud density

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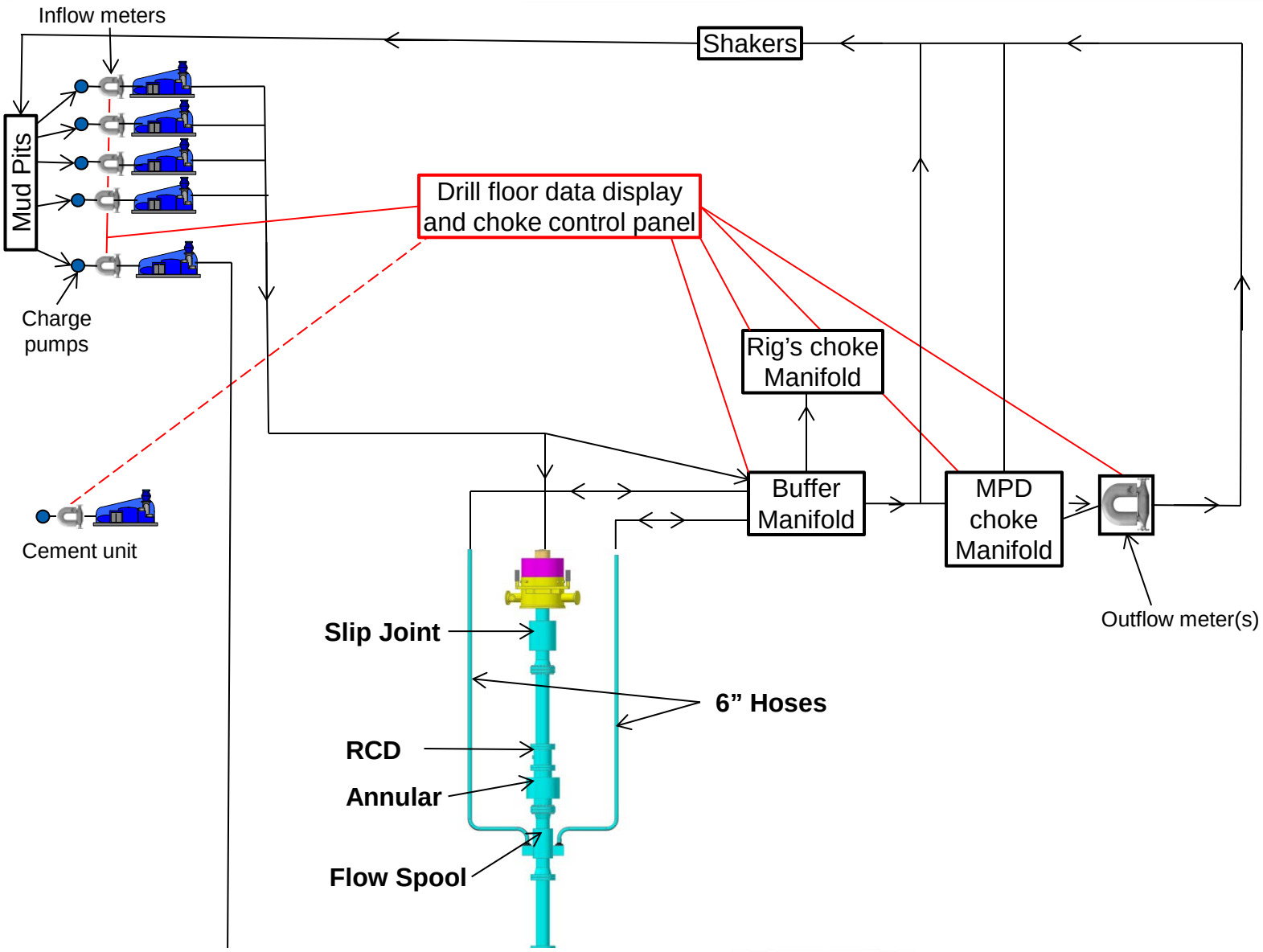
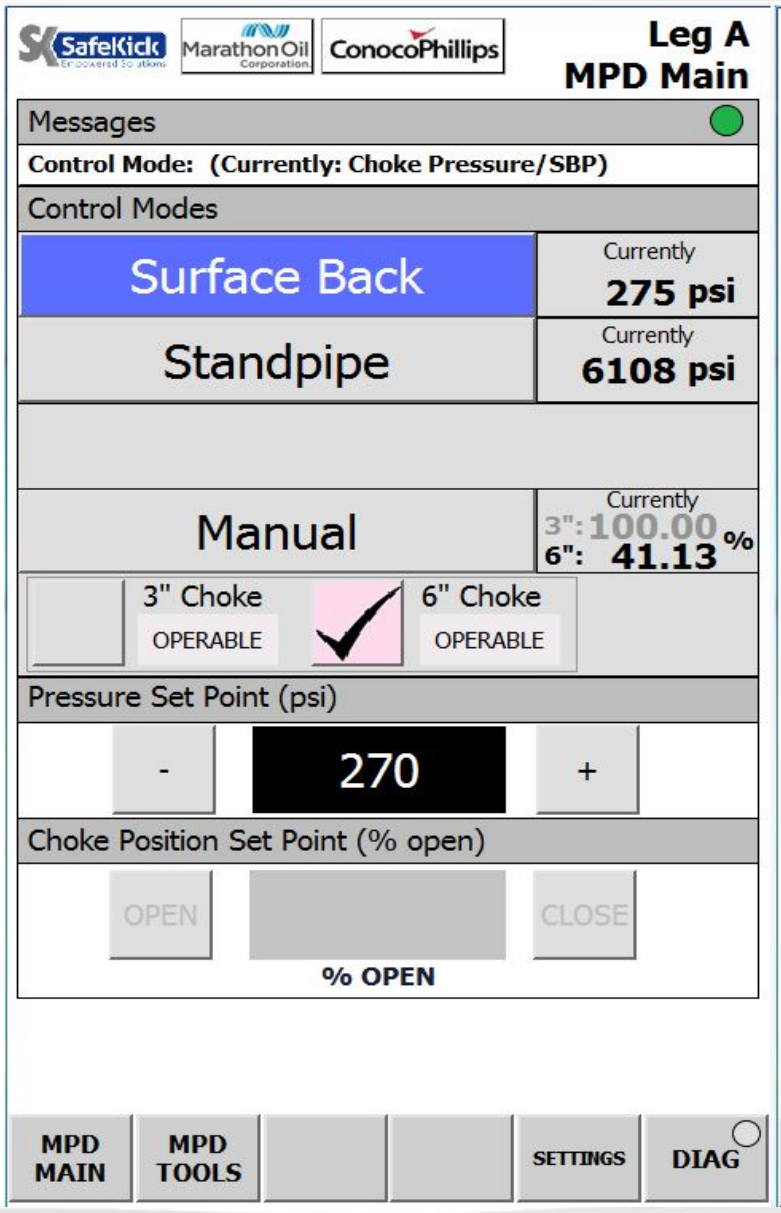
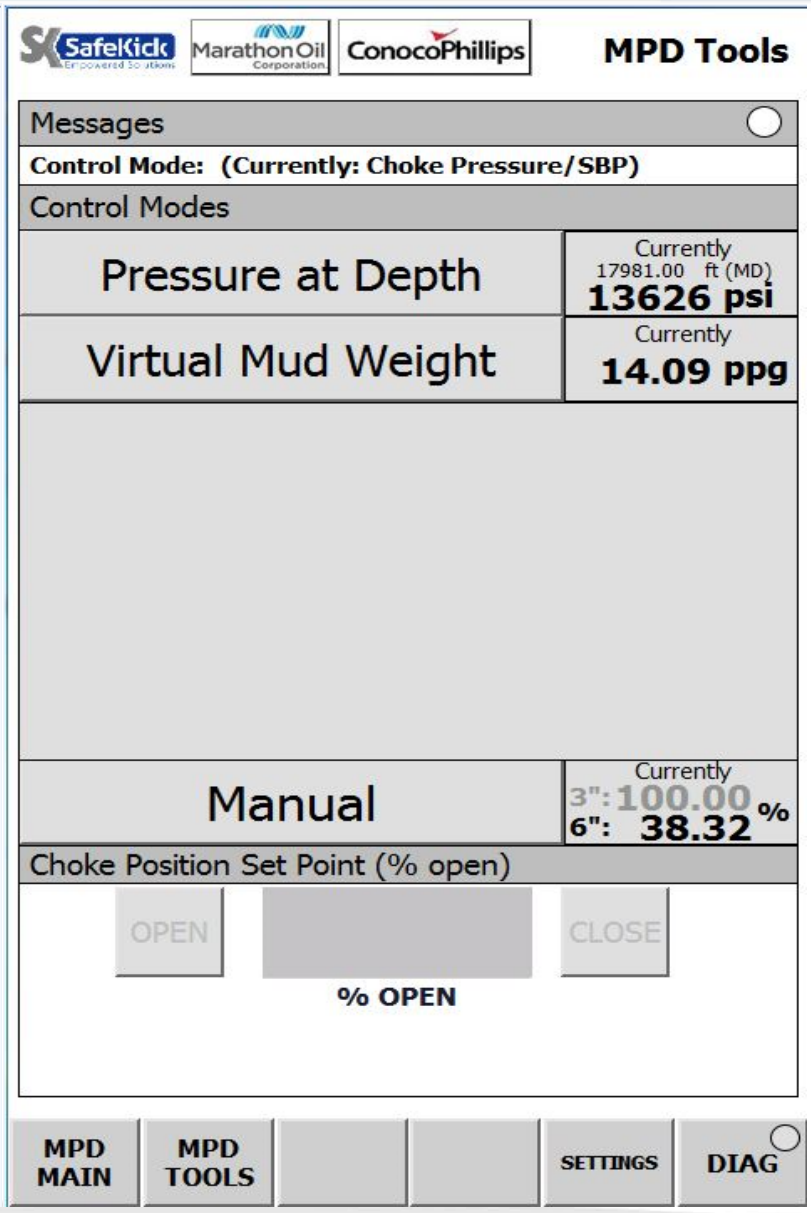
GENERALIZED SCHEMATIC FOR DP RIG



DRILLER CAN MATCH BHP TO TARGET





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REGULATORY

- MPD only allowed in the GOM from a surface stack subject to NTL No. 2008-G07.
- This NTL specifies that MPD with a subsea BOP is not covered by that document.
- The NTL goes on to say that MPD operations from a floater are not precluded but Alternative Compliance documentation and approval is required.
- Approval to conduct MPD operations with a mud weight below pore pressure is required for each well and will be considered for approval on a case by case basis.
- This has been granted for two wells so far; one finished and one in progress

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BSEE BROUGHT ON BOARD EARLY

- **January 2012 - Presentation to BSEE New Orleans; discussed MPD and Indonesia project.**
- **April 2014 - Presentation to New Orleans region office; discussed MPD and introduced project; discussed plans and requirements**
- **July 2014 - Herndon (Washington) office; introduced MPD and this project**
- **December 2014 – Houma office about work in their district**
- **March 2015 - Lake Jackson office about work in their district**

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SUBSEQUENT BSEE INVOLVEMENT

- **Additional presentations in:**
  - New Orleans
  - Houma
  - Lake Jackson
- **BSEE personnel also participated in:**
  - In house MPD engineering training
  - Third party office staff introduction to MPD
  - Choke control system testing at LSU
  - HAZID and HAZOP meetings
- **BSEE has been cooperative and helpful every step of the way**

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STANDARDS

- Currently the only related industry accepted standard for MPD is API RP 92M which only covers operations with a surface BOP stack.
- An IADC committee is currently working on a recommended practice document covering subsea BOP operations but it is not yet completed or adopted.
- Like most companies, Marathon did not yet have policies and procedures in place for MPD, much less MPD in floating operations.
- ABS currently developing Appendix 7 to their Classification of Drilling Systems certification to cover MPD systems but not yet finalized.

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ABS INVOLVEMENT

- Valiant carries ABS-CDS certification
- To keep that certification, any new equipment added to the vessel must also be so certified.
- ABS has certified this MPD system installation

RCD

- Previously only one RCD available for use as part of a riser below the tension ring
- Several potential improvements identified
- Surface version of the head selected used extensively good success
- Vendor innovative and responsive

OPERATIONAL PROCEDURES

- 61 operational procedures prepared by a combined group from Marathon, ConocoPhillips, and third party engineering company
- These procedures made available for review to Marathon, ConocoPhillips and Maersk. Revisions made based on those reviews.
- Used on first well, revised and supplemented by joint group and final versions currently under third party review
- After final review, will be officially adopted by Maersk, Marathon, and ConocoPhillips. Subsequent changes will require going through a formal Management of Change process.

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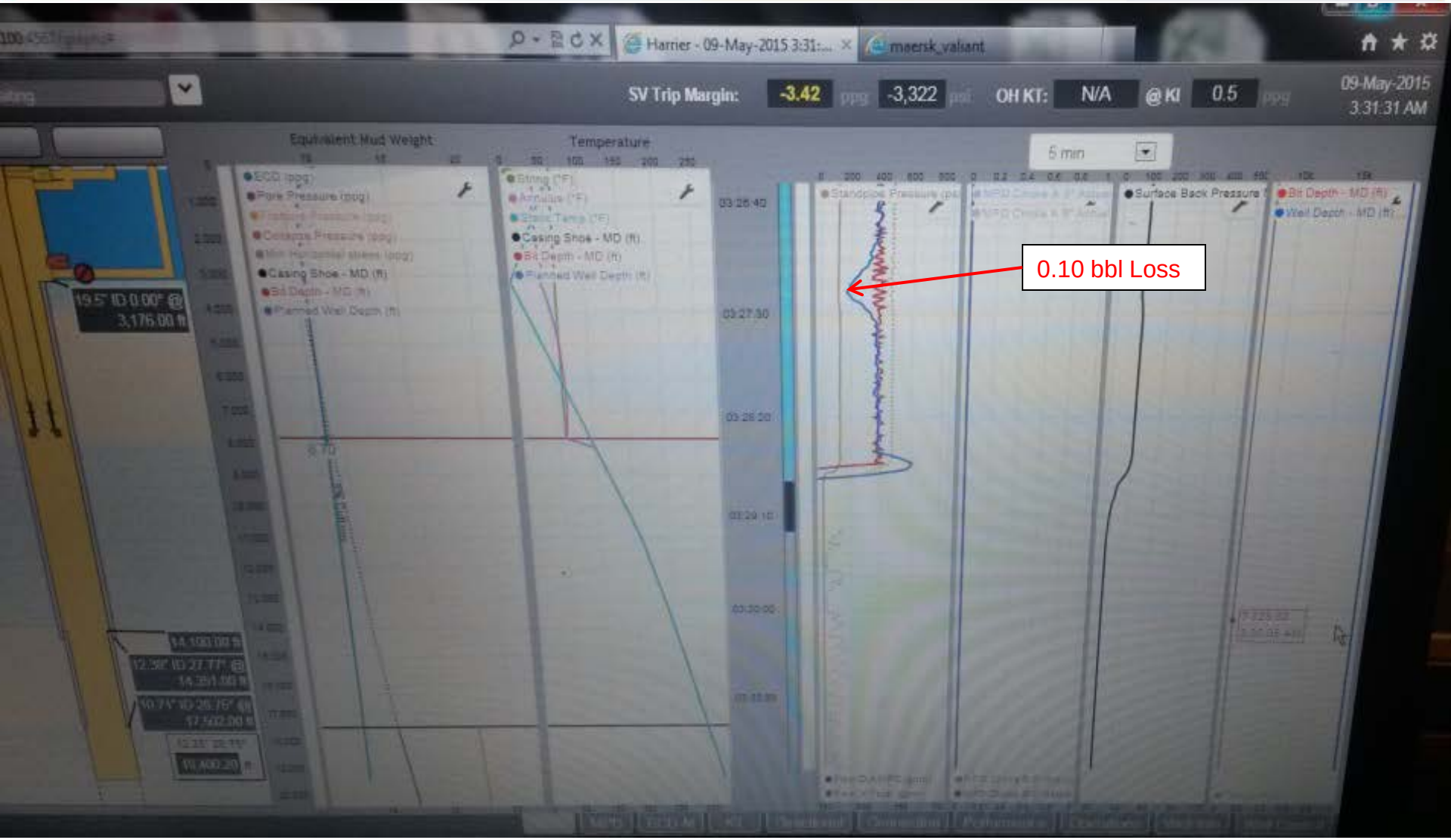
TRAINING

MAERSK VALIANT CREW MPD TRAINING MATRIX - Rev3 7/21/2015

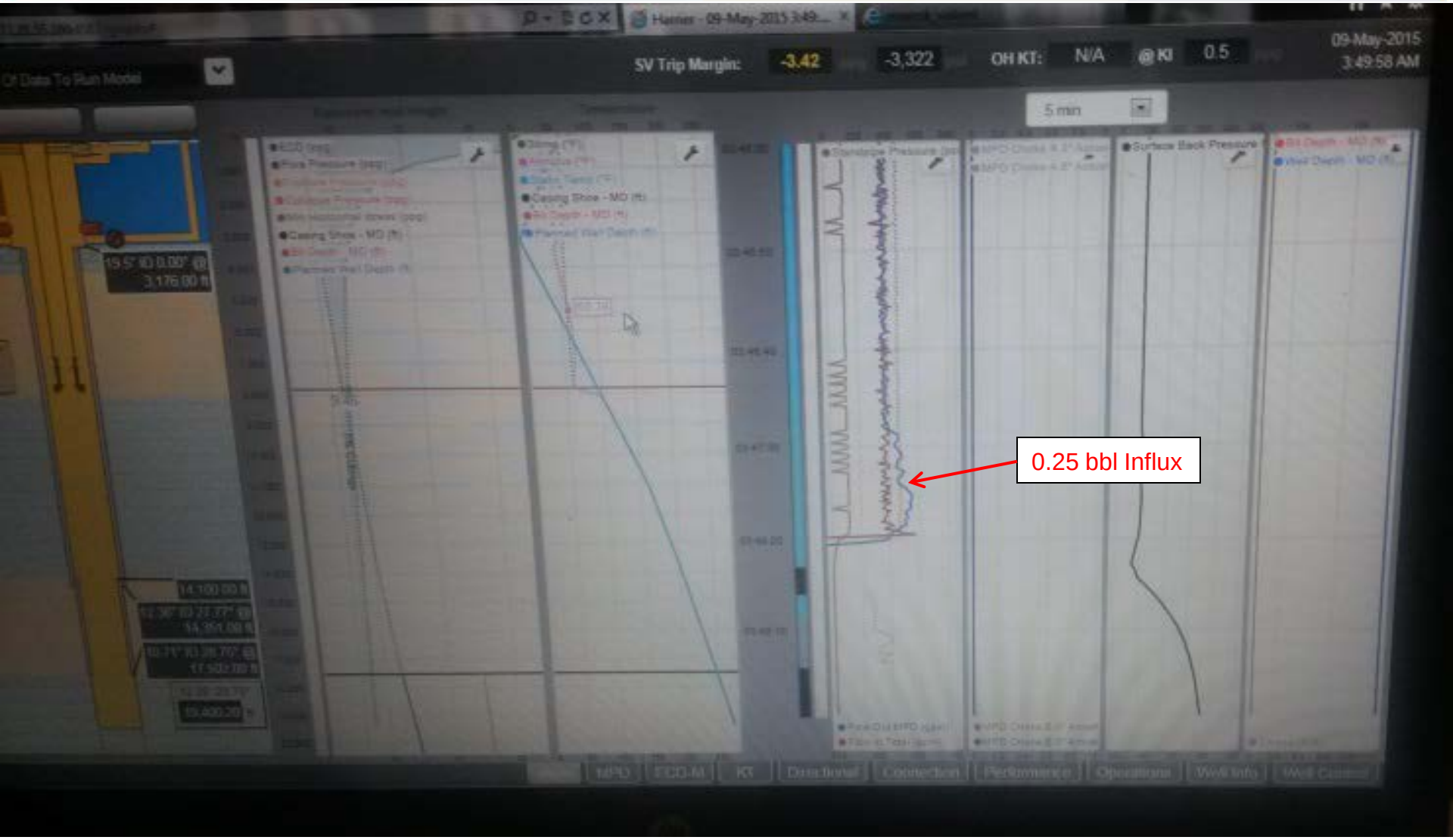
	Participant							
Crew:	A	A	C	C	E	E	G	G
Position:	Driller - Main	AD - Main	Driller -Main	AD-Main	Driller - Main	AD - Main	Driller - Main	AD - Main
Name:	Hardy, Brian	Chevalier, Jeremy	Evan, Will	Garton, Steve	Harris, Jeremy	Plumber, Quincy	Fortner, Robert	Kovalovs, Vasilijs
PROCEDURE OR ACTIVITY								
1.0 Procedure for Testing BOP while holding SBP on Riser	X	X	X	X			X	X
4.0 CLFP Readings during MPD Operations	X	X			X	X	X	X
6.0 Converting from Managed Pressure Drilling Operations to Conventional Drilling	X	X	X	X	X	X		
7.0 Converting from Conventional Drilling to Managed Pressure Drilling Operations	X	X	X	X	X	X		
12.0 Drilling with Early Kick Detection	X	X	X	X	X	X	X	X
26.0 Managed Pressure Drilling with ECD Only	X	X	X	X	X	X	X	X
27.0 Managed Presure Operation with SBP while Drilling	X	X					X	X
28.0 Flow Check during MPD Operations	X	X	X	X	X	X		
40.0 SPR's during MPD Operations	X	X	X	X	X	X	X	X
42.0 Stabbing New Bearing Assembly	X	X	X	X	X	X		
43.0 Transition from MPD to Well Control	X	X	X	X	X	X	X	X
45.0 Tripping in the Hole with MPD	X	X	X	X	X	X		
46.0 Tripping Out of the Hole with MPD	X	X	X	X	X	X	X	X
51.0 Changing an RCD Bearing Assembly Under Pressure			X	X	X	X	X	X
57.0 Equalizing Pressure Across BOP	X	X	X	X	X	X	X	X
59.0 Influx test	X	X	X	X	X	X	X	X

NOTE: An X indicates that this person was present when this operation was conducted

LOSS DETECTION



INFLUX DETECTION



WHAT HAVE WE DONE SO FAR?

- Installed equipment and integrated it into the rig package
- Trained crews in MPD as normal operation The driller operates the system.
- Demonstrated ability to detect influx in <1 bbl
- Mitigated effects of wellbore breathing
- Reduced wellbore instability problems
- Tripped with no losses or gains with minimal operating window

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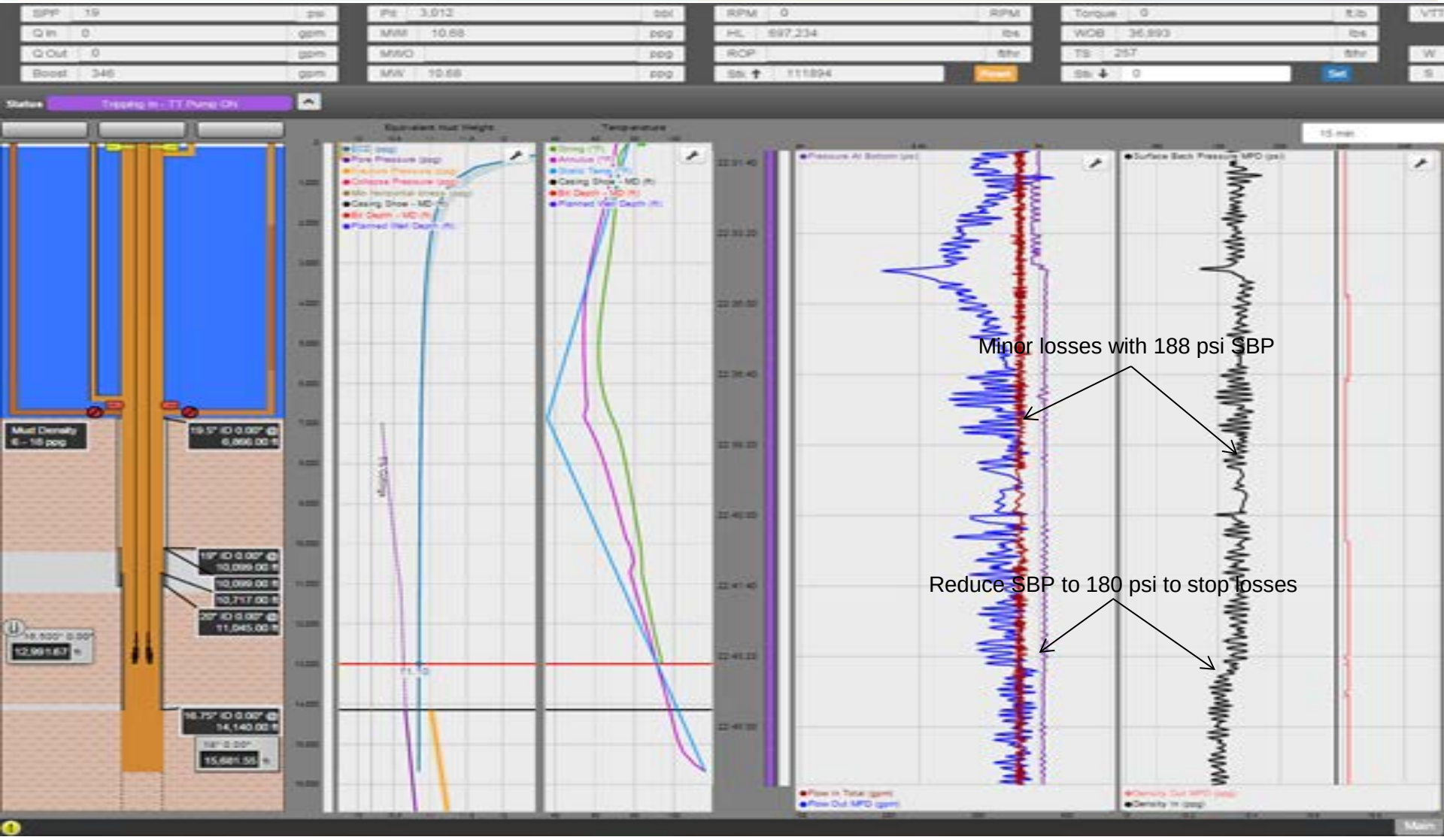
BENEFITS OF FINE CONTROL



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WHAT HAVE WE DONE SO FAR?

- Obtained ABS-CDS certification for MPD installation
- Obtained BSEE approval to take the mud weight below pore pressure
- Drilled hole sections overbalanced with a mud weight below pore pressure using MPD methods
- Changed mud weight while drilling and maintained a constant wellbore pressure at a selected point throughout the operation.
- Conducted dynamic wellbore integrity tests while drilling.

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CONCLUSIONS

- MPD equipment can be added to an existing rig package even while the rig is in operation
- By selecting each of the components separately it is possible to get a much better total package than is possible from a single source. This also makes it possible to modify or upgrade any individual part
- Owning the equipment rather than renting gives the user much more control over what is provided and how it is used. Also facilitates upgrading individual components as new technology becomes available.

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CONCLUSIONS

- **Integrating the MPD package into the rig allows much better crew training and performance.**
- **Adding flowmeters to the inlet gives much more reliable flow rates than counting pump strokes and allows real time input of true mud weight, even when it varies.**
- **MPD provides substantial benefits even when conventional operations are possible.**

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THANK YOU

QUESTIONS?

DO YOU REALLY NEED MPD?

- It is often heard that we have been getting along quite well without MPD for many years and don't really need it.
- That is indeed true for many wells. However we are continually drilling more and more challenging wells with narrower and narrower operating windows and many wells we would like to drill will require some type of unconventional approach.
- In many situations, especially in deep water, MPD reduces risk, improves safety and reduces cost, even on wells that can be drilled by conventional means.

OLD WAY

PROGRESS

TODAY

FOR THE CHALLENGING JOBS

LOTS OF OPTIONS

PROJECT TIMELINE

- **6-6-2013** First feasibility report to management
- **1-8-2014** Approval to proceed
- **3-7-2014** First equipment orders placed
- **4-29-2014** First meeting with BSEE
- **5-23-2014** Piping installation begins on board during transit from Africa
- **8-7-2014** Choke and control system testing begins at test facility
- **5-1-2015** Field trials begin
- **6-1-2015** Installed on first well ready to begin MPD operations

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