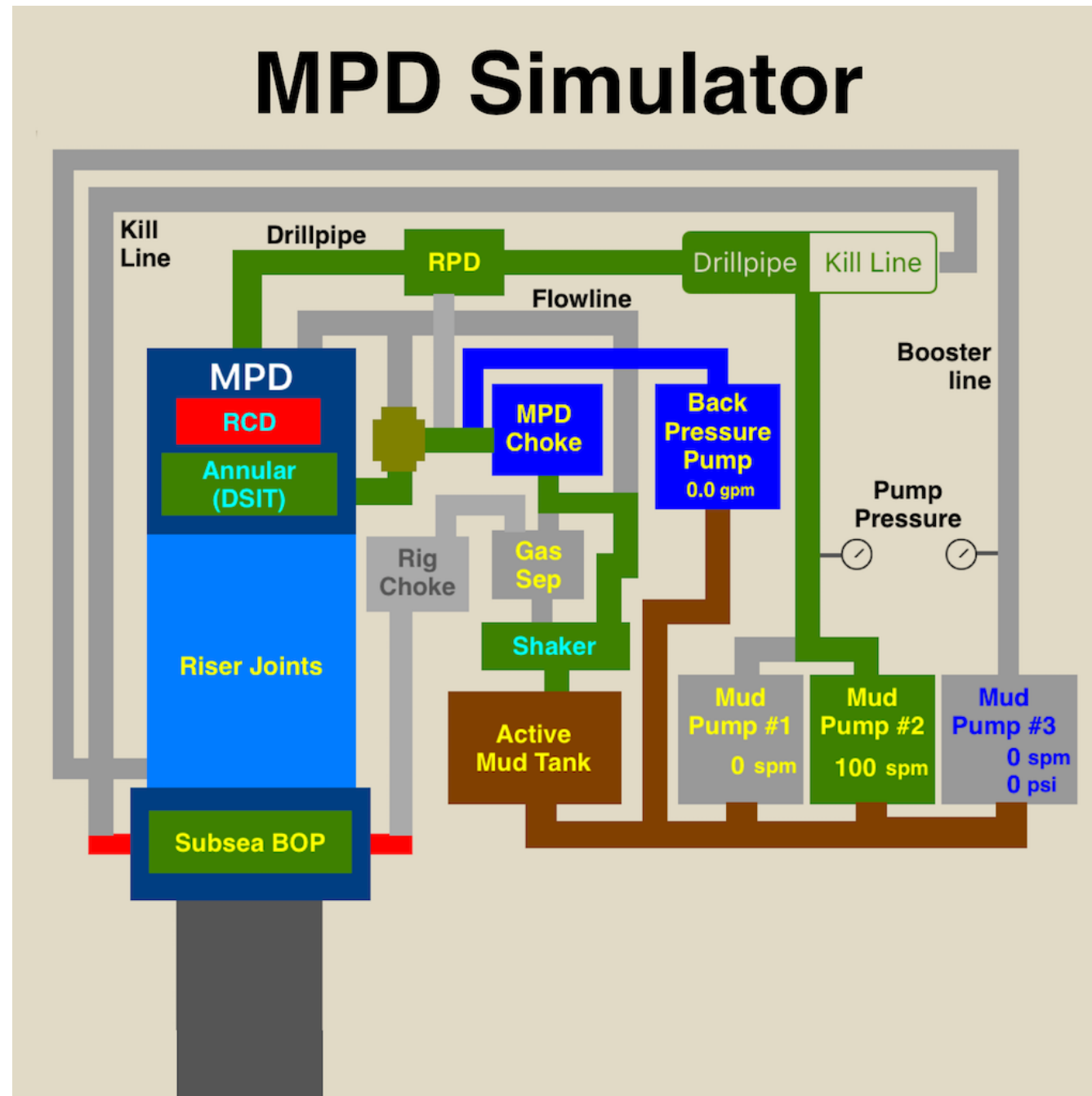




# MPD Simulator

iPad Version 1.0



**Disclaimer**

**Introduction**

**Single Bubble Model**

**Data Files**

**Unit Systems**

**Well Configuration**

**Circulating System**

**Drilling**

**Hydraulics**

**MPD Choke**

**BackPressure**

**BackPressure Pump**

**Rig Pump Diverter**

**BP w/ Riser Booster Pump**

**Kill Mud Weight**

**Graph Analysis**

**Dynamic Well Control**

**About**

## CHAPTER 2

# Disclaimer

These tools and materials are provided 'as is' without warranties of any kind, express or implied.

Please verify the tools provided by this application by yourself before you use them. Ensure you understand the impact of using these tools.

Any use you choose to make of these tools & materials is undertaken by you entirely at your own risk.

## Note:

This app was created with an educational proposal to help students and teachers of drilling engineering and has no intention of replacing the professional softwares.

It is also a useful tool for other professionals in the oilfield, such as technicals and engineers.

Thanks



## CHAPTER 3

# Introduction

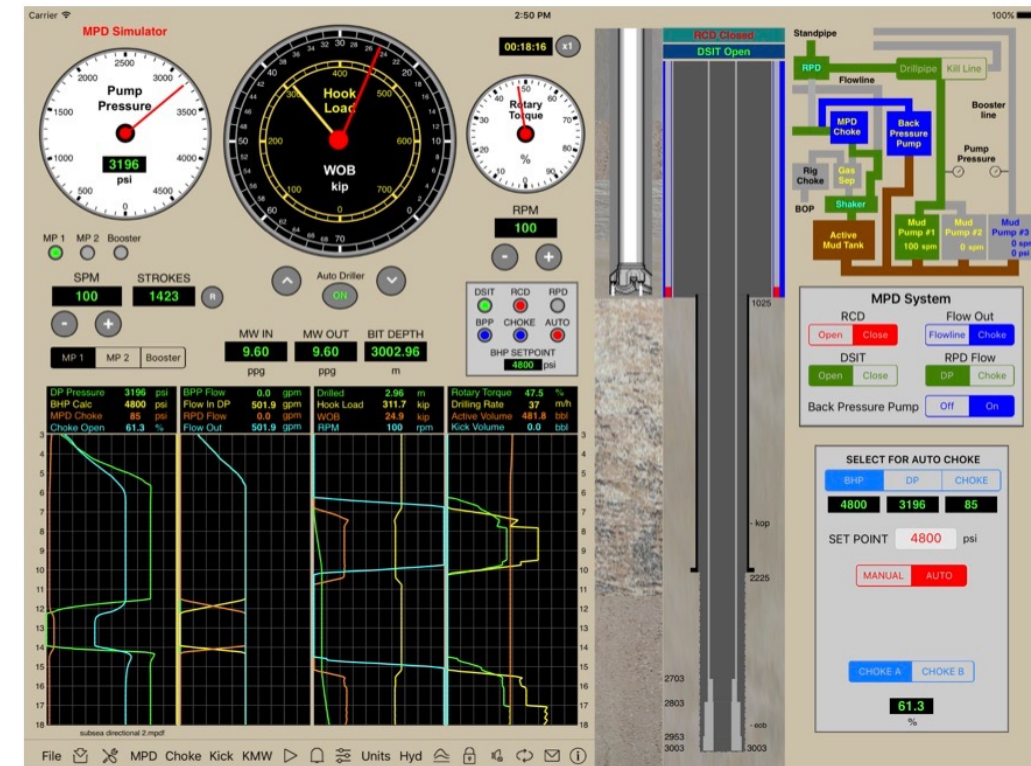
This app is designed for both iPhone and iPad.

This application provides practical simulations of the Dynamic Well Control on the Managed Pressure Drilling (MPD) operations in the oil field services.

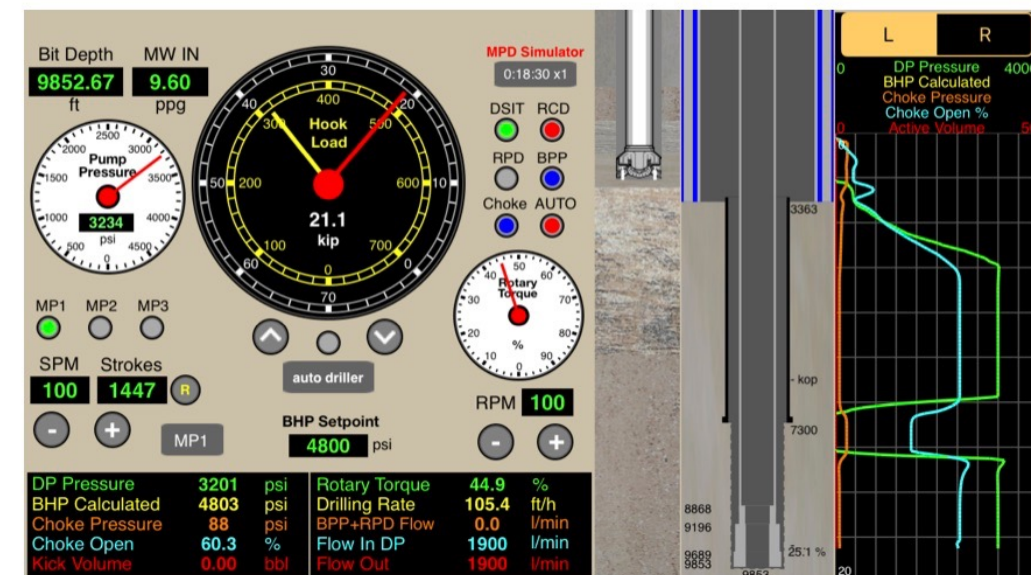
With Managed Pressure Drilling (MPD), when kicks occur, they are typically smaller, contained more quickly, and, in some cases, they may be circulated out through MPD equipment without drilling or circulation interruption.

This simulator is the new project based on the Drilling Simulator 2 available on our portfolio on the App Store, but specifically for dynamic well control on onshore and offshore operations (deepwater).

iPad Pro version:



iPhone 6 version:







### **MPD System on this simulator:**

1. RCD – Rotating Control Device
2. Annular Preventer (or Drill String Isolation Tool – DSIT)
3. Automated Choke for CBHP (Constant Bottom Hole Pressure), Constant Drill Pipe Pressure and Constant Choke Pressure.
4. RPD – Rig Pump Diverter
5. BPP – BackPressure Pump

### **Features:**

1. Driller Interface based on Pressure Gauge, Weight Indicator, Rotary Torque gauge and **Geolograph**.
2. Choke Interface based on Hydraulic **Choke** Digital Panel.
3. Graph in full screen (with background color in black or white) for analysis.
4. Pre-recorded data form
5. Three codes (admin, instructor, student) to view the gas into the borehole, the pressure at bottom, at shoe and at bop and to enable / disable the Lag Time (by adjusting the choke to change the kill pressure and drill pipe pressure, etc).

### **Attention: The Initial codes: "0000"**

Note: If lose the admin code:

1. Export all data files to iCloud;
2. Delete the app on iPad
3. Re-install it from App Store.
4. Use the initial code: "0000"
5. Import data files from iCloud

### **Other features also available:**

A graphical very useful tool for training of roughnecks, derrickmen, drillers, toolpusher, drilling engineers and students in the well control procedures.

- Ability to drilling, kick detection, shut-in, stabilization of pressures;
- Interactive System: no pre-set methods;
- Ability to apply control methods: Driller's method, wait and weight, dynamic volumetric and static volumetric (lubricate and bleed);
- Hydraulics and Hydrostatics;



- Behavior of the kick;
- Applied with subsea stack or surface stack;
- Set well with until 4 sections: riser, casing, liner, open hole ;
- Set Drillstring with drillpipe1, drillpipe2, heavy weight, drill-collar1, drillcollar2

**Others apps** very useful of our portfolio for Well Control:

- Drilling Hydraulics
- Drilling Simulator
- Kick Tolerance
- Kick Game
- Leak-Off Test Simulator
- Leak-Off Test Analyzer
- Well Control Methods
- Well Control Simulator
- Well Control Worksheets

These tools can complement (work with) this simulator by creating files which can be used in this application;

**Notes:**

1. This is a basic modeling that simulates drilling operations based in panels for drilling, kick detection, shut-in the well, stabilization of pressures and the choke operations during the well control operations using a hydraulic choke panel simulator.
2. This simulator is limited and is not applied to some complex situations.
3. This simulator does not uses the BOP / Rig Choke, just the MPD System, ONLY.

Please, report us bugs and suggestions for improvements.

Thanks

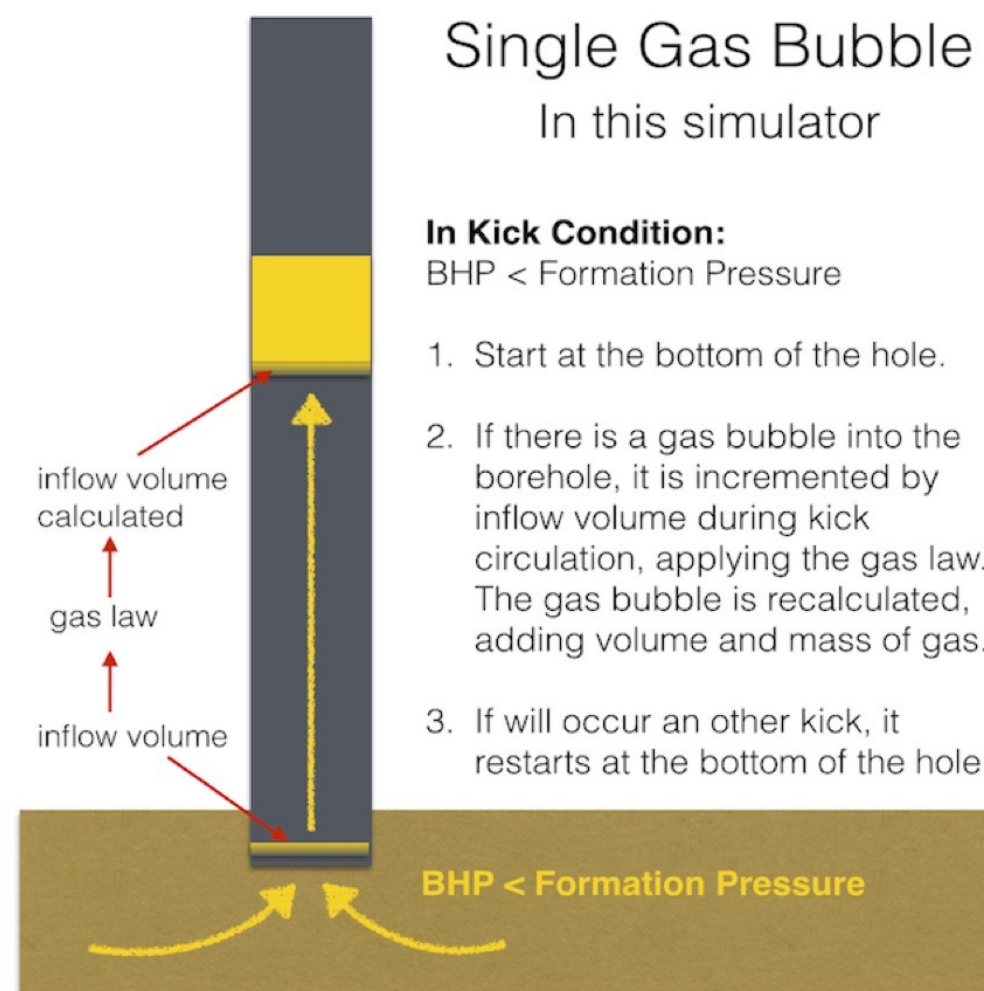
## CHAPTER 4

# Single Bubble Model

### Kick Model in this simulator:

The model assumes that the kick starts as a single bubble at the bottom of the hole and migrates upward as a single bubble from the bottom to the surface.

In underbalanced condition ( $BHP < \text{Form Pressure}$ ) during control, the single bubble volume is incremented with the inflow volume from formation to the well.





## CHAPTER 5


# Data Files

This app work with the extension (\*.mpdf)


It's recommended first to create a data file to work with this app and to enable the **“Save”** button on views.

This app only opens data files locally in the Documents folder !

Use iCloud or others storage providers to import or export data files !

 **On My iPad**

This application opens only data files in the local documents folder of this application.

**Download**




Download a data file from iCloud container or iCloud Drive/storage providers (Dropbox,...).

**iCloud container**

- Use this option to retrieve data files sent to iCloud from this iPad.
- Use this option also to share data with other apps compatibles installed in this device.

**iCloud Drive / Dropbox**

- Use the iCloud Drive option to download/ upload data files on iCloud Drive or other storage providers accessible via iCloud Drive interface or download from Dropbox directly.


**Upload**
 / **Open in...**



Upload the file selected to iCloud container or iCloud Drive/storage providers (Dropbox, ...).

Carrier 3:32 PM 100%


**Data Files**

iCloud iCloud Drive

 **Dropbox**






 **On My iPad**

File Name: .mpdf

+ New Surface + New Subsea  **Save**

subsea 4 kick surface 2B.mpdf  
subsea 4 kick surface.mpdf  
subsea directional 1.mpdf  
subsea directional 2.mpdf  
surface 1 kick 1 DM MPD 1.mpdf  
surface 1 kick 1 DM MPD 2.mpdf  
surface 1 kick 1 DM MPD 3.mpdf  
surface 1 kick 1 DM MPD 4.mpdf  
surface 1 kick 1 Stab.mpdf  
surface 1 kick 1.mpdf  
surface 1 MPD Dom 1.mpdf  
surface 1 MPD Dom 2.mpdf  
surface 1 MPD Dom 3.mpdf

Current: #

   **Open**   **iCloud Drive Open In...**

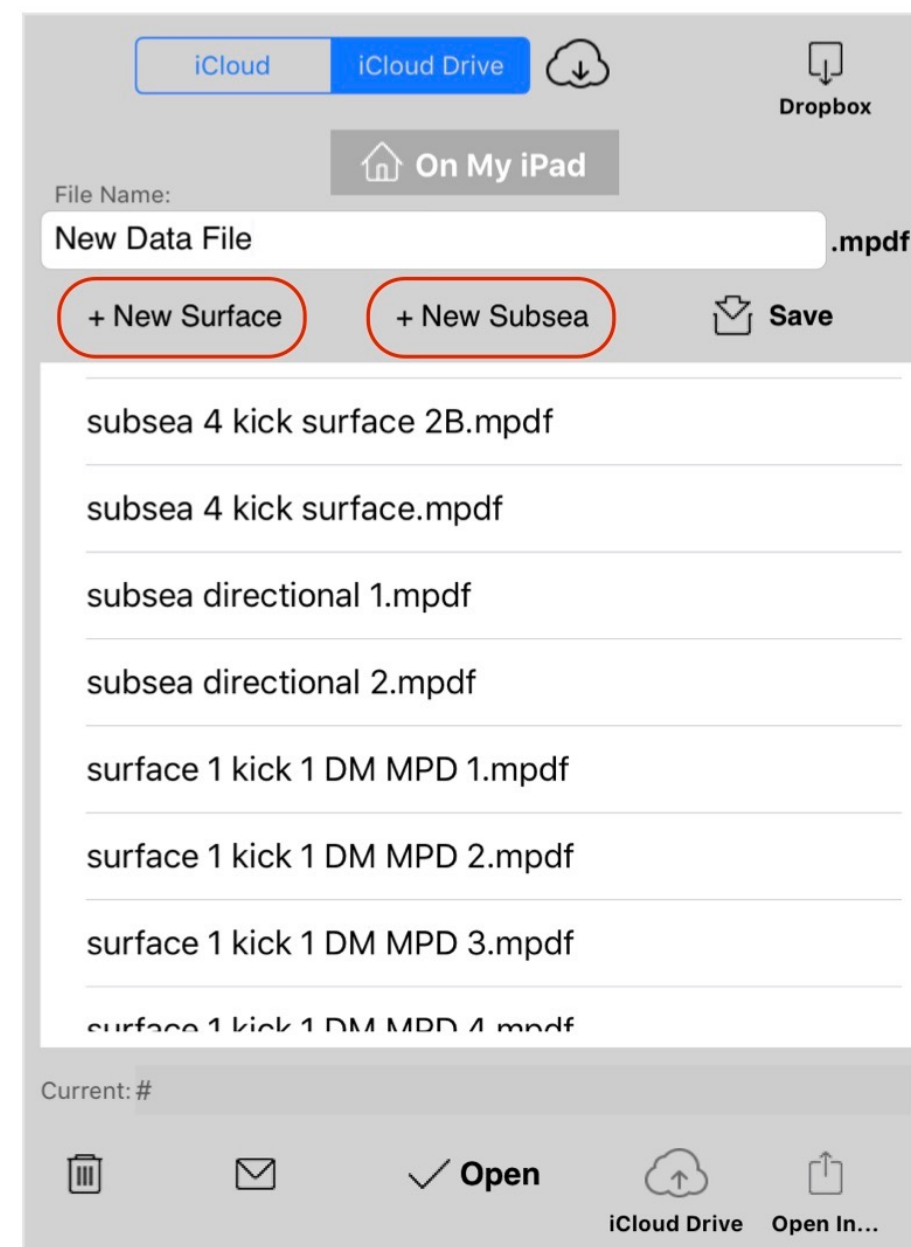
Import from Other Apps Units



## SECTION 1

# Creating a New File

1. Input the file name in text box and tap on **[+ New Surface]** or **[+ New Subsea]** button.
2. The file will be created with default values.
3. The file will be saved on local document folder.

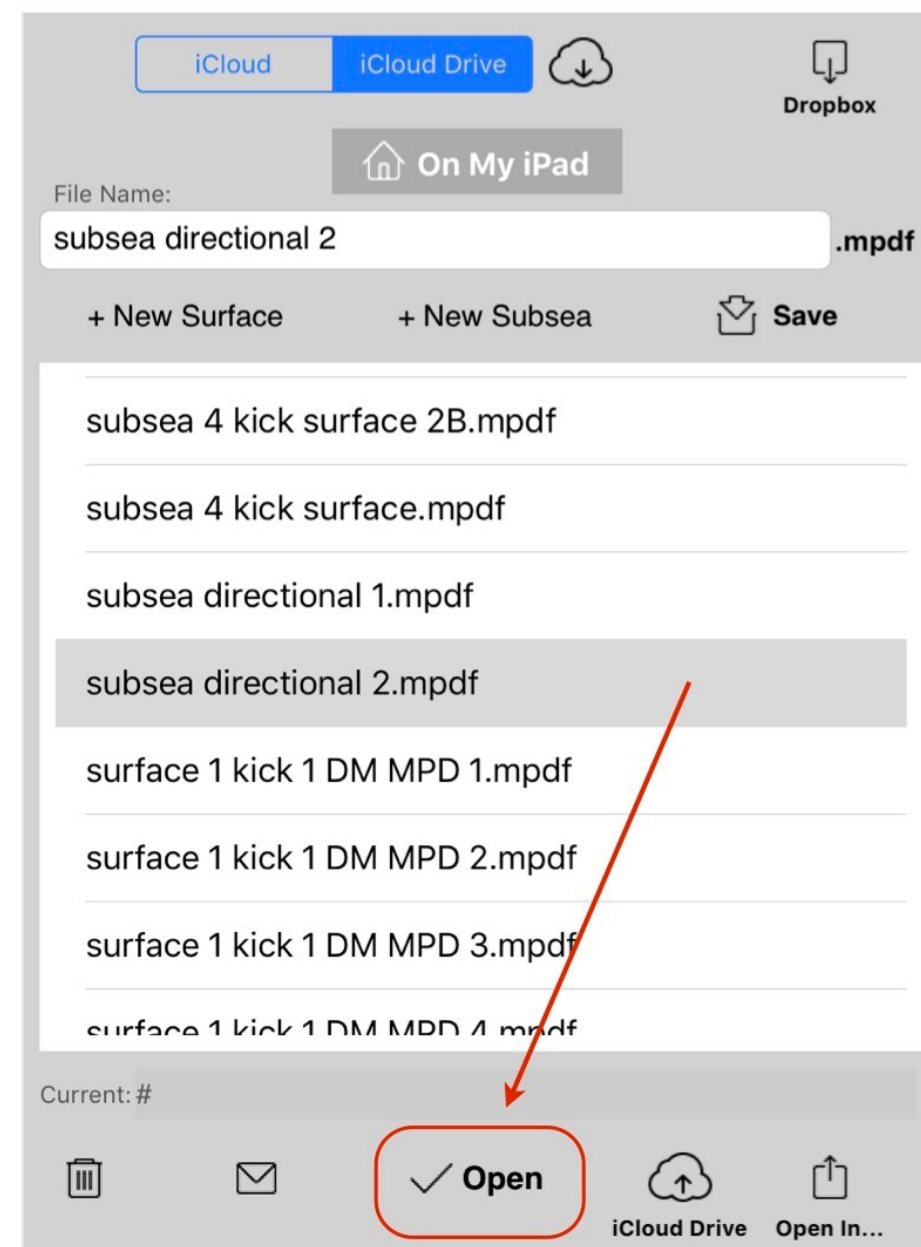




## SECTION 2

# Open a Data File

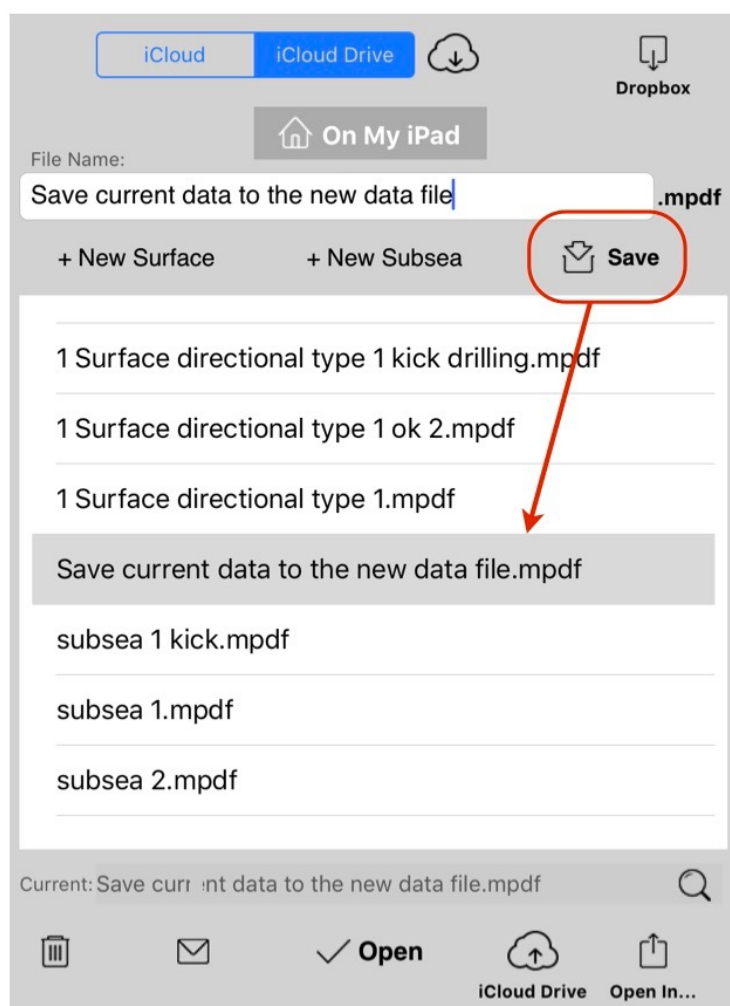
When TAP on “Open” button, the data that are on the Data File Highlighted are loaded in memory and can be saved with a new name (see Save As...)



## SECTION 3

# Save As...

1. Input the File Name in the TextBox.
2. TAP on **Save** button. The data file is saved on local document folder.



### Notes:

Save the exercise in several critical points to different data files:

### Examples:

1. At the beginning of circulation
2. Gas near casing shoe
3. Gas after casing shoe
4. Gas near to bop (Subsea Stack)
5. Gas near to surface
6. All gas out
7. Kill Mud near to BHA
8. Kill Mud near to drill bit
9. Kill Mud near to casing shoe
10. Kill Mud near to bop



## SECTION 4

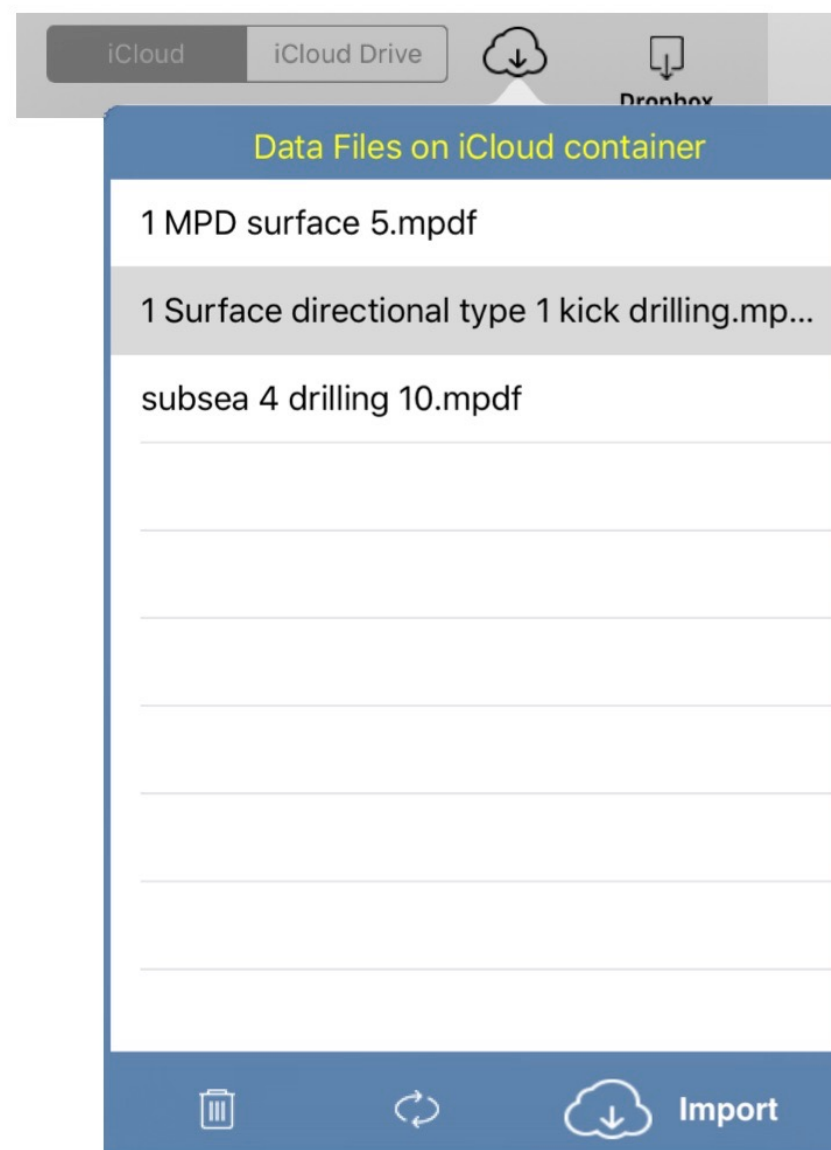
# Data File on iCloud

1. Check iCloud Settings
2. **iCloud Drive --> ON**



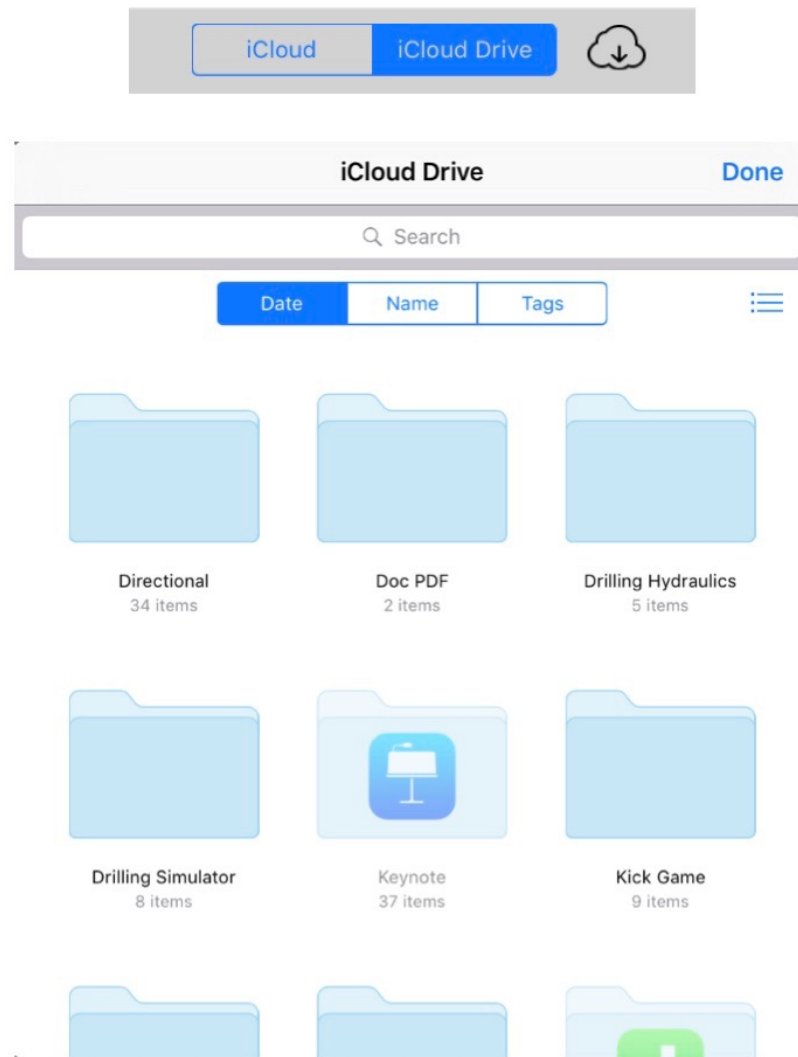
## iCloud Container:

- Use this option to retrieve data files sent to iCloud from the same Apple Id on any device.

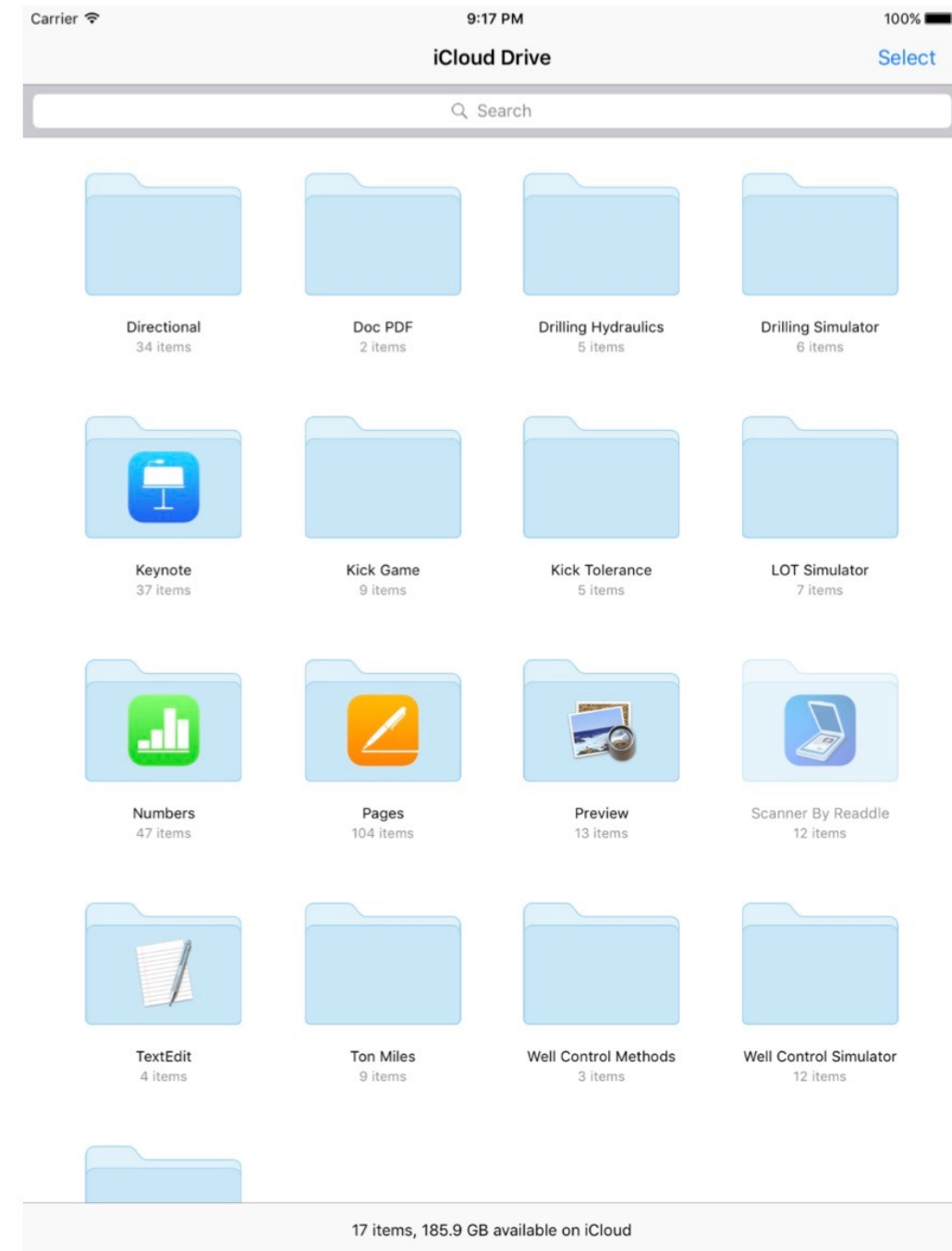


## iCloud Drive:

Use the this option to download/upload data files on iCloud Drive or other storage providers accessible via iCloud Drive interface.

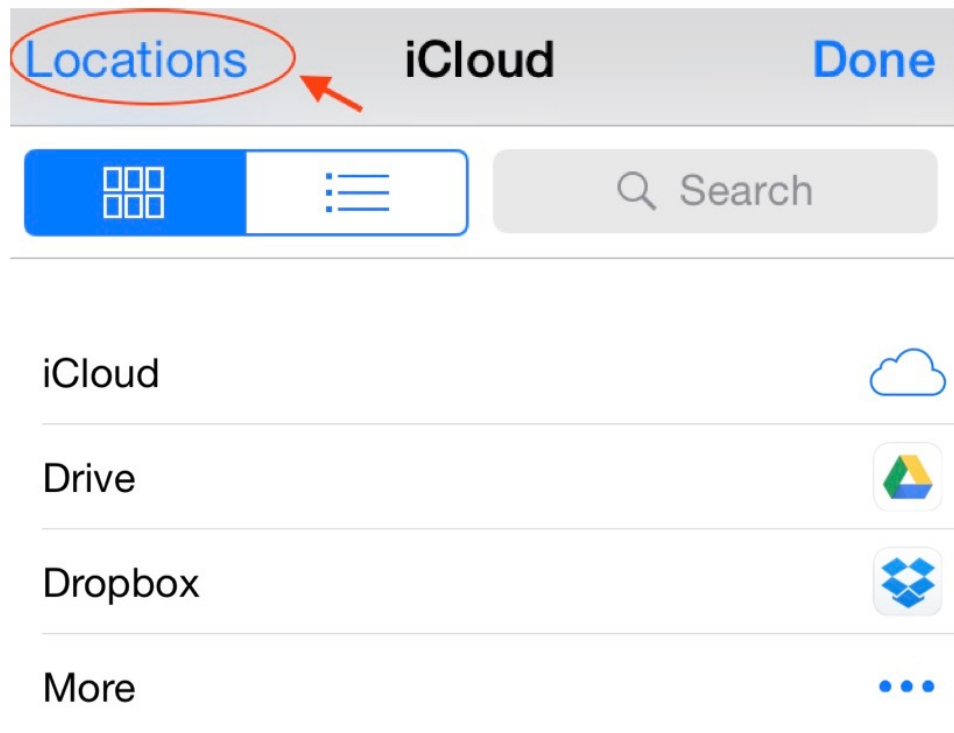


## Using the iCloud Drive app (available on iOS 9)

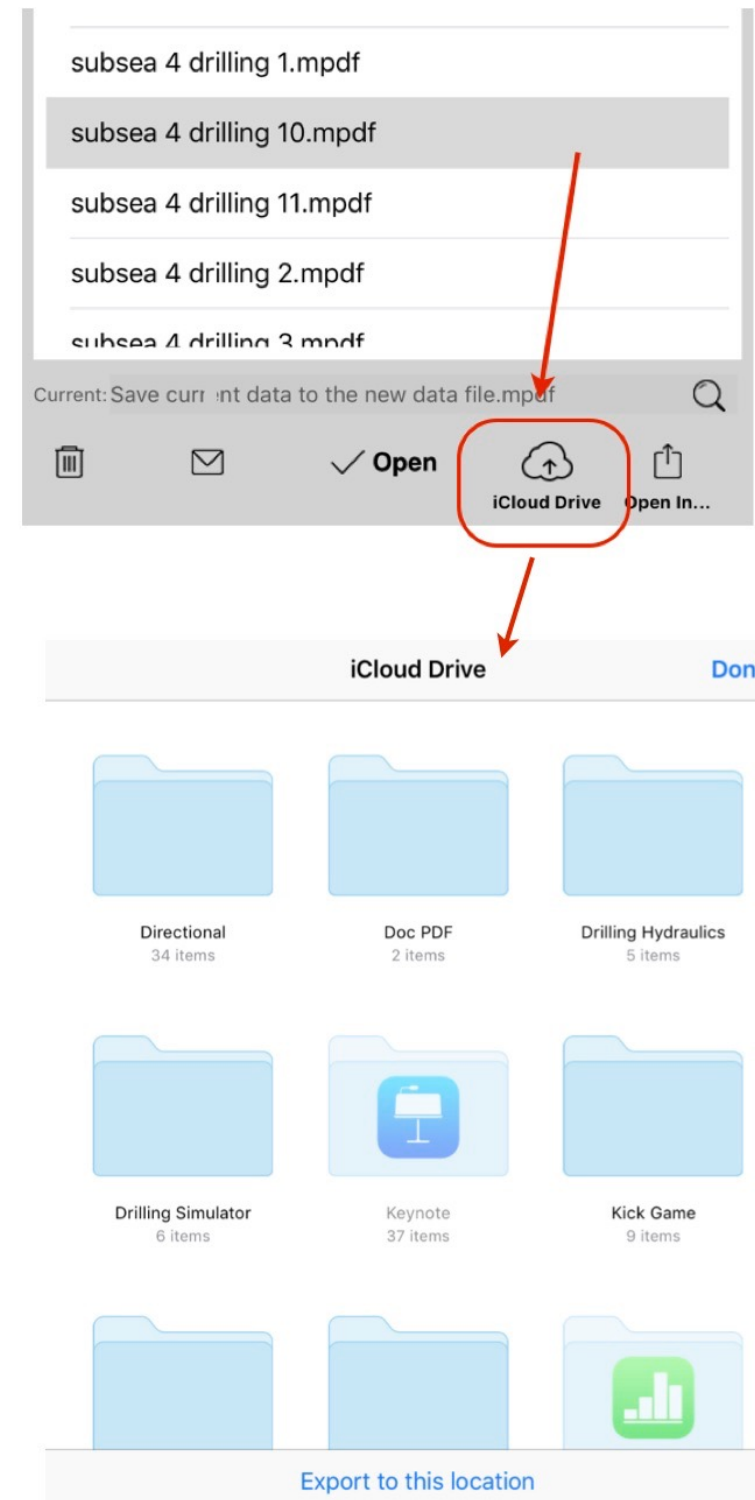




## Accessing other Storage Providers via iCloud Drive interface:



## Exporting data files to iCloud Drive

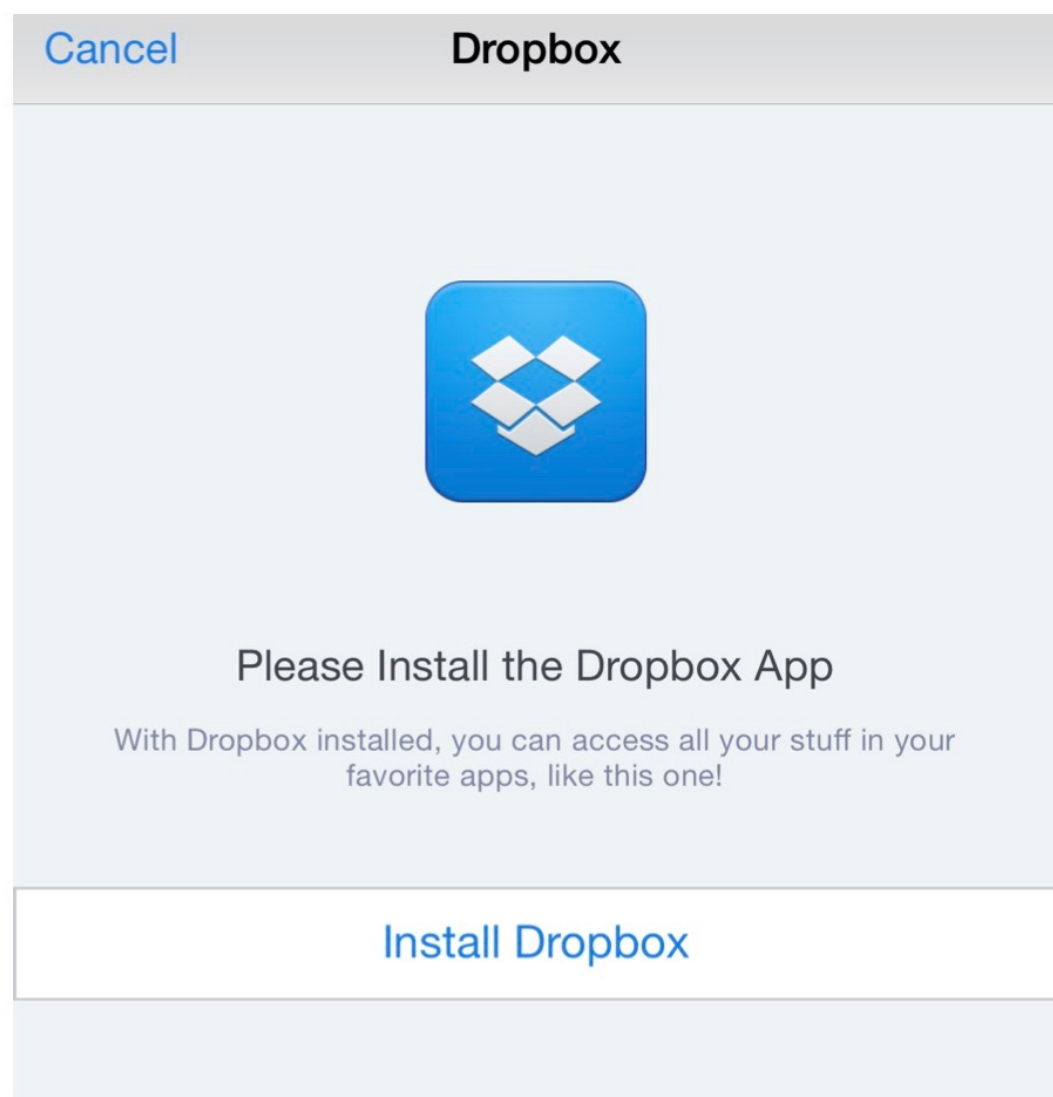




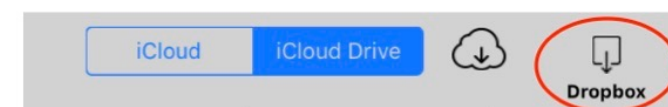
## SECTION 5

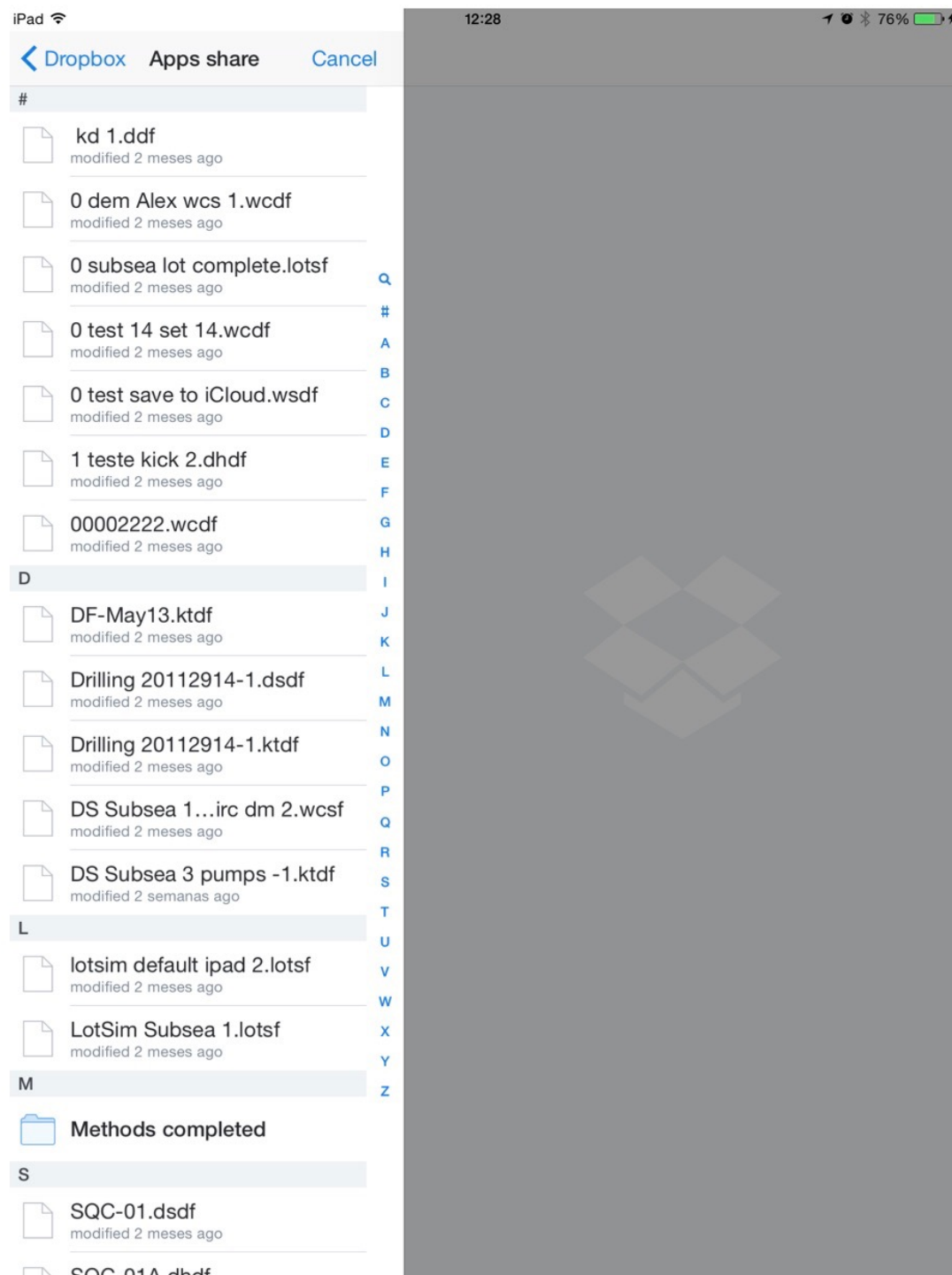
# Data Files on Dropbox

1. Install the Dropbox app on your device
2. **Do a login in the Dropbox app**



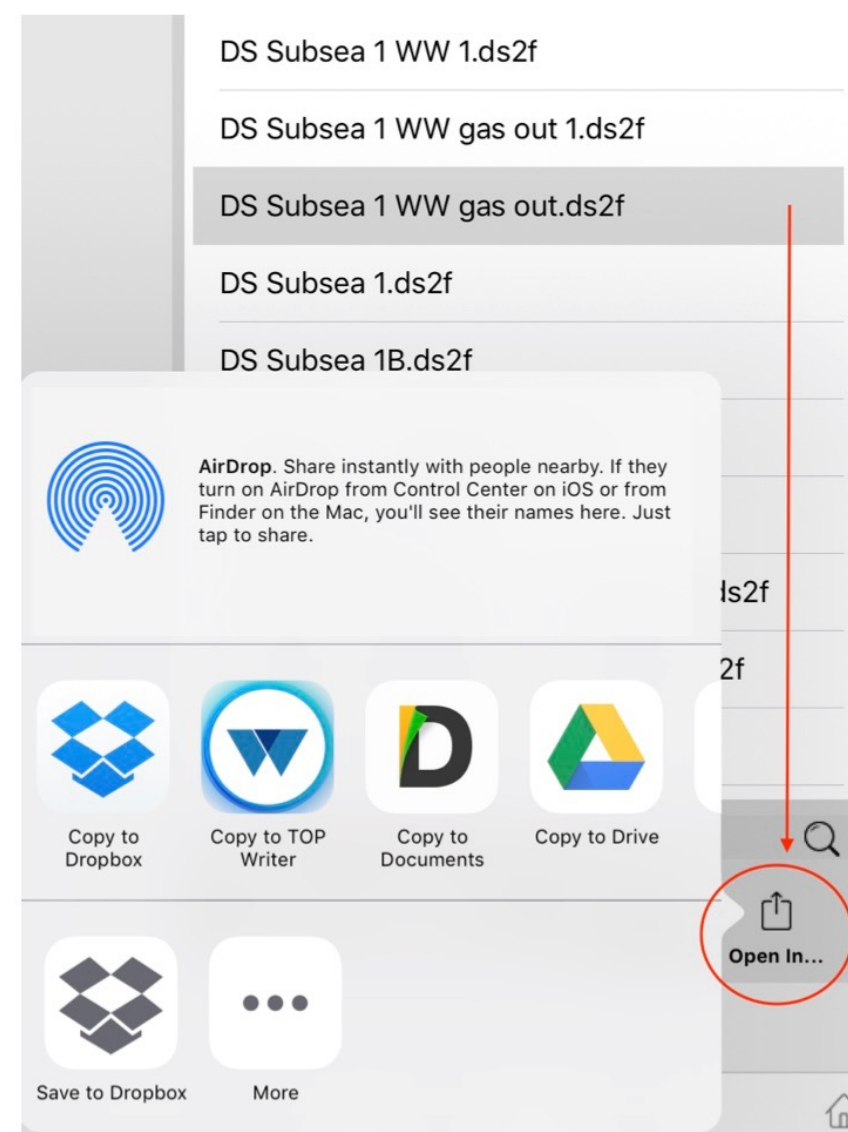
## Importing from Dropbox





## Upload to Dropbox:


To submit a data file to Dropbox provider, use the **Open In...** button and open it in the Dropbox app:

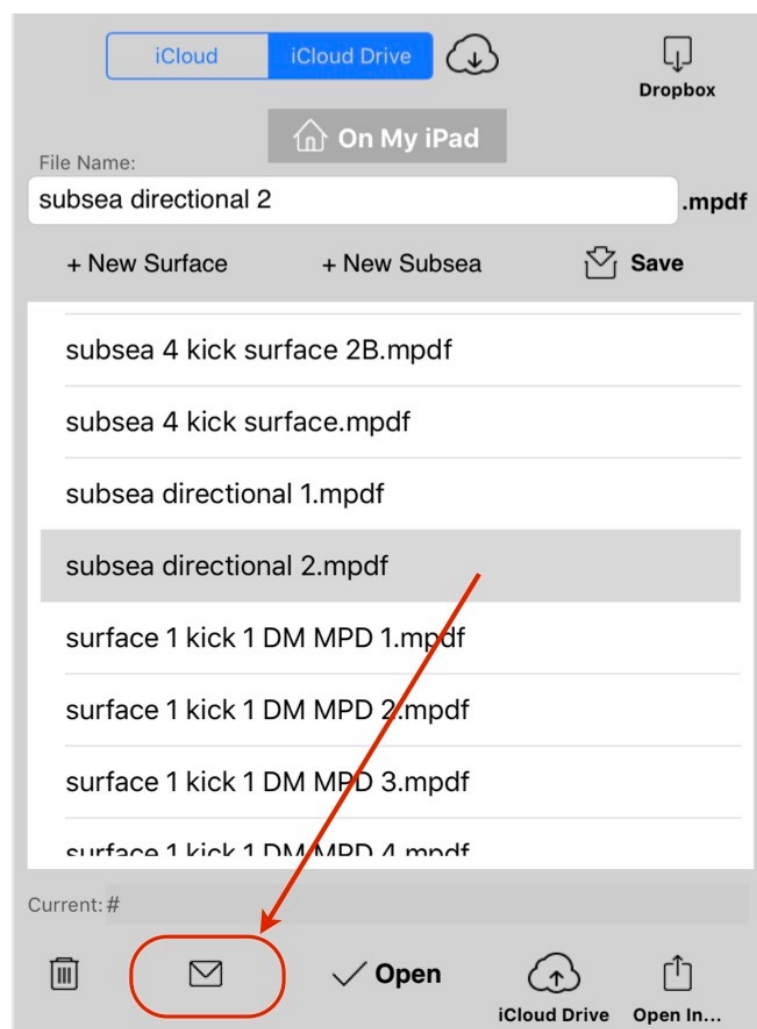




## SECTION 6

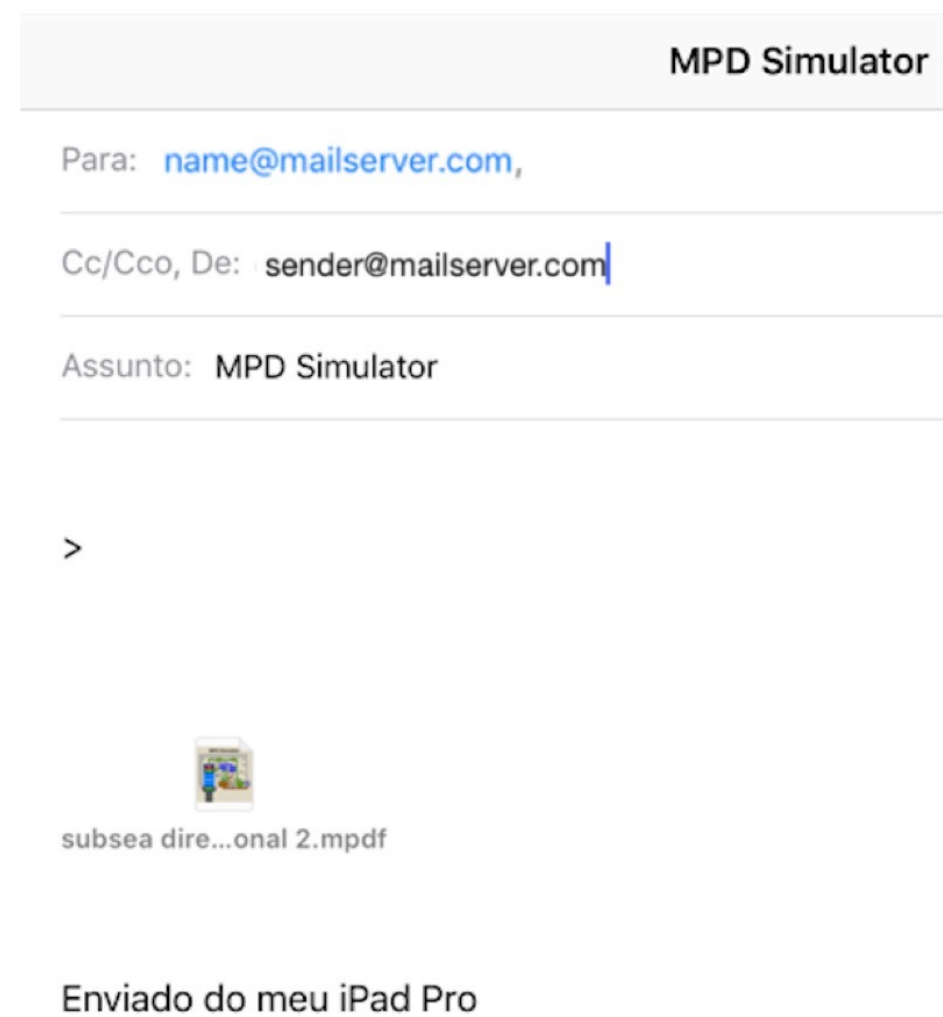
# Send a data file by Email

1. Select the data file.
2. TAP on  button.



1. Input the mail address to send:
2. Edit the subject.

Note: Configure an account mail on **Mail app**



## SECTION 7

# Importing from other apps

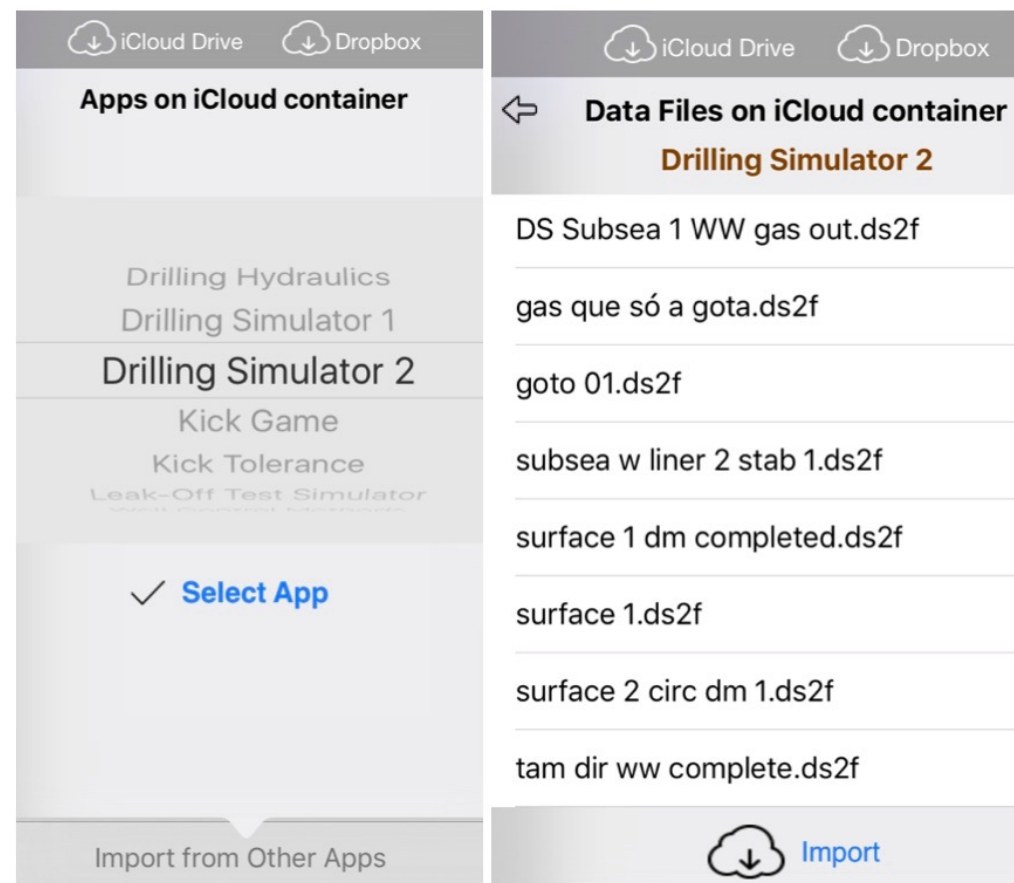
### COMPATIBLES APPS ON OUR PORTOLIO:

1. Drilling Hydraulics
2. Drilling Simulator 1
3. Drilling Simulator 2
4. Kick Game
5. Kick Tolerance
6. Leak-Off Test Simulator
7. Well Control Methods
8. Well Control Simulator

### Note:

This App “Drilling Simulator 2” and the App “Well Control Worksheets” only import data from these 8 apps.

Tap on “**Import from Other Apps**” button on toolbar:



## CHAPTER 6

# Unit Systems

Select units per Unit System:  
METRIC, SI or OILFIELD

or per parameter.

Note about Gravity value used in the hydrostatic calculations:

Hydrostatic Pressure (Pa)  
= Gravity (m/s<sup>2</sup>) x Density (kg/m<sup>3</sup>) x Height (m)

This app uses the value **Gravity = 9.80665 m/s<sup>2</sup>**

—> Hydrostatic Pressure (Pa)  
= 9.80665 x Density (kg/m<sup>3</sup>) x Height (m)

—> Hydrostatic Pressure (psi)  
= 0.051948 x Density (ppg) x Height (ft)

	METRIC	SI	OILFIELD	Others
Pressure	bar	kPa	psi	atm
Density	kg/l	kg/m <sup>3</sup>	ppg	lb/ft <sup>3</sup>
Gradient	bar/m	kPa/m	psi/ft	psi/m
Length	m	m	ft	ft
Diameter	mm	mm	inch	cm
Area	mm <sup>2</sup>	mm <sup>2</sup>	sq. in	cm <sup>2</sup>
Volume	liter	m <sup>3</sup>	bbl	ft <sup>3</sup>
Capacity	liter/m	m <sup>3</sup> /m	bbl/ft	bbl/m
Flow Rate	l/min	m <sup>3</sup> /min	gpm	ft <sup>3</sup> /min
Power	kw	kw	hp	hp
Force	kgf	daN	lbf	N
Jet Velocity	m/s	m/s	ft/s	ft/s
Temp Grad	C/100m	C/100m	F/100ft	F/100ft
Plastic Visc	mPa.s	mPa.s	cP	cP
Yield Point	kg/m <sup>2</sup>	N/m <sup>2</sup>	lb/100ft <sup>2</sup>	Pa
Hookload	ton	ton	kip	kip
Pipe Weight	kg/m	kg/m	lb/ft	lb/ft
Mass/Weight	kg	kg	lb	lb



## CHAPTER 7

# Well Configuration



On Main view, tap on button on toolbar to edit:

1. well parameters
2. mud, gradients
3. drill bit
4. mud pumps
5. volumes
6. chokes
7. surface connections
8. etc.

Carrier 4:42 PM 100%

Vertical Well Directional Well Builder

Well Configuration

Kick-Off Point 4921.26 ft TVD

End Of Build Up 7874.02 ft 7363.17

Casing shoe 5905.51 ft 5885.63

Well depth 9842.52 ft 8347.42

Casing ID 12.4150 in

Hole size 8.5000 in

without Liner with Liner Liner

Surface Stack Subsea Stack

Air Gap 82.02 ft

Water Length 3280.84 ft

Mud Line Depth 3362.86

Riser ID 18.7500 in

Kill / Choke ID 3.0000 in

Booster Line ID 4.0000 in

	Length ft	OD in	ID in	Weight lb/ft	Cap Int bbl/ft	Vol Int bbl	Displac bbl/ft	Vol Steel bbl
DP 1	4265.09	5.5000	4.7780	21.90	0.0222	94.59	0.0072	30.75
DP 2	4593.18	5.0000	4.2760	19.00	0.0178	81.59	0.0065	29.97
HW	328.08	5.0000	3.0000	49.00	0.0087	2.87	0.0155	5.10
DC 1	492.13	6.2500	2.8125	96.00	0.0077	3.78	0.0303	14.89
DC 2	164.04	6.7500	2.8125	102.00	0.0077	1.26	0.0366	6.00
Bit @ 9842.52				Nominal 260.7 kip		184.09		86.71
				w/ buoyancy factor 222.5 kip		Total		Total

Hookload

	Internal			Annular Drill Pipe 1			Annular Drill Pipe 2		
	ft	bbl/ft	bbl	ft	bbl/ft	bbl	ft	bbl/ft	bbl
Riser	3362.86	0.3415	1124.31	3362.86	0.3122	1049.72		0.3173	
Casing	2214.57	0.1497	316.54	902.23	0.1204	108.58	1312.34	0.1255	164.63
Liner	1968.50	0.0745	133.74		0.0451		1968.50	0.0502	98.77
Hole	2296.59	0.0702	126.64		0.0408		1312.34	0.0459	60.24

	Annular Heavy Weight			Annular Drill Collar 1			Annular Drill Collar 2		
	ft	bbl/ft	bbl	ft	bbl/ft	bbl	ft	bbl/ft	bbl
Riser		0.3173			0.3036			0.2973	
Casing		0.1255			0.1118			0.1055	
Liner		0.0502			0.0365			0.0302	
Hole	328.08	0.0459	15.06	492.13	0.0322	15.87	164.04	0.0259	4.25
Choke Line	0.0087	bbl/ft		Surface to Bit 192.09	bbl		Riser Annular 1049.72	bbl	
Booster Line	29.40	bbl		Bit to Shoe 95.42	bbl		Total Volume 1820.29	bbl	
	52.27	bbl		Bit to BOP 467.41	bbl		Bit to Choke 496.81	bbl	

MP 1 MP 2

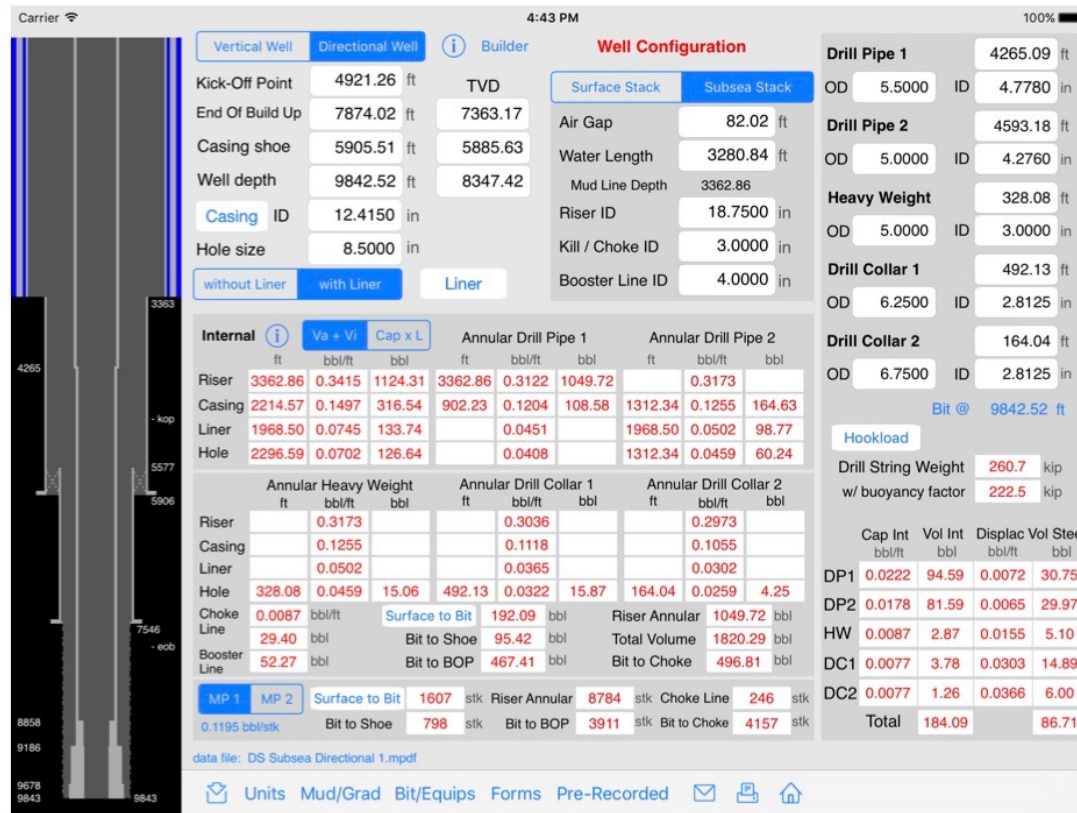
Surface to Bit 1607 stk Riser Annular 8784 stk Choke Line 246 stk

0.1195 bbl/stk Bit to Shoe 798 stk Bit to BOP 3911 stk Bit to Choke 4157 stk

data file: DS Subsea Directional 1.mpdf

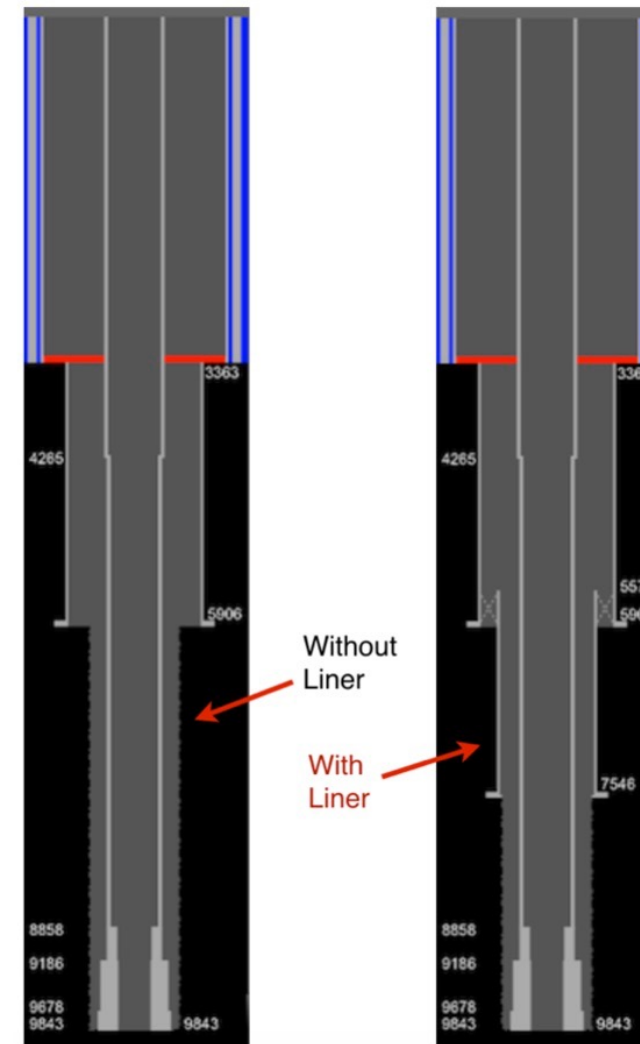
Units Mud/Grad Bit/Equips Forms Pre-Recorded

## iPad on horizontal position:



## Well with Liner

	Measured	TVD
Top Depth	5577.4 ft	5577.4 ft
Shoe Depth	7545.9 ft	7545.9 ft
OD	9.6750 in	Weight 43.5 lb/ft
ID	8.7550 in	Grade N80



## Casing

Weight	43.5 lb/ft	Grade	N80
Size	9.6250 in	ID	8.7550 in
Burst	6330 psi	DF	1.25 80.0 %
Burst/DF	5064 psi	1.1 - 1.4	70 - 90

Burst -> Burst Pressure

DF -> Design Factor (values 1.1 to 1.4)

Also named "SF - Safety Factor" (values 70% - 90%)

## Vertical Well

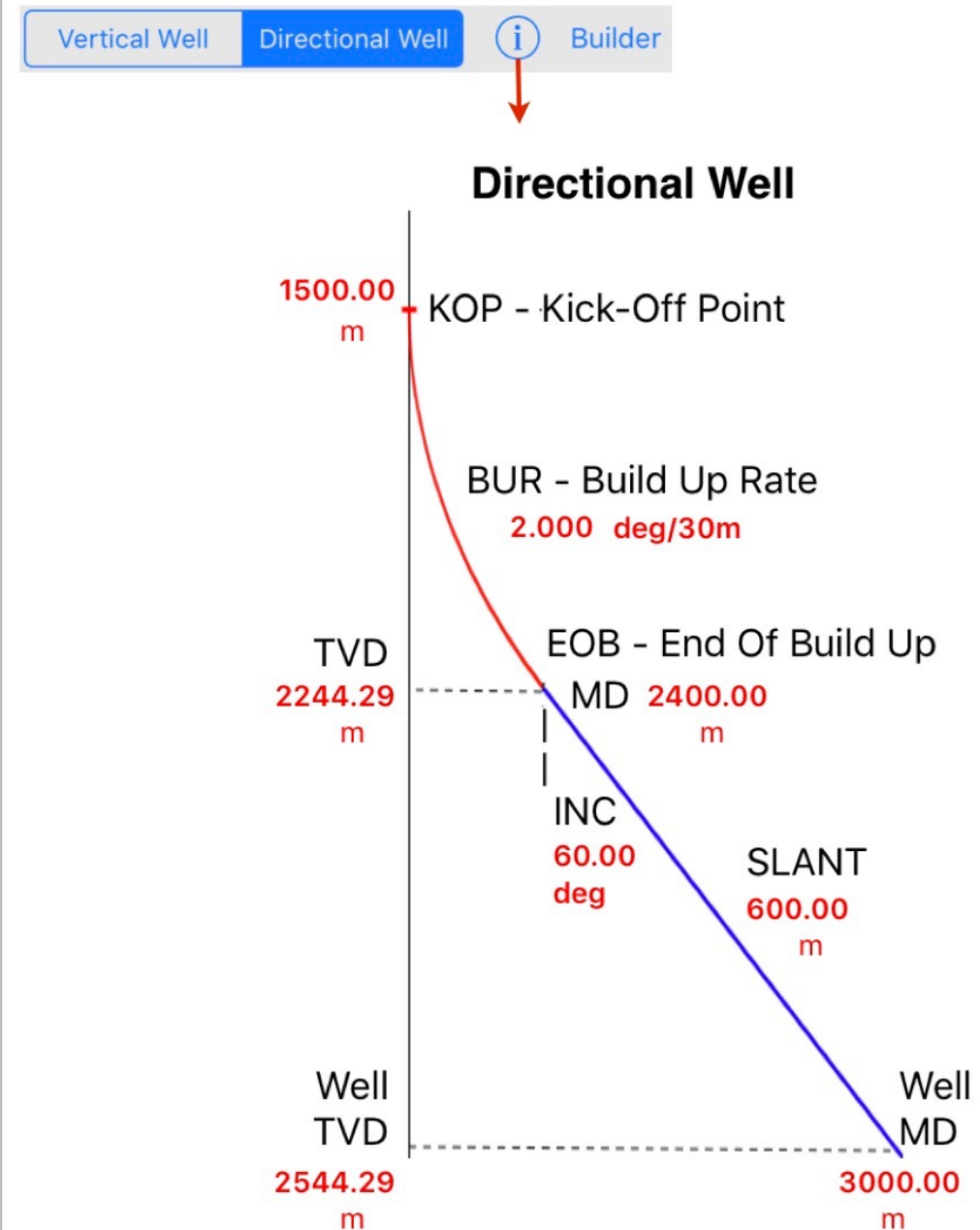
Vertical Well
Directional Well

Casing shoe	5905.51	ft
Well depth	9842.52	ft
Casing ID	12.4150	in
Hole size	8.5000	in

## Directional Well

Vertical Well
Directional Well
*i* Builder

Kick-Off Point	4921.26	ft	TVD
End Of Build Up	7874.02	ft	7363.17
Casing shoe	5905.51	ft	5885.63
Well depth	9842.52	ft	8347.42
Casing ID	12.4150	in	
Hole size	8.5000	in	



Calculations:

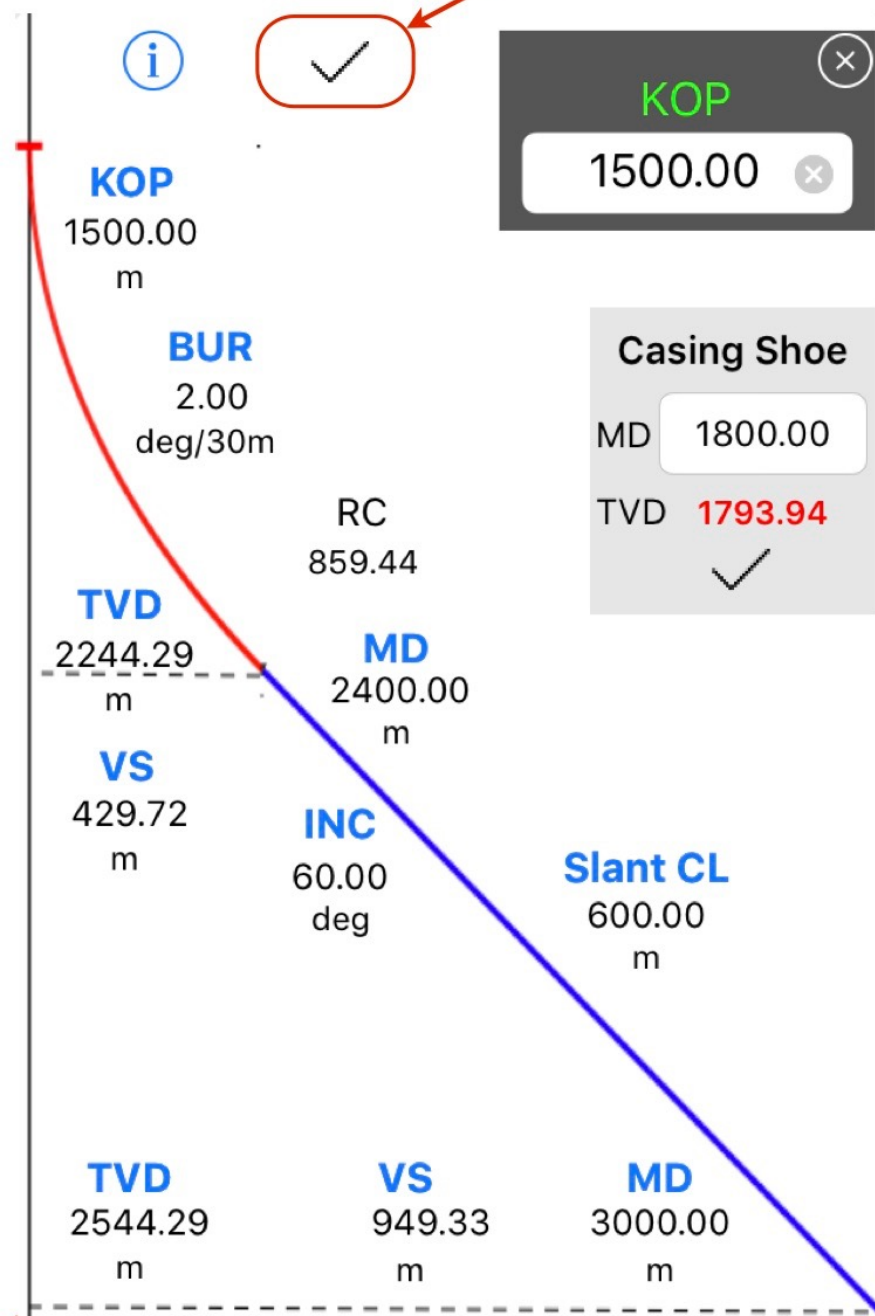
Friction Loss --> Measured Depth

Hydrostatic --> True Vertical Depth



## Directional Type I Builder:

Tap to Save



Edit parameters from top to down

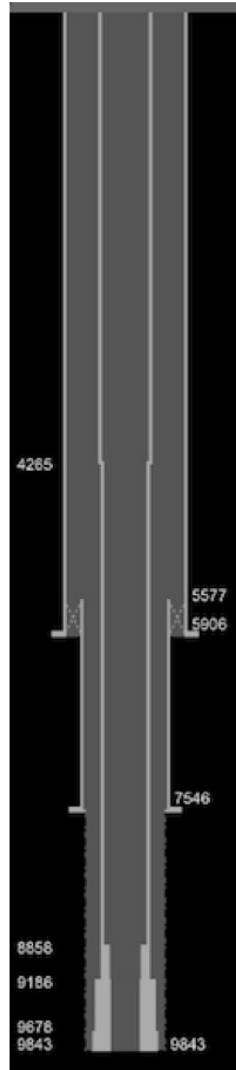
### Directional Terms

<b>KOP</b>	- Kick Off Point
<b>BUR</b>	- Build Up Rate
<b>DOR</b>	- Drop Off Rate
<b>DLS</b>	- Dog leg Severity
<b>RC</b>	- Radius of Curvature
<b>INC</b>	- Inclination, Drift
<b>TVD</b>	- True Vertical Depth
<b>MD</b>	- Measured Depth
<b>VS</b>	- Vertical Section
<b>CL</b>	- Course Length = MD2 - MD1
<b>N/S</b>	- North / South coordinate
<b>E/W</b>	- East / West coordinate
<b>TR</b>	- Turn Rate
<b>HD</b>	- Horizontal Displacement
<b>CD</b>	- Closure Distance (= HD)
<b>AZI</b>	- Azimuth

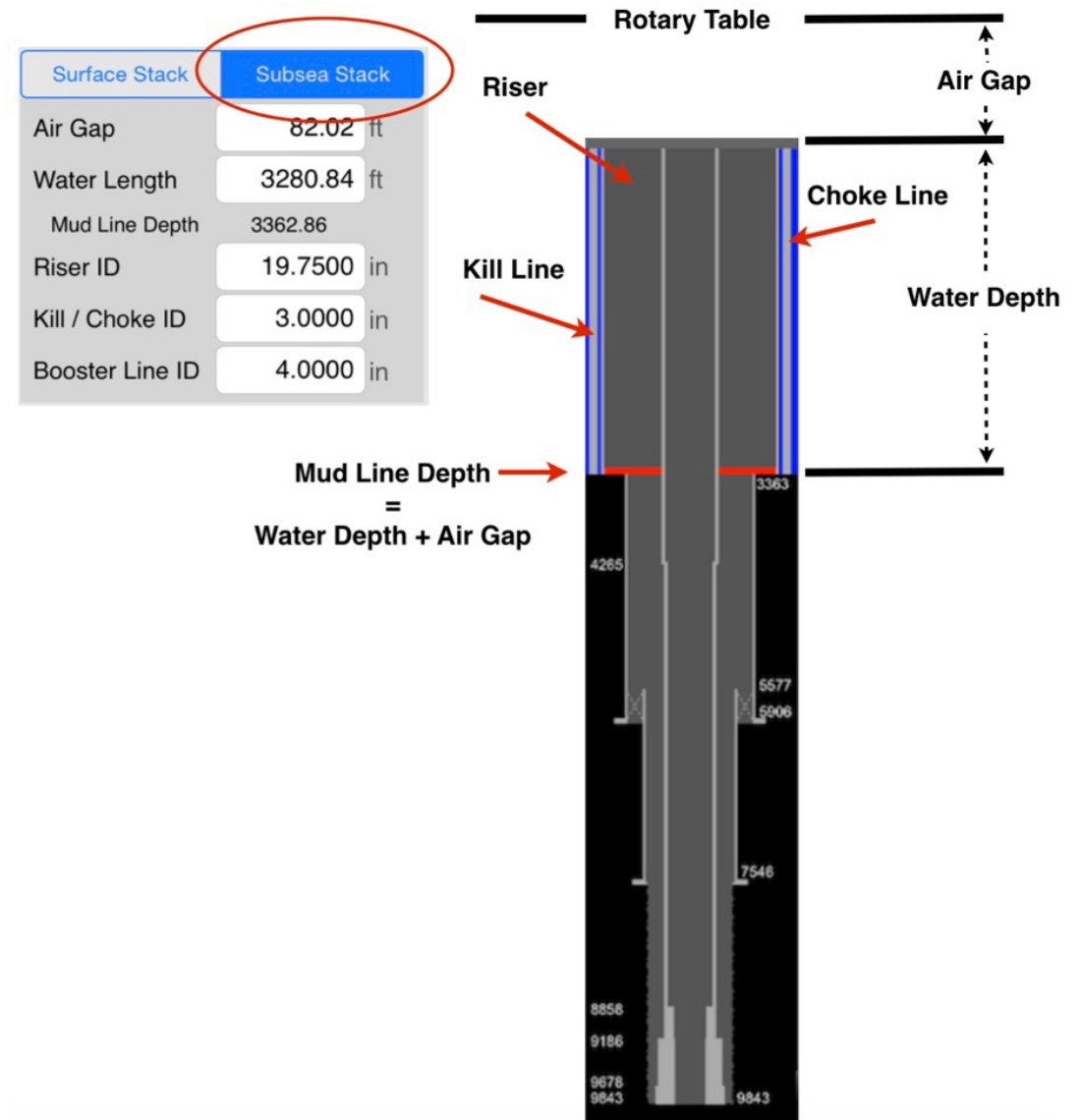
Tap on titles of the buttons (**blue**) to edit parameters.

## Surface Stack (Land Rigs, Jack-Up Rigs, etc)

Surface Stack    Subsea Stack



## Subsea Stack (Semi-Submersible Platform, Drill Ship, etc)



## Drill String

The drill string can be configured with:

- 2 types of drill pipes (DP1 and DP2)
- 1 heavy weight drill pipe (HW)
- 2 drill collars (DC1 and DC2)

iPad on **vertical** position

	Length ft	OD in	ID in	Weight lb/ft
DP 1	4265.09	5.5000	4.7780	21.90
DP 2	4593.18	5.0000	4.2760	19.50
HW	328.08	5.0000	3.0000	49.00
DC 1	492.13	6.2500	2.8125	96.00
DC 2	164.04	6.7500	2.8125	102.00
Bit @	9842.52	Nominal		263.0
		w/ buoyancy factor		224.5

Hookload

Elevation System Weight	120	kip
Drill String Nominal Weight	268.1	kip
w/ Buoyancy	228.8	kip
Hook Load	348.8	kip

### Note:

The Pipe Nominal Weight Parameter just can be edited with iPad on **vertical** Position

iPad on **Horizontal** position

DP1

		in
Drill Pipe 1	OD	5.5000
4265.09 ft	ID	4.7780
Drill Pipe 2	OD	5.0000
4593.18 ft	ID	4.2760
Heavy Weight	OD	5.0000
328.08 ft	ID	3.0000
Drill Collar 1	OD	6.2500
492.13 ft	ID	2.8125
Drill Collar 2	OD	6.7500
164.04 ft	ID	2.8125
Hookload	Bit @	9842.52 ft
Drill String Weight	263.0	kip
w/ buoyancy factor	224.5	kip

DP2

HW  
DC1  
DC2

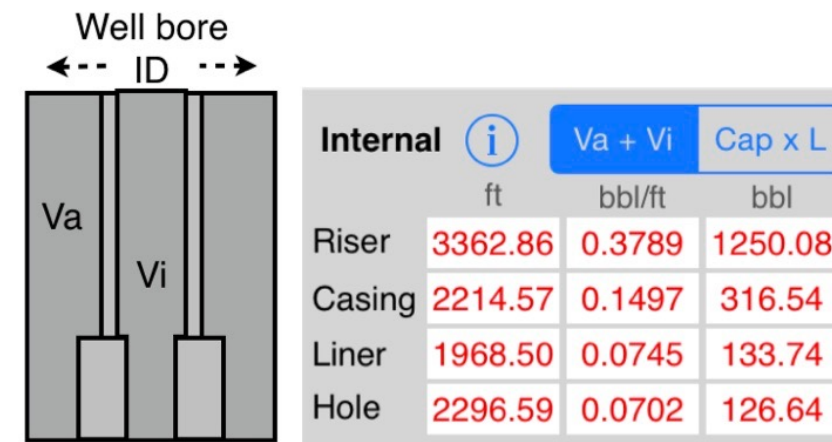


## Capacities and Volumes

	Length ft	OD in	ID in	Weight lb/ft	Cap Int bbl/ft	Vol Int bbl	Displac bbl/ft	Vol Steel bbl
DP 1	4265.09	5.5000	4.7780	21.90	0.0222	94.59	0.0072	30.75
DP 2	4593.18	5.0000	4.2760	19.50	0.0178	81.59	0.0065	29.97
HW	328.08	5.0000	3.0000	49.00	0.0087	2.87	0.0155	5.10
DC 1	492.13	6.2500	2.8125	96.00	0.0077	3.78	0.0303	14.89
DC 2	164.04	6.7500	2.8125	102.00	0.0077	1.26	0.0366	6.00
Bit @	9842.52		Nominal	263.0	kip	184.09		86.71
			w/ buoyancy factor	224.5	kip	Total		Total

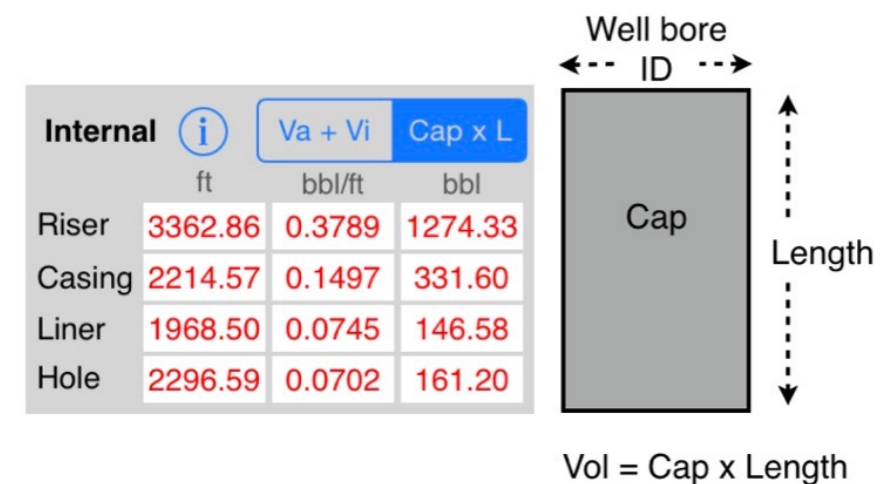
Internal	ft	bbl/ft	bbl	Annular Drill Pipe 1	ft	bbl/ft	bbl	Annular Drill Pipe 2	ft	bbl/ft	bbl
Riser	3362.86	0.3789	1250.08	3362.86	0.3496	1175.50		0.3547			
Casing	2214.57	0.1497	316.54	902.23	0.1204	108.58	1312.34	0.1255	164.63		
Liner	1968.50	0.0745	133.74		0.0451		1968.50	0.0502	98.77		
Hole	2296.59	0.0702	126.64		0.0408		1312.34	0.0459	60.24		
Annular Heavy Weight											
Riser		0.3547			0.3410			0.3347			
Casing		0.1255			0.1118			0.1055			
Liner		0.0502			0.0365			0.0302			
Hole	328.08	0.0459	15.06	492.13	0.0322	15.87	164.04	0.0259	4.25		
Choke Line	0.0087	bbl/ft	Surface to Bit	193.67	bbl	Riser Annular	1175.50	bbl			
Booster Line	29.40	bbl	Bit to Shoe	95.42	bbl	Total Volume	1947.65	bbl			
	52.27	bbl	Bit to BOP	467.41	bbl	Bit to Choke	496.81	bbl			
MP 1	MP 2	Surface to Bit	1621	stk	Riser Annular	9836	stk	Choke Line	246	stk	
0.1195 bbl/stk		Bit to Shoe	798	stk	Bit to BOP	3911	stk	Bit to Choke	4157	stk	

Internal Volume (just volume of fluid)  
Calculated without the steel volume (drill string)



Drill String ID  
 $Vol = Va + Vi$

Total Internal Volume  
(volume of fluid + volume of steel)



## Strokes Calculations

Surface To Bit	Volume bbl	Strokes stk
Surface Lines	9.57	80
Drill String	184.09	1540
	<b>193.67</b>	<b>1621</b>

## Strokes with Mud Pump #1

MP 1	MP 2	Surface to Bit	1621	stk	Riser Annular	9836	stk	Choke Line	246	stk
0.1195 bbl/stk		Bit to Shoe	798	stk	Bit to BOP	3911	stk	Bit to Choke	4157	stk

## Strokes with Mud Pump #2

MP 1	MP 2	Surface to Bit	1276	stk	Riser Annular	7744	stk	Choke Line	194	stk
0.1518 bbl/stk		Bit to Shoe	629	stk	Bit to BOP	3079	stk	Bit to Choke	3273	stk

## Mud (Drilling Fluid)

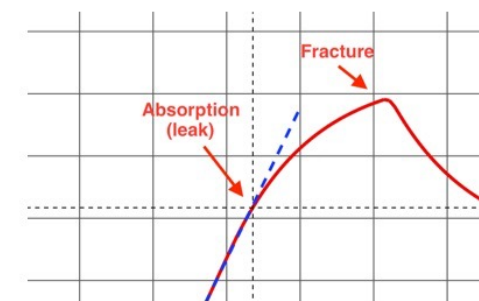
This app works just with parameters used in the hydraulics calculations:

-> Mud Weight, Plastic Viscosity, Yield Point and Initial Gel

Mud Weight	9.60	ppg	MW Gradient	0.4987	psi/ft
Plastic Viscosity	15.0	cP	@ 300 rpm	25	Direct Reading Viscometer:
Yield Point	10.0	lb/100ft <sup>2</sup>	@ 600 rpm	40	- YP in lb/100ft <sup>2</sup>
Initial Gel	5.0	lb/100ft <sup>2</sup>			- PV in cP
Sea Water Density	8.50	ppg	Rheological Model	Power	Bingham

## Fracture and Absorption Gradients

The Absorption Gradient is the Leak Gradient detected on the LOT (Leak-Off Test)



On Mud & Gradients view:

Formation Data @ Shoe Depth	Absorption Gradient	14.30	ppg	0.7429	psi/ft
	Fracture Gradient	14.80	ppg	0.7688	psi/ft
	Porosity	35.0	%	Permeability	100

## Temperature Gradient

Temperature Gradient	1.400	F/100ft			
Temperature at Surface	28.0	°C	82.4	°F	301.1 K 542.0 °R
Temperature at Mud Line	4.0	°C	39.2	°F	277.1 K 498.9 °R

## Hydrostatic Calculations

Buoyancy Factor	0.8534				
Shoe Depth Hydrostatic	3640.5	psi	@ Shoe TVD	2225.00	m
Absorption Pressure	5422.8	psi	Max @ surface	1782.2	psi
Fracture Pressure	5612.3	psi	Max @ surface	1971.8	psi
Bottom Hole Hydrostatic	4908.6	psi	@ Well TVD	3000.00	m
Bottom Hole Temperature	54.4	°C	129.9	°F	327.5 K 589.6 °R

## Equipments

MPD Choke Diameter A	2.0000	in
MPD Choke Diameter B	2.0000	in
Maximum MPD Pressure	5000	psi
Active Pit Capacity	700.00	bbl
Active Pit Volume	500.00	bbl
Surface Circulation Volume:		
Circ. by flowline @ 100 spm	30.00	bbl
Circ. by choke @ 40 spm	7.00	bbl

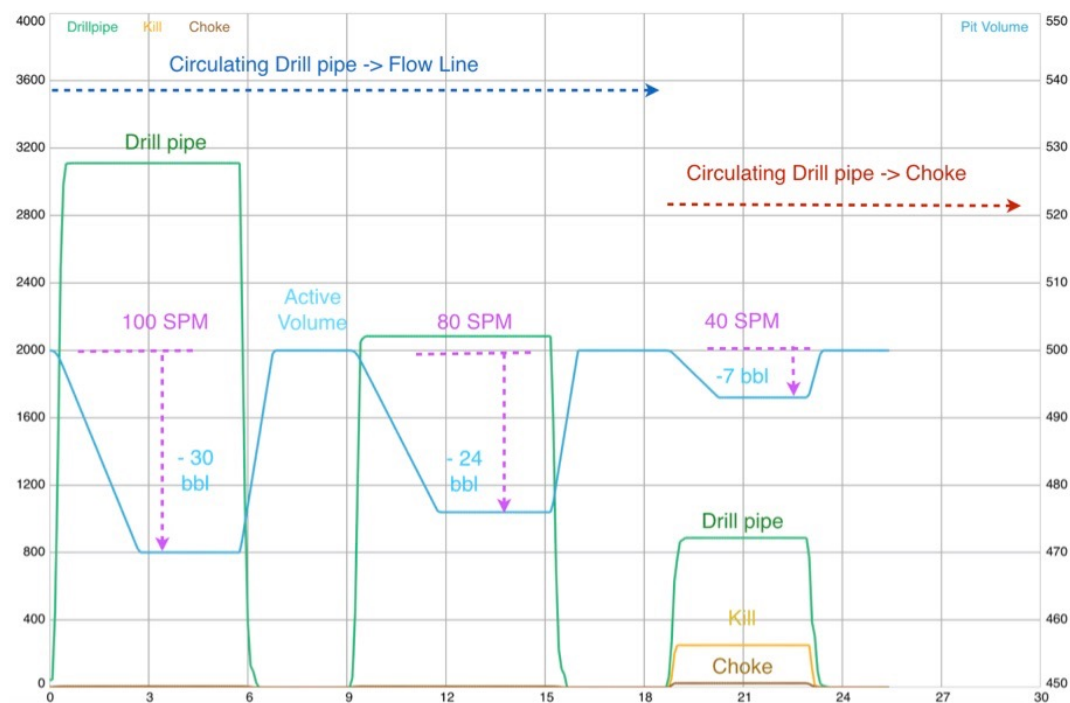
### About the Surface Circulation Volume (SCV):

Surface Circulation Volume = Volume of the flow line, pipes, etc when circulating at the surface.

When occur a kick on the drilling, the driller stops the mud pump and the "Surface Circulation Volume" return to tank.

The calculation of the real volume of the kick = Static Vol. after shut-in the well - Dynamic Volume on drilling - Surface Circulation Volume.




**Circulating Drillpipe -> Flow Line**

SPM = 0  
Static Volume = 500 bbl  
SCV = 0 bbl

SPM = 100  
Dynamic Volume = 470 bbl  
SCV = 30 bbl

SPM = 80  
Dynamic Volume = 476 bbl  
SCV = 24 bbl

SPM = 40 (mud pump stopped)  
Active Volume = 100 bbl  
SCV = 0 bbl

**Circulating Drillpipe -> Choke**

SPM = 0  
Static Volume = 500 bbl  
SCV = 0 bbl

SPM = 40  
Dynamic Volume = 493 bbl  
SCV = 7 bbl









**BIT NOZZLES**
**BIT NOZZLES**

Coefficient 0.9500

Total Flow Area 0.3313 sq.in

Nozzles

TFA Fixed

	Qty.		Size (1/32) in	mm
	1		12	9.5250
	1		12	9.5250
	1		12	9.5250
	0		0	0.0000

**MUD PUMPS 1 & 2 (FLOW IN DRILL PIPE)**
**Mud Pumps 1 & 2 Riser Booster Pump**

	#1	#2
Liner Diameter	6.5000	6.5000 in
Max Pressure	4200.0	4200.0 psi
Stroke Length	12.0000	12.0000 in
Rod Diameter	2.0000	2.0000 in
Power	1600.0	1600.0 hp
Efficiency	97.0	97.0 %
Pump Type	Triplex Duplex	Triplex Duplex
Maximum Speed	120	120 spm
True Pump Output	0.1195	0.1195 bbl/stk
	5.0192	5.0192 gal/stk

## RISER BOOSTER PUMP

\* Mud Pump #3 used to Riser Booster Line (Subsea only).

Mud Pumps 1 & 2
Riser Booster Pump

#3

Liner Diameter	6.5000	in
Max Pressure	4200.0	psi
Stroke Length	12.0000	in
Rod Diameter	2.0000	in
Power	1600.0	hp
Efficiency	97.0	%
Pump Type	Triplex Duplex	
Maximum Speed	120	spm
True Pump Output	0.1194	bbl/stk
	5.0148	gal/stk

\* Mud Pump #3 used to Riser Booster Line (Subsea only).

## TRAVELING ASSEMBLY AND SURFACE CONNECTIONS

Elevation System	120	kip
DS Nominal Weight	263.6	kip
DS w/ Buoyancy	224.9	kip
Hook Load	345.2	kip

### SURFACE CONNECTIONS


	Length ft	ID in
Stand pipe	100.00	4.0000
Hose	85.00	3.5000
Swivel	22.00	3.5000
Kelly	48.00	4.0000
from Mud Pump to Stand pipe	6.00	bbl
Surface Lines *	9.57	bbl

\* Volume included on surface to bit strokes.

### Rig Type:

1	2	3	4	5	6
---	---	---	---	---	---

	ft	in
Standpipe	100.00	5.0000
Mud Hose	85.00	3.5000
Swivel / TD	22.0	3.5000
Kelly / Stands	48.0	4.0000


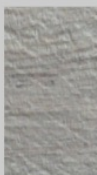
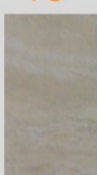
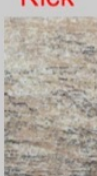
 Set

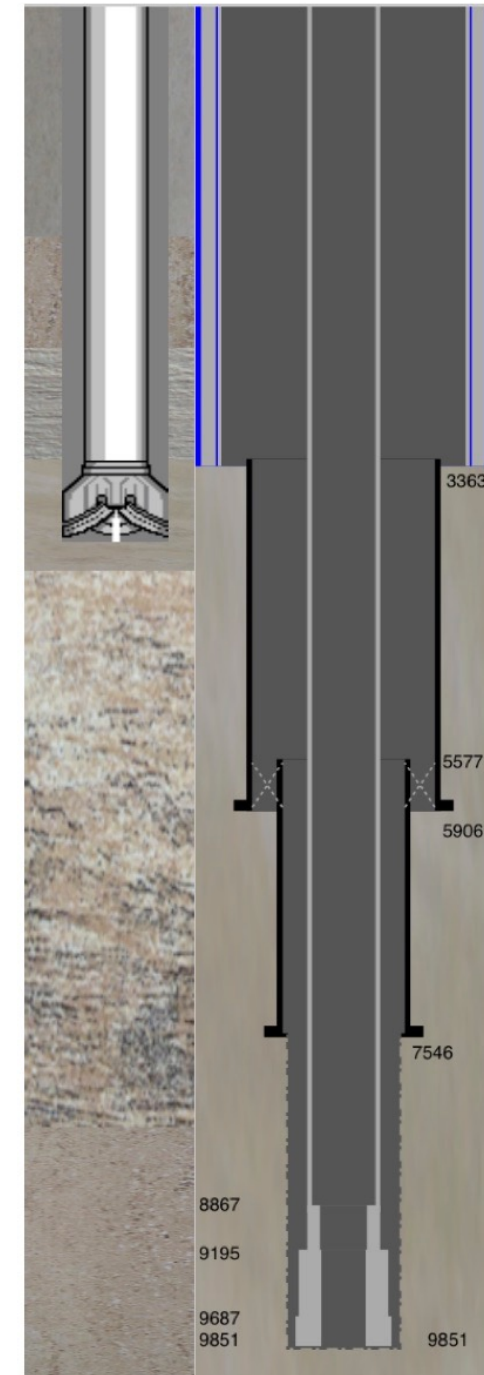
## Formations to Drill

Set the height and difficulty to drill (soft to hard 100%) for formations #1, #2 and #3. The last (#4) is the kick formation.

Set the parameters:

permeability, difficulty to drill (soft to hard 100%), Pore Equivalent density and the fluid density.

<b>F1</b>	Height	3.28 ft
	Soft	30.0 % Hard
<b>F2</b>	Height	3.28 ft
	Soft	50.0 % Hard
<b>F3</b>	Height	3.28 ft
	Soft	40.0 % Hard
<b>Kick</b>	Permeability	300 mD
	Pore Equiv. Density	10.75 ppg
	Soft	60.0 % Hard
	Fluid Density	2.00 ppg







CHAPTER 8

Pre-Recorder Data

Carrier

1:33 AM

100%

MPD Simulator

PRE-RECORDED - SUBSEA STACK

WELL:

RIG:

DATE: May 1, 2016

BY:

WELL, FLUID, LOT AND EQUIPMENTS	Sea Water Length ( Lsw )	1000.00	m	True Vertical Depth ( TVD )	2794.29	m		
	Sea Water Density ( psw )	8.50	ppg	Measured Depth ( MD )	3003.89	m		
	Mud Line Depth ( Dml )	1025.00	m	Shoe Vertical Depth ( TVD,shoe )	2222.44	m		
	Mud Weight ( pm )	9.60	ppg	0.4987	psi/ft	Shoe Measured Detph ( MD,shoe )	2225.00	m
	Fracture Gradient	14.80	ppg	0.7688	psi/ft	BOP Testing Pressure ( Pt,BOP)	5000	psi
	Active Surface Volume	500.00	bbl	Casing Burst Pressure	6330 / 1.25	5064	psi	

MAXIMUM STATIC PRESSURES	Maximum Allowable At Surface Pressure, MAASP = 0.1704 x ( pf - pm ) x TVD,sap					1970	psi
	Maximum Casing Pressure: (Burst Pressure/DF) - 0.1704 x (pm x Dml - 8.50 x Lsw)					4836	psi
	Maximum BOP Pressure = ( Pt,BOP) - 0.1704 x (pm x Dml - 8.50 x Lsw)					4772	psi
	Maximum Subsea Equipment Pressure: Smaller of ( Max Casing or Max BOP )					4772	psi

\* DF = Design Factor

LENGTH, CAPACITY AND VOLUM...

$Cv,i = ID^2 / 1029.4147$

$Vi(bbl)=Cv,i \times L$

$Cv,a = (BoreD^2 - OD^2) / 1029.4147$

$Va(bbl)=Cv,a \times L$

Drill String	ID (in)	OD (in)	Cv,i (bbl/ft)	L (m)	Vi (bbl)	Annular	Cv,a (bbl/ft)	L (m)	Va (bbl)
Drillpipe, DP1	4.2760	5.0000	0.0178	2703.89	157.57	Open Hole - DC2	0.0259	50.00	4.25
Drillpipe, DP2	4.2760	5.0000	0.0178			Open Hole - DC1	0.0322	150.00	15.87
Heavy Weight, H...	3.0000	5.0000	0.0087	100.00	2.87	Open Hole - HW	0.0459	100.00	15.06
Drill Collar, DC1	2.8125	6.2500	0.0077	150.00	3.78	Open Hole - DP2	0.0459		
Drill Collar, DC2	2.8125	6.7500	0.0077	50.00	1.26	Open Hole - DP1	0.0459	478.89	72.12
Total Drill String				3003.89	165.49	Total Open Hole		778.89	107.30
Open Hole	8.5000		0.0702	778.89	179.36	Liner - DP2			
Liner						Liner - DP1			
Casing	8.7550	9.6250	0.0745	1200.00	293.17	Casing - DP2	0.0502		
Riser	19.7500		0.3789	1025.00	1274.33	Casing - DP1	0.0502	1200.00	197.55
Kill / Choke Line	3.0000		0.0087	1025.00	29.40	Riser - DP2	0.3547		
Booster Line	4.0000		0.0155	1025.00	52.27	Riser - DP1	0.3547	1025.00	1192.65

MUD PUMPS			$\delta mp = \delta \times \epsilon$	SPM = Flow / (42.00 x $\delta mp$ )		SLOW CIRCULATION RATE pressure in (psi)				
Nº	$\delta$ (bbl/stk)	$\epsilon$ (%)	$\delta mp$ (bbl/stk)	100.0 gpm	150.0 gpm	Flow (gpm)	SPM	Pump Pressure	Ch Line Loss	Casing Friction
PUMP 1	0.1232	97.0	0.1195	19.9	29.9					
PUMP 2	0.1232	97.0	0.1195	19.9	29.9					

VOLUMES AND STROKES			Vol (bbl)	Stk, MP1	Stk, MP2
Surface Connections (Lines)			9.57	80	80
Internal Drill String			165.49	1385	1385
Surface to Bit (Surface Connections + Drill String)			175.06	1465	1465
Bit to Shoe			107.30	898	898
Bit to BOP			304.85	2551	2551
Bit to Choke			334.25	2797	2797
Drill String + Annular + Choke Line			499.74	4182	4182
Riser Annular			1192.65	9980	9980
Total Active Fluid System Volume			2283.64		

Kill

Drillpipe

Choke

Sea Water

1000.00

Mud Line

1025.00

Shoe

2222.44 / 2225.00

Well

2794.29 / 3003.89

subsea directional 2.mpdf

Units

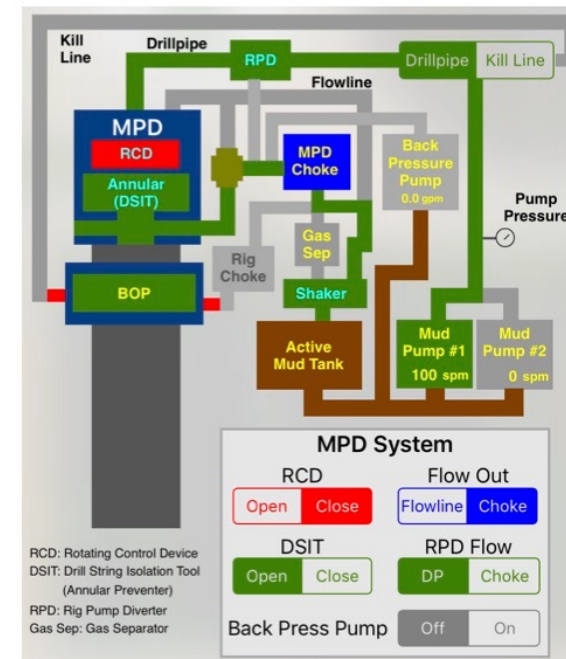
## CHAPTER 9

# Circulating System

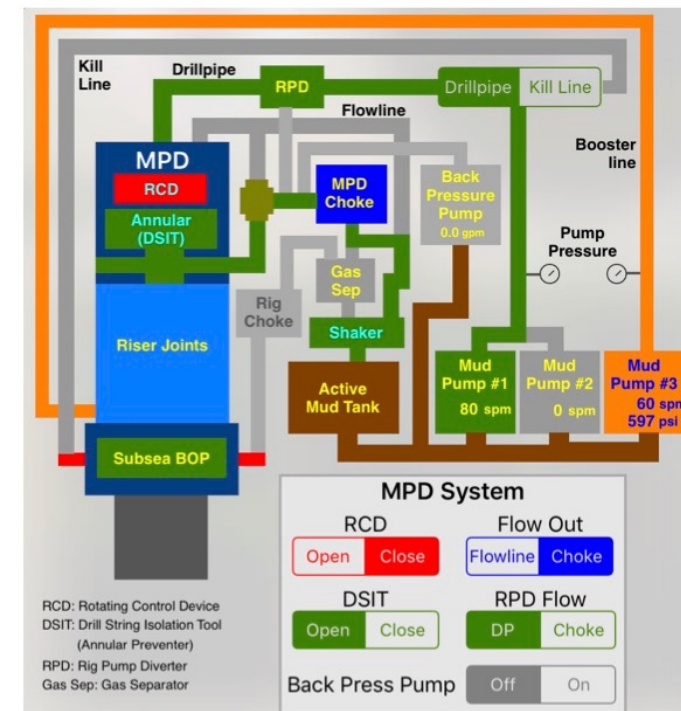
The system is different for wells with surface stack or subsea stack.

1. For rigs with surface stack (land rigs, jack-up rigs, etc) only two mud pumps.
2. For subsea stack (semi-submersible, drill-ship, etc) are 3 mud pumps, with the mud pump #3 only for riser booster line.
3. The system allow circulation for Drill String or for Kill line.
4. The return can be by flow line or by MPD choke.
5. This simulator does not uses the Rig BOP / Rig Choke, just the MPD System, ONLY.

## Surface Stack



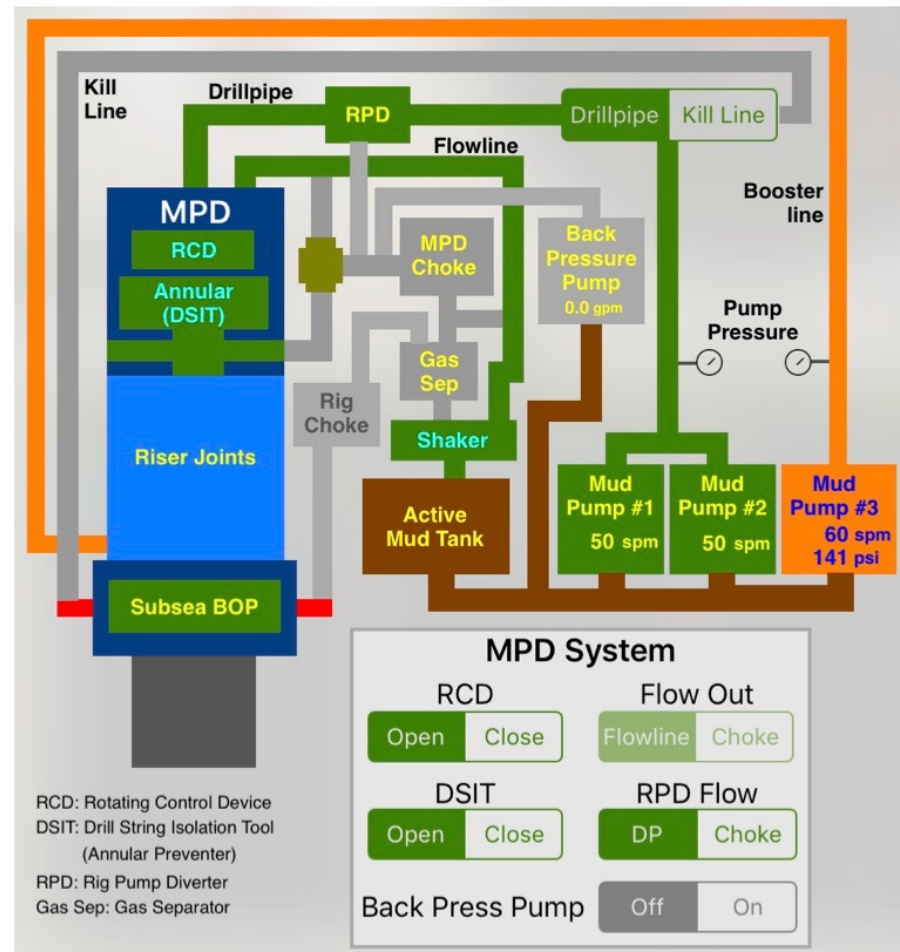
## Subsea Stack





## Drill String with return by Riser/Flow Line

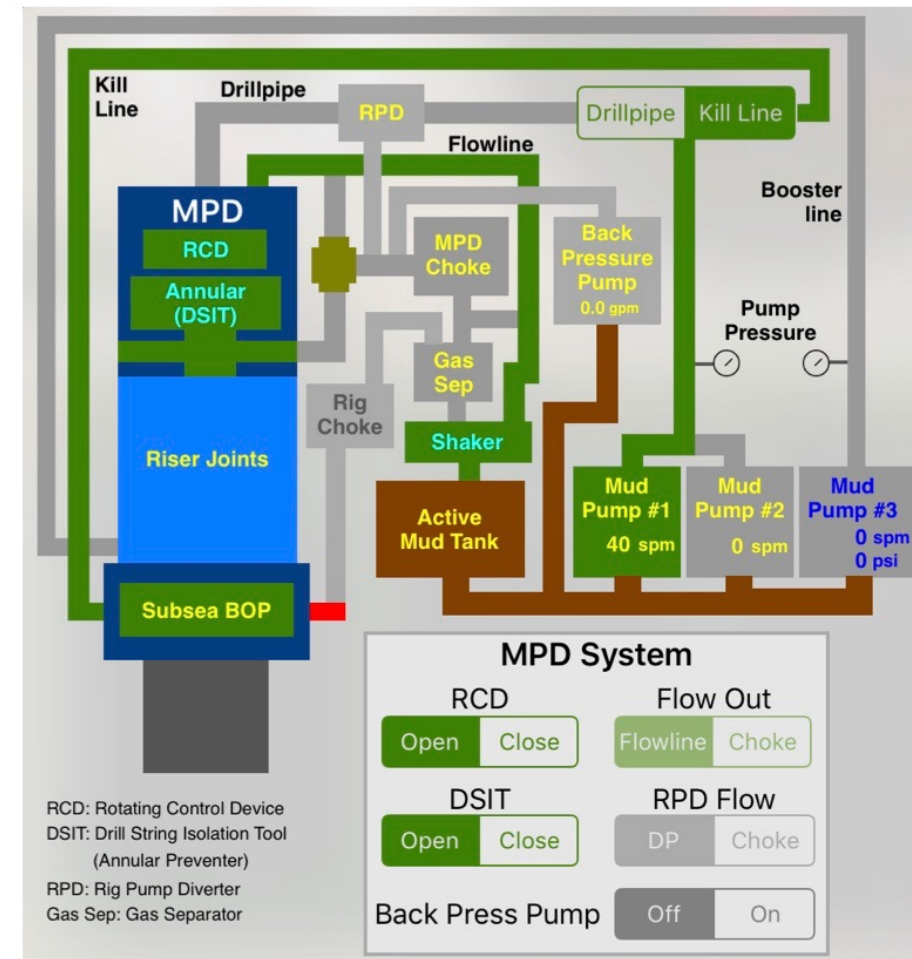
MPD By-Passed on Drilling with Subsea Stack.



Record the DP Pressure at Drilling Flow Rate with return to Flowline. Drilling with MPD, the system detects the formation influx (kick) and well control will be dynamic on the same drilling flow rate.

## Kill Line with return by Riser/Flow Line

Used to record the Kill/Choke Line Pressure Losses at Slow Circulating Rate on Kill Pressure Gauge:



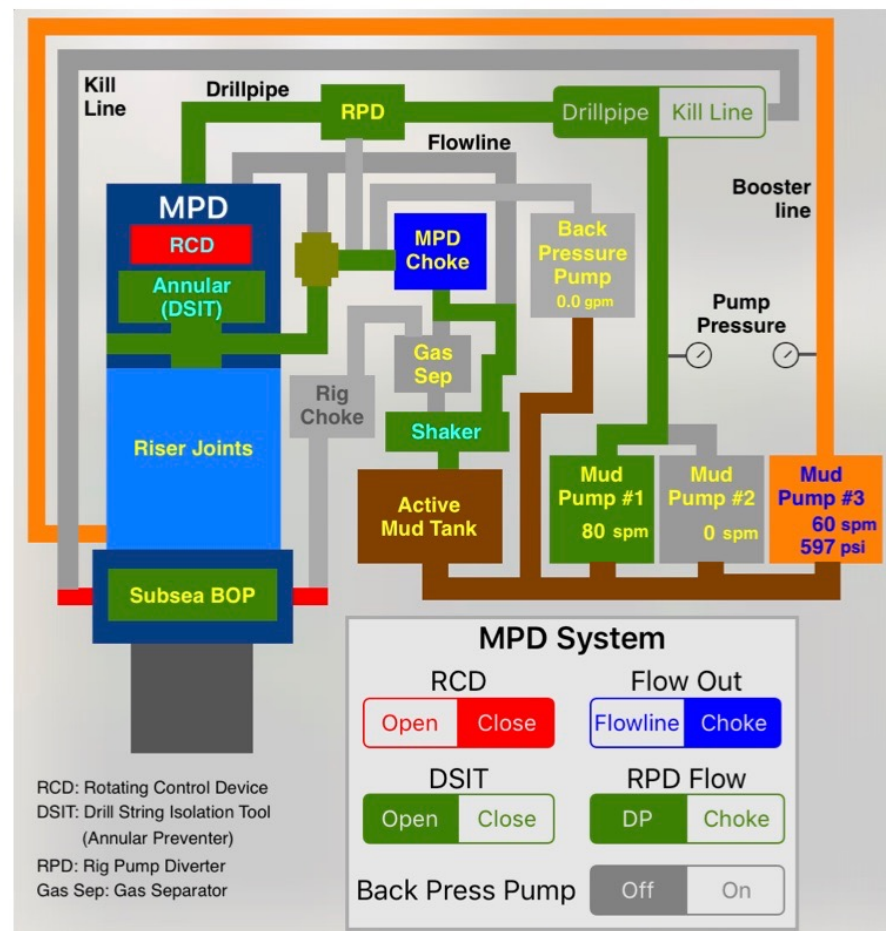
Important parameter used on the dynamic volumetric method.



## Drill String with return by MPD Choke

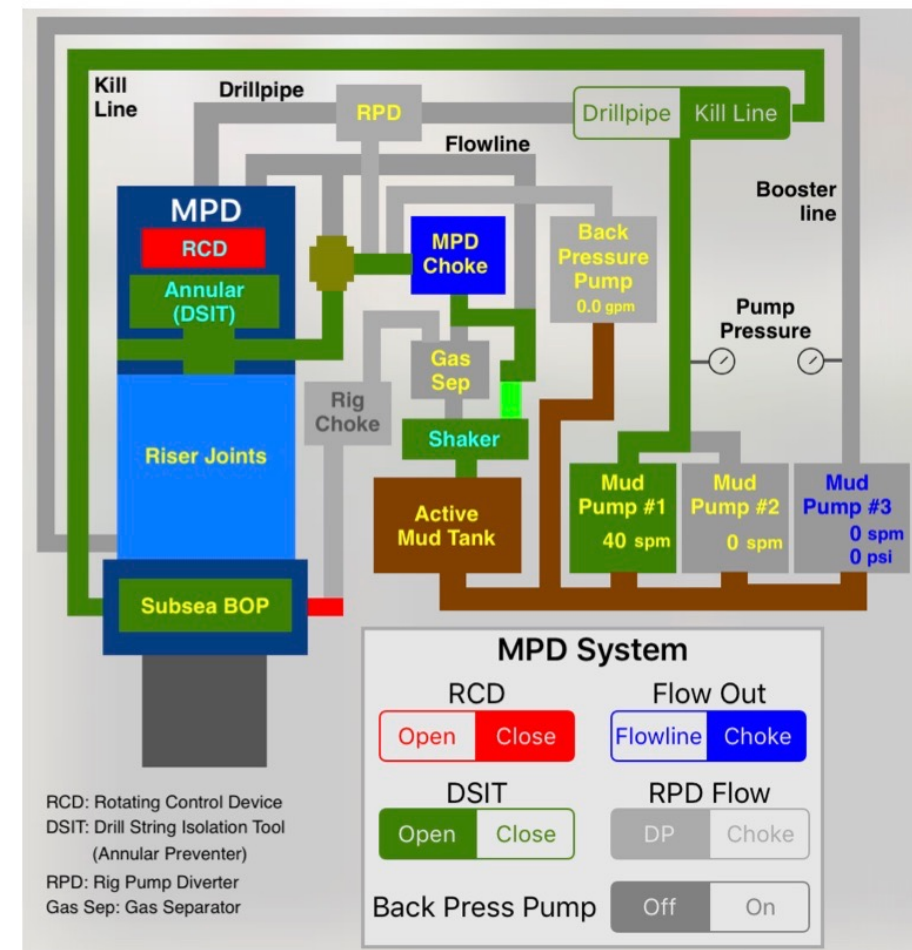
Used normally to drilling with MPD and for dynamic well control applying a BackPressure at choke to maintain  $BHP > \text{pore pressure}$  and shoe pressure  $< \text{fracture pressure}$ .

The methods applied are the Driller's Method and Weight and Wait. For dynamic control with MPD, the driller's method is most used.



## Kill Line with return by Choke

Used to Well Control applying the Dynamic Volumetric Method





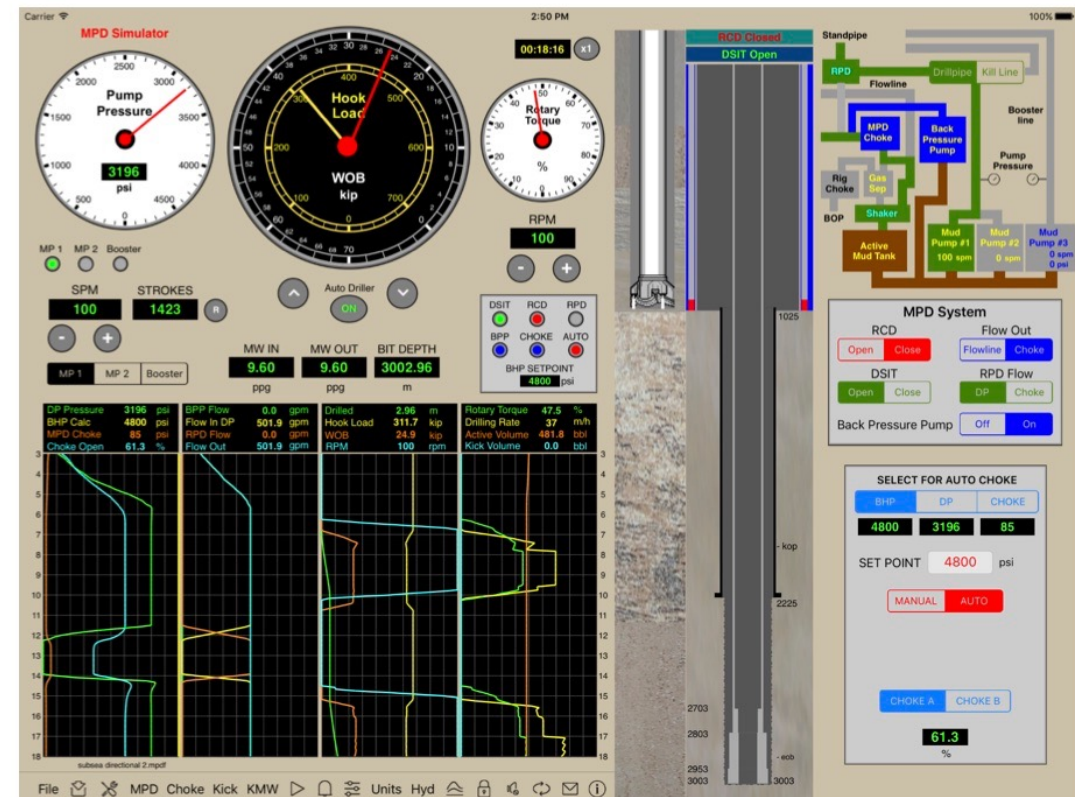
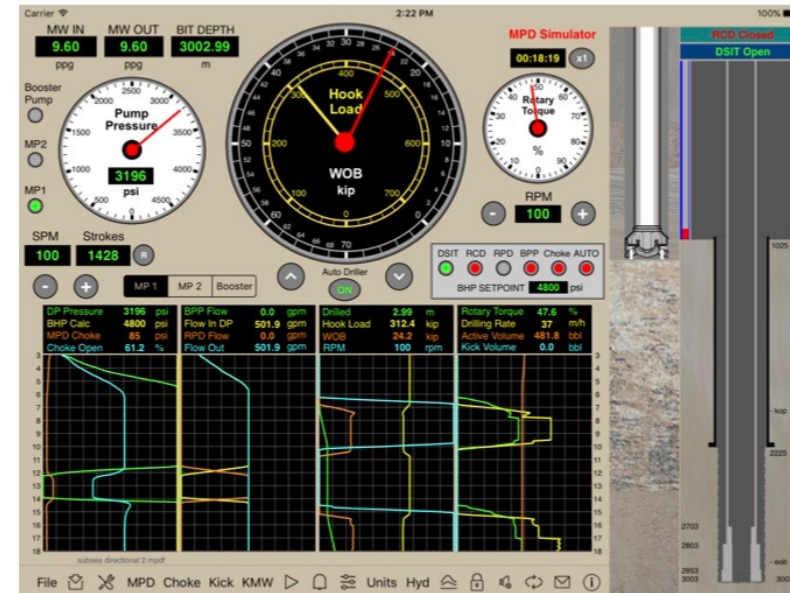
## CHAPTER 10

# Drilling

Main Interface

iPad x iPad Pro on horizontal position

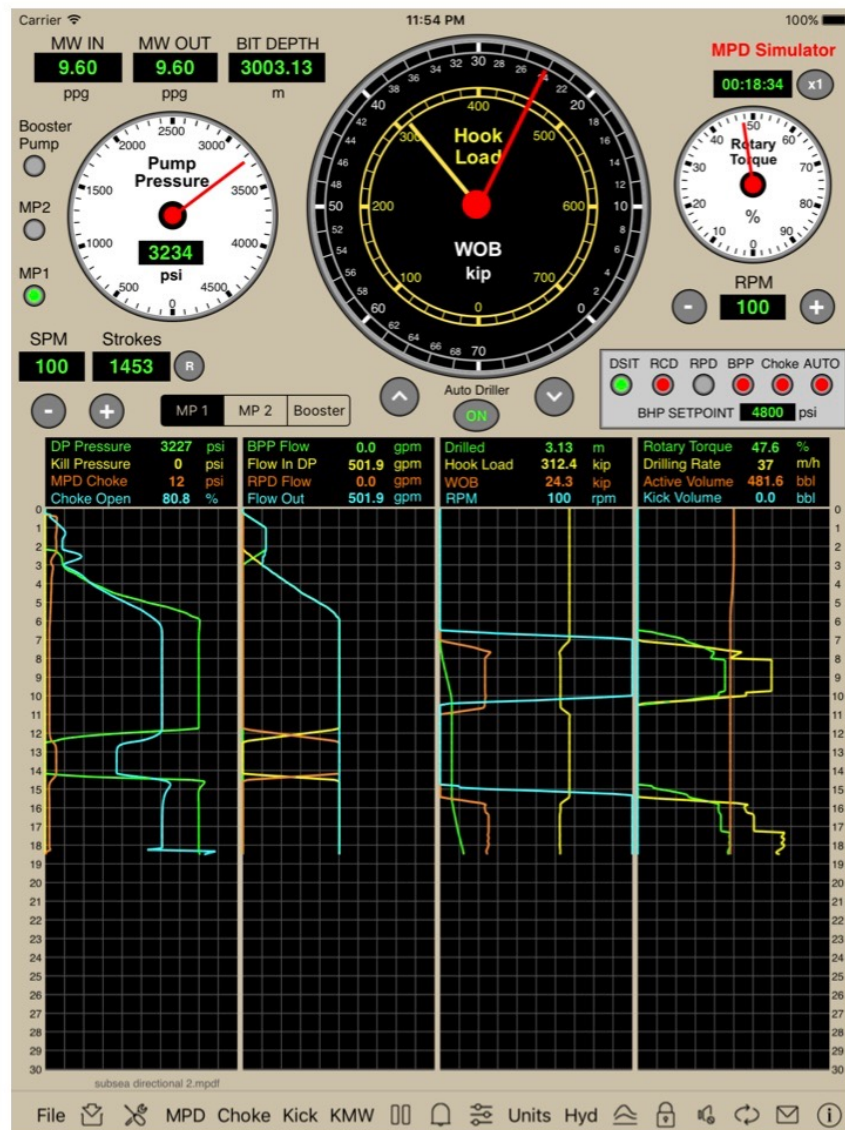
This app is optimized for iPad Pro



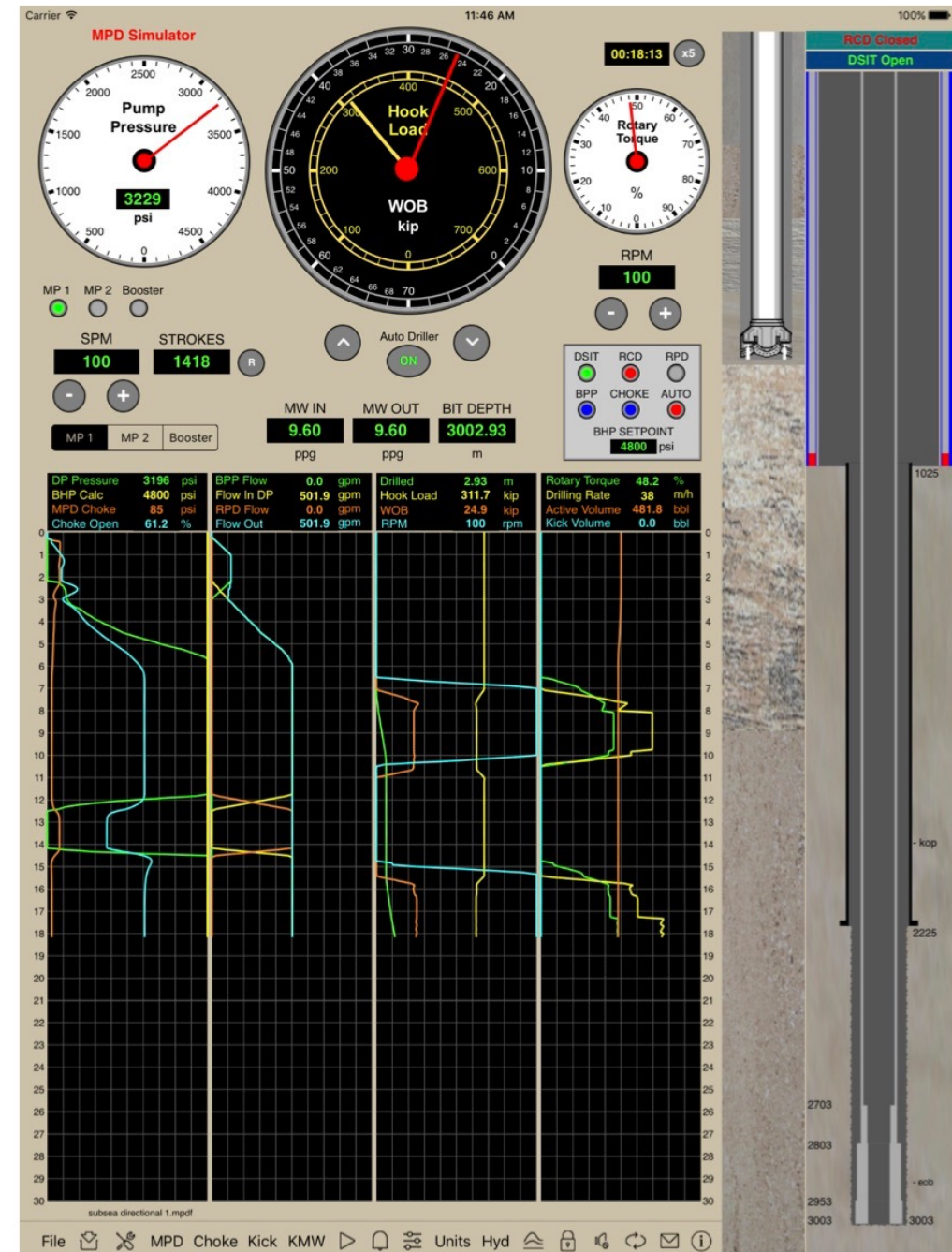


On vertical position

iPad, iPad Air, iPad Mini



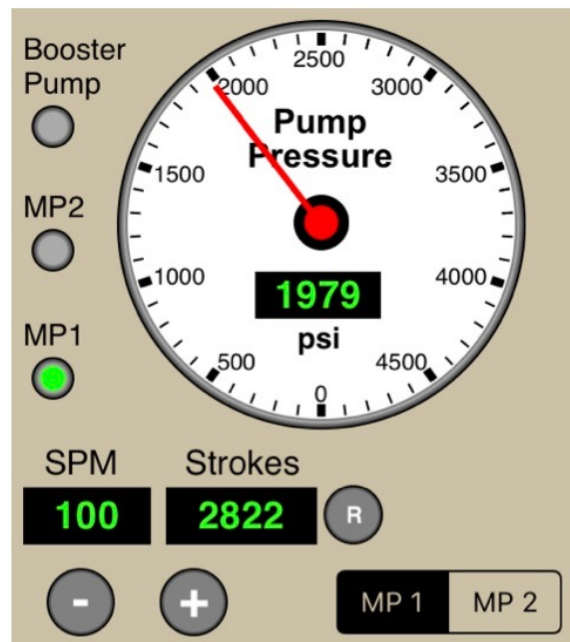
iPad Pro





## Selecting Mud Pumps

For wells with surface stack:

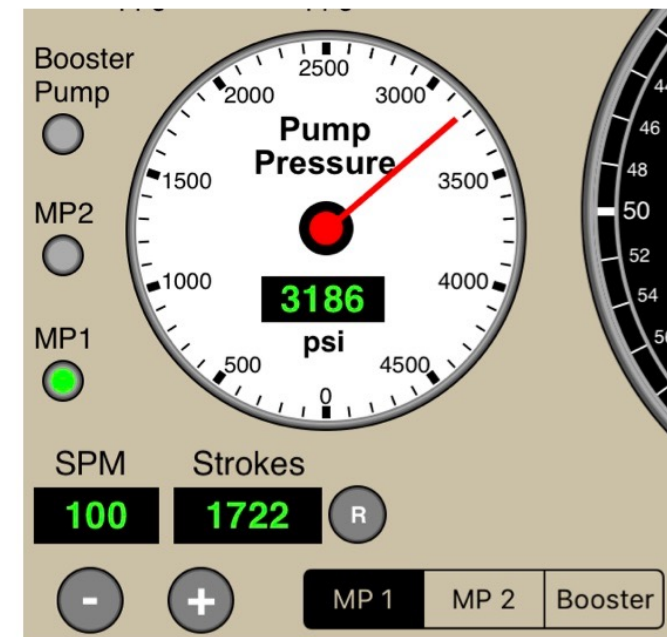


Select MP 1 for Mud Pump #1 and MP 2 for Mud Pump #2.

The color is GREEN for SPM > 0.

Tap on "R" button to reset total strokes.

For wells with subsea stack:



Select MP 1 for Mud Pump #1 and MP 2 for Mud Pump #2.

The color is GREEN for SPM > 0.

The mud pump #3 is for the Riser Booster Line, only.

## The Weight Indicator



Move Drill-String to Up  
- WOB

Tap on OFF button to enable the Auto Driller

Move DrillString to Down  
+ WOB

Hook Load on Yellow Scale and WOB on White Scale.

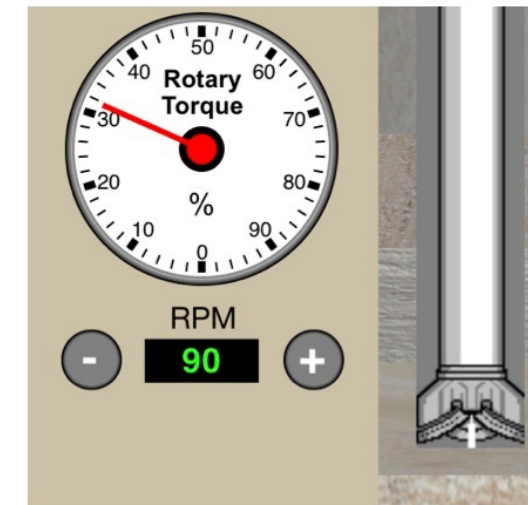
Auto Driller On -> Maintain WOB (Weight On Bit) constant

Digital Values on Graph:

Drilled	2.88	m
Hook Load	311.7	kip
WOB	24.9	kip
RPM	100	rpm

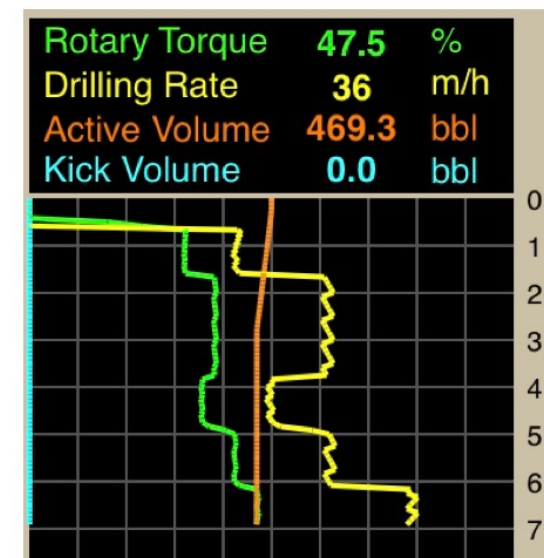
## Drill Bit Rotation

Tap on “ - “ and “ + “ buttons to set RPM



## RPM Effects:

1. On Rotary Torque and Drill String Animation
2. On Drilling Rate (ROP - Rate Of Penetration)



## MPD Status



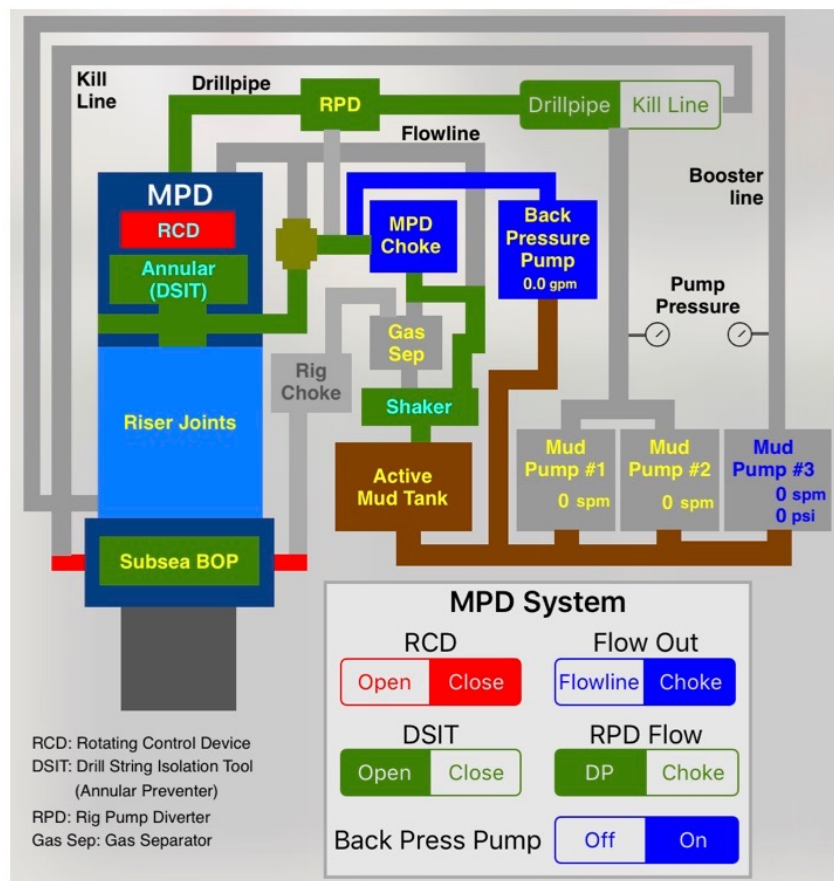
DSIT and RCD: **GREEN**: OPEN **RED**: CLOSED

RPD: **GREEN**: TO STANDPIPE **BLUE**: TO CHOKE

BPP: **GRAY**: OFF **BLUE**: ON

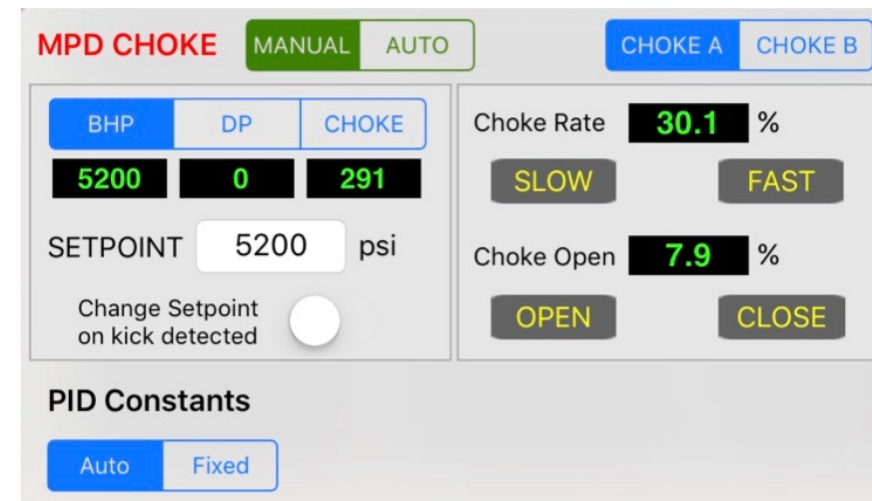
CHOKE: **GRAY**: TO FLOWLINE **BLUE**: TO CHOKE

PRESSURE SETPOINT SELECTED.

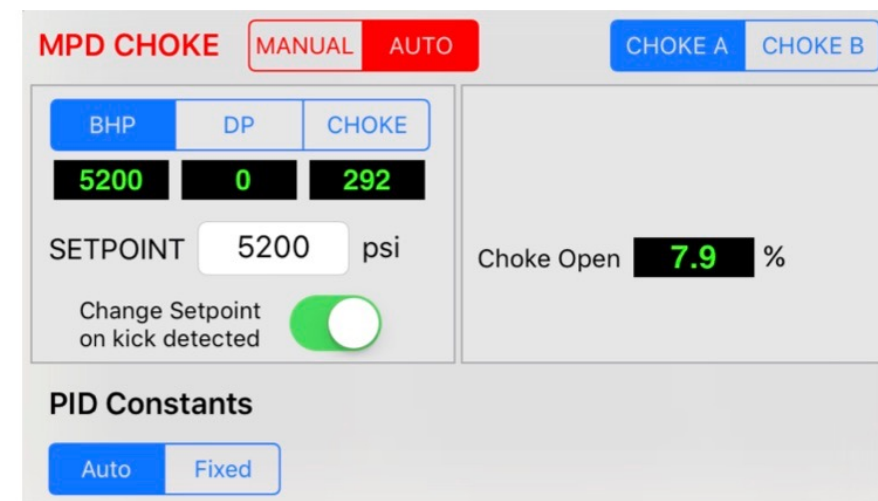


## MPD CHOKE

### MANUAL MODE:



### AUTO MODE:

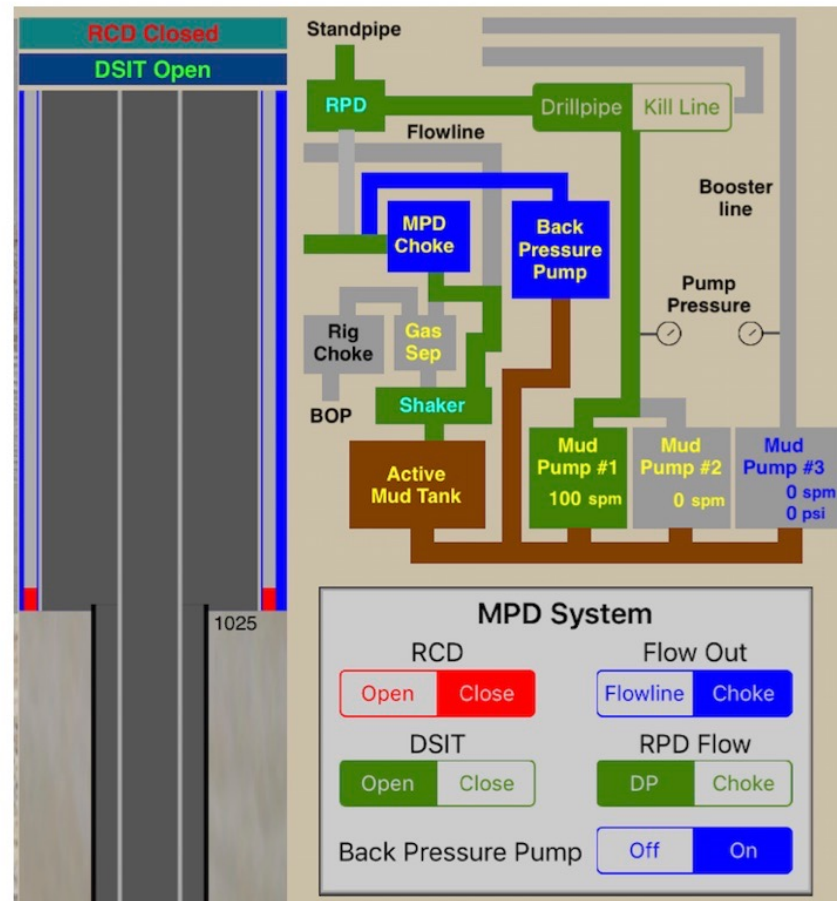


### AUTO MODE: PID CONSTANTS [AUTO / FIXED]





The iPad Pro version has this PLUS on landscape position:



**SELECT FOR AUTO CHOKE**

BHP DP CHOKE

4908 0 0

SET POINT 5008 psi

MANUAL AUTO

Choke Rate

slow 50.0 fast

%

CHOKE A CHOKE B

open 0.0 close

%

**SELECT FOR AUTO CHOKE**

BHP DP CHOKE

4800 3196 85

SET POINT 4800 psi

MANUAL AUTO

CHOKE A CHOKE B

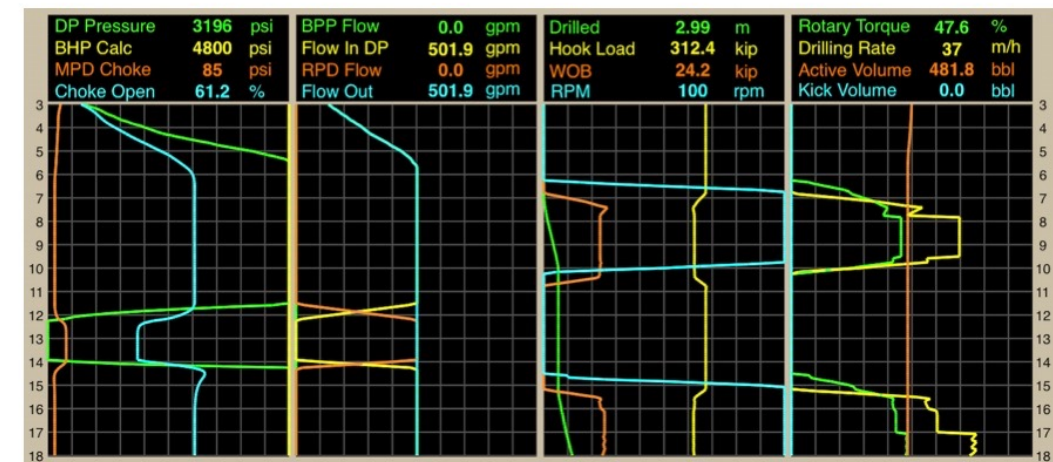
61.3

%

## Drilling Parameters

MW IN	MW OUT	BIT DEPTH
9.60	9.60	3002.99
ppg	ppg	m

## Graph



## Alarms and Sound Level

**Alarms:** Pump 1 Fail, Pump 2 Fail, MPD Fail and Fracture

**Set Alarms**

MPD Kick Detection 2.0 bbl

**Reset Failures**

Pump 1 Pump 2 MPD Fracture

**Sound Level**

Background

Mud Pump

Accum. Pump

Rotary Table

Gas Out

Drawwork

Brake

## Kick Informations

Kick							Reset
Volume bbl	Pressure psi	Depth ft	Length ft	Top ft	Density ppg	Mass lb	Hydrost psi
17.66	4805.11	9844.68	577.78	9266.90	0.84	621.68	25.11

## Informations with Code

Features by request from schools to apply test for students.

### Parameters:

1. Lag Time
2. Kick Informations
3. Pressures at the borehole
4. Digital values in gauges

With codes for ADMIN, INSTRUCTOR and STUDENT

Attention: The Initial codes: "0000"

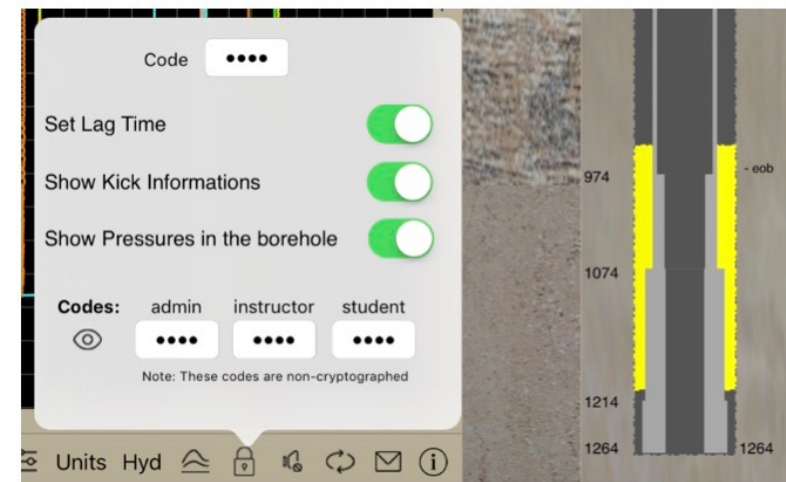
### Notes:

If lose the admin code:

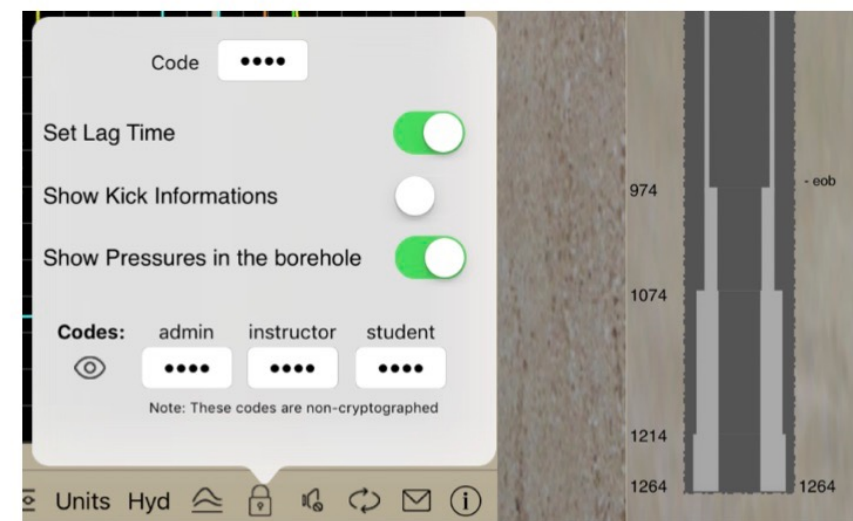
1. Export all data files to iCloud;

2. Delete app on iPad
3. Re-install it from App Store.
4. Use the initial code: "0000"
5. Import data files from iCloud

Kick Informations ON:



Kick Informations OFF:





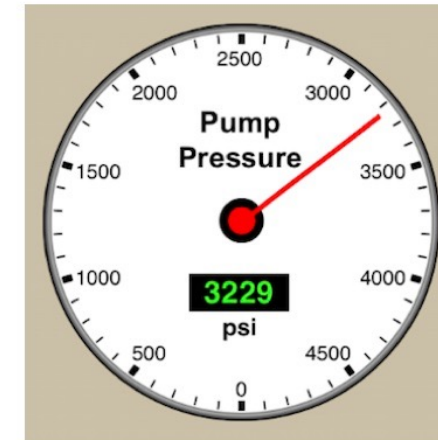
## Hydraulics with “Pressures in the borehole ON”:

MP 1	100.0	spm	MP 2	0.0	spm	MP 3	0.0	spm
	501.9	gpm		0.0	gpm	Booster Line	0.0	gpm
Drill Bit						Bottoms-up		
Flow Rate on bit		501.9	gpm		System Losses			
Nozzles Loss		2029.1	psi		Surface			
Hydraulic Power		594.2	hp		Drill string		28.5	psi
HHP / Sq. Inch		10.472	hp/sq.in		Annular		910.0	psi
Perc Nozzles Loss		65.4	%		Choke Line		143.0	psi
Jet Velocity		486.1	ft/s		Percent		0.0	psi
Force of Impact		1208.6	lbf				34.8	%
Absorption Pressure		5422.8	psi		Max. Kill Press, Abs		1709.9	psi
Fracture Pressure		5612.3	psi		Max. Kill Press, Fract		1899.5	psi
MPD Pressure		1682.0	psi		Max. MPD Pressure		5000.0	psi
TVD m		Hydrost psi	Friction psi		Pressure psi		ECD ppg	Critical ppg
Shoe Depth		2225.0	3640.5		77.2		3717.7	9.80
Bottom Hole		3000.0	4908.5		143.0		5051.4	9.88
Formation		3000.0					4857.3	

## Hydraulics with “Pressures in the borehole OFF”:

MP 1	100.0	spm	MP 2	0.0	spm	MP 3	0.0	spm
	501.9	gpm		0.0	gpm	Booster Line	0.0	gpm
<b>Drill Bit</b>						<b>Bottoms-up</b>		
Flow Rate on bit		501.9	gpm		125 min			
Nozzles Loss		2029.1	psi		<b>System Losses</b>			
Hydraulic Power		594.2	hp		Surface		28.5	psi
HHP / Sq. Inch		10.472	hp/sq.in		Drill string		910.0	psi
Perc Nozzles Loss		65.2	%		Annular		143.0	psi
Jet Velocity		486.1	ft/s		Choke Line		0.0	psi
Force of Impact		1208.6	lbf		Percent		34.8	%
		TVD m	Hydrost psi				TVD m	Hydrost psi
<b>Shoe Depth</b>		2225.0	3640.5		<b>Bottom Hole</b>		3000.0	4908.5

## Pump Pressure Gauge:



The **Pump Pressure** is the reading at the pump discharge.

For mud pumps aligned to the drill string, the Pump Pressure includes the losses in the line from the mud pump to standpipe.

For Well Control, use the parameters in digital values:

DP Pressure	3196	psi
BHP Calc	4800	psi
MPD Choke	85	psi
Choke Open	61.2	%

In this example:

The losses into the line from the mud pump to standpipe

is equal to **3229 - 3196 = 33 psi**



## Set Maximum Values on Graph

**Graph Maximum Values**
Reset Graph

Pressure	4000	psi	<b>Kill Pressure</b>	BHP + Set Point
Weight On Bit	100	kip	Flow Rate	1000 gpm
Hook Load	500	kip	Drilled	25 m
Active Volume	1000	bbl	Drilling Rate	50 m/h
Kick Volume	50	bbl	Rotary Speed	100 rpm

Time
From the Beginning
Shift to End

to
15
30
45
60
75
90
120
>= 150
min

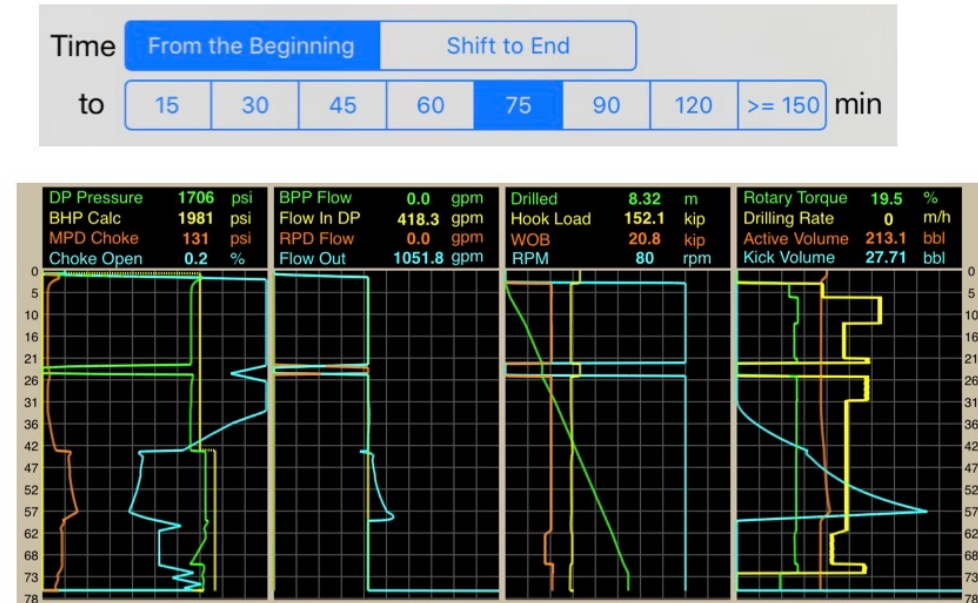
**Gauge Range**

Max on Pressure Gauge	1000	2000	3000	<b>5000</b>	10000	psi
Max on Weight Indicator	200	400	<b>800</b>	1200	kip	

## Show Graph: Shift to End



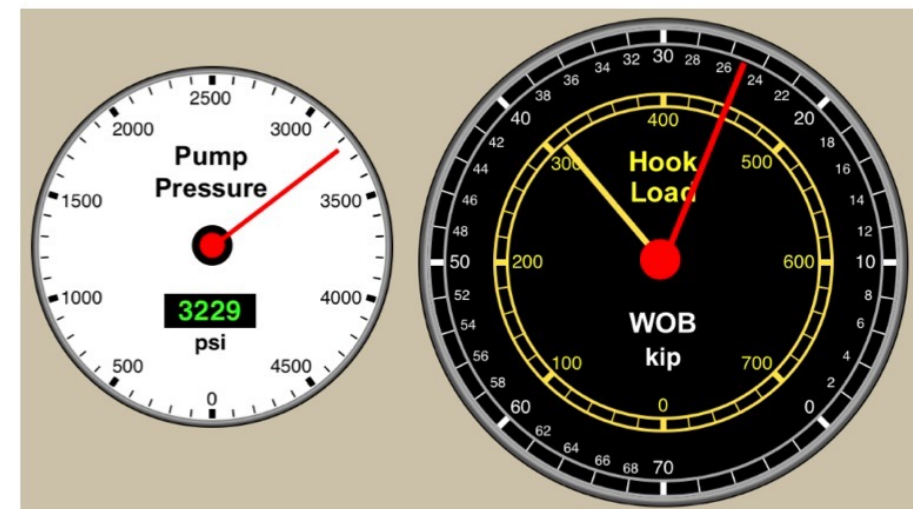
## Show Graph: From the beginning



## Gauges: Maximum Pressure and Maximum Hookload

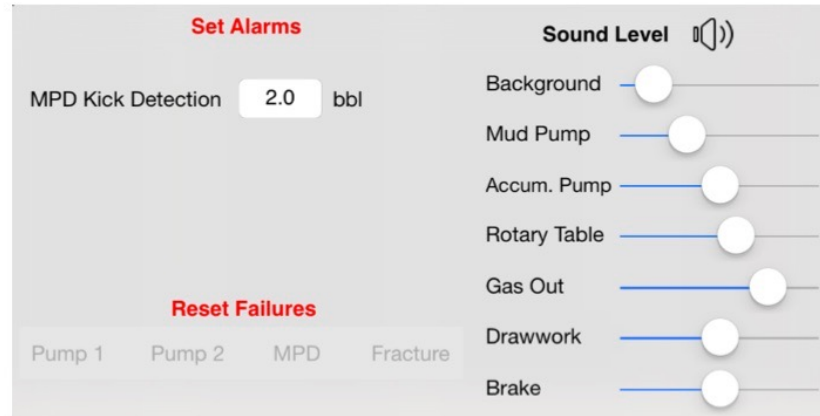
**Gauge Range**

Max on Pressure Gauge	1000	2000	3000	<b>5000</b>	10000	psi
Max on Weight Indicator	200	400	<b>800</b>	1200	kip	



## Set Sound Level

Menu icon:



Sound ON:



Sound OFF:



## Reset Failures (Red Color)

Example: SPM > 120 on Mud Pump #2

Tap on PUMP 2 button in red color:

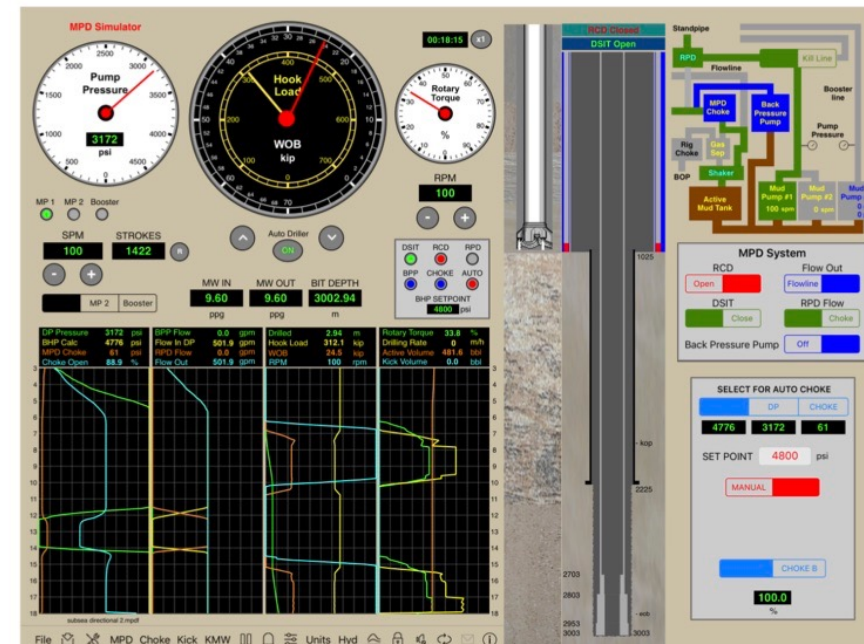


## Send Screenshot by email

Menu icon:



Attachments in PDF and PNG image formats:







## CHAPTER 11

# Hydraulics

## The hydraulics calculations

MP 1	100.0	spm	MP 2	0.0	spm	MP 3	0.0	spm
	501.9	gpm		0.0	gpm	Booster Line	0.0	gpm
Drill Bit						Bottoms-up	125	min
Flow Rate on bit			501.9	gpm		System Losses		
Nozzles Loss			2029.1	psi				
Hydraulic Power			594.2	hp		Surface	28.5	psi
HHP / Sq. Inch			10.472	hp/sq.in		Drill string	910.0	psi
Perc Nozzles Loss			65.4	%		Annular	143.0	psi
Jet Velocity			486.1	ft/s		Choke Line	0.0	psi
Force of Impact			1208.6	lbf		Percent	34.8	%
Absorption Pressure			5422.8	psi	Max. Kill Press, Abs		1709.9	psi
Fracture Pressure			5612.3	psi	Max. Kill Press, Fract		1899.5	psi
MPD Pressure			1682.0	psi	Max. MPD Pressure		5000.0	psi
		TVD m	Hydrost psi	Friction psi	Pressure psi	ECD ppg	Critical ppg	
Shoe Depth		2225.0	3640.5	77.2	3717.7	9.80	14.30	
Bottom Hole		3000.0	4908.5	143.0	5051.4	9.88	9.50	
Formation		3000.0			4857.3			

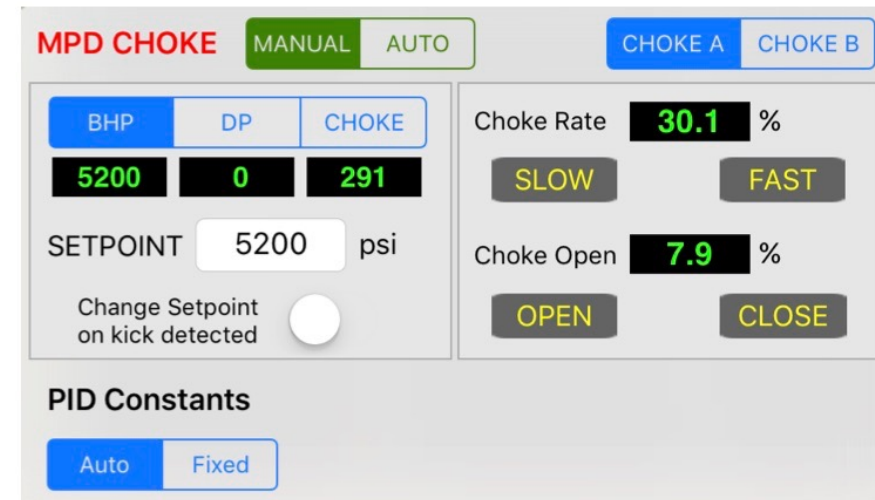


## CHAPTER 12

# MPD Choke

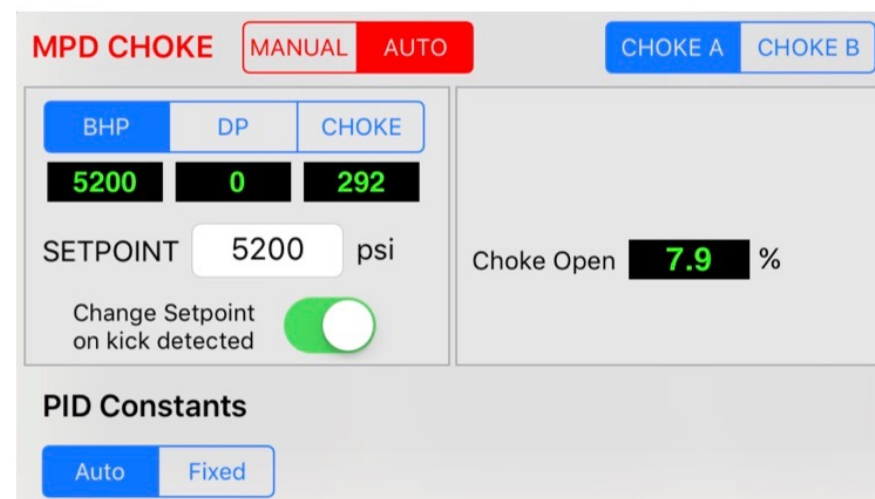
- Choke Interface - Digital Panel.
- This simulator does not use the BOP / Rig Choke, just the MPD System, ONLY.
- It is possible to use the MPD Choke in Manual Mode.
- For a better user experience in simulating conventional rig choke, please, buy the apps “Well Control Simulator 2” or “Drilling Simulator 2”, both available on our portfolio on the App Store.

### MPD CHOKE IN MANUAL MODE:



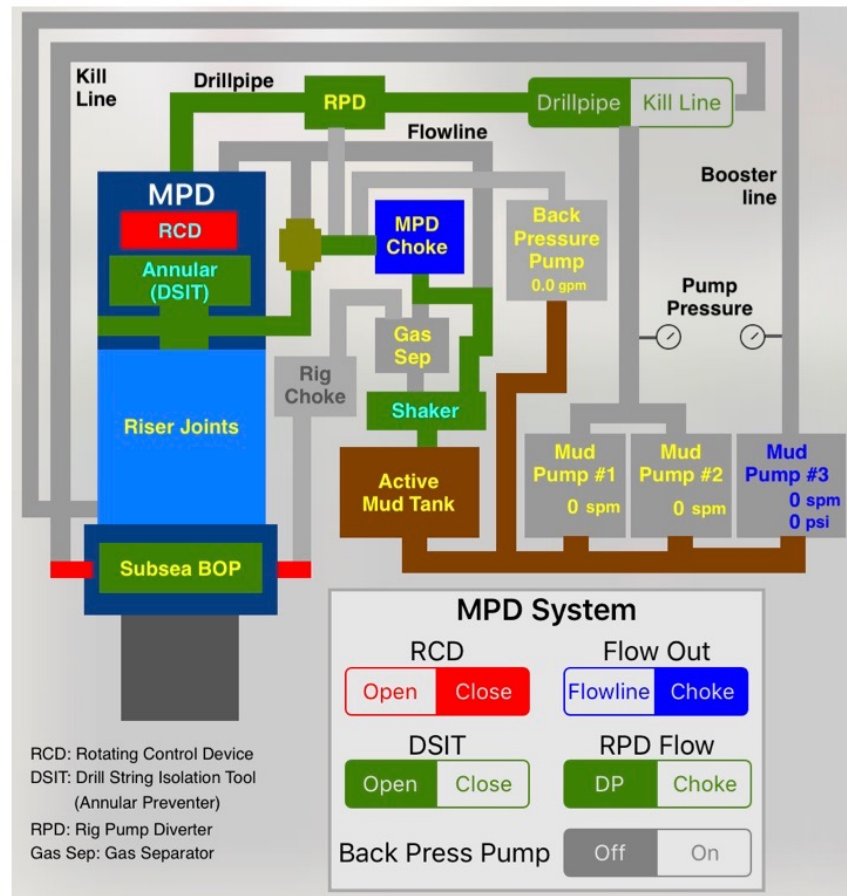
The interface for MPD Choke in Manual Mode. It features a top bar with 'MPD CHOKE' in red, and 'MANUAL' (selected) and 'AUTO' buttons. Below this are 'CHOKE A' and 'CHOKE B' buttons. The main panel has three columns: 'BHP' (5200), 'DP' (0), and 'CHOKE' (291). A 'SETPOINT' of 5200 psi is shown with a toggle for 'Change Setpoint on kick detected'. On the right, 'Choke Rate' is 30.1% with 'SLOW' and 'FAST' buttons, and 'Choke Open' is 7.9% with 'OPEN' and 'CLOSE' buttons. At the bottom, 'PID Constants' are set to 'Auto'.

### CHOKE IN AUTO MODE: PID CONSTANTS [AUTO]



The interface for MPD Choke in Auto Mode. It features a top bar with 'MPD CHOKE' in red, and 'MANUAL' and 'AUTO' (selected) buttons. Below this are 'CHOKE A' and 'CHOKE B' buttons. The main panel has three columns: 'BHP' (5200), 'DP' (0), and 'CHOKE' (292). A 'SETPOINT' of 5200 psi is shown with a toggle for 'Change Setpoint on kick detected' which is turned on. On the right, 'Choke Open' is 7.9%. At the bottom, 'PID Constants' are set to 'Auto'.

FOR WELL CONTROL -> CIRCULATION BY CHOKE.



In auto mode (in this simulator), the flow after choke will be normally to the flowline/shale shaker and will be changed automatically to the mud gas separator/shale shaker on kick detected.

## MPD Chokes A & B

Set the choke diameters at config/equipments:

MPD Choke Diameter A	2.0000 in
MPD Choke Diameter B	2.0000 in

Default diameters: 2.0 inches (both)

## MPD Choke in Manual Mode

**MPD CHOKE**
MANUAL
AUTO
CHOKE A
CHOKE B

BHP	DP	CHOKE
5200	0	291

SETPOINT 5200 psi

Change Setpoint on kick detected ☐

Choke Rate **30.1** %

SLOW
FAST

Choke Open **7.9** %

OPEN
CLOSE

**PID Constants**

Auto
Fixed

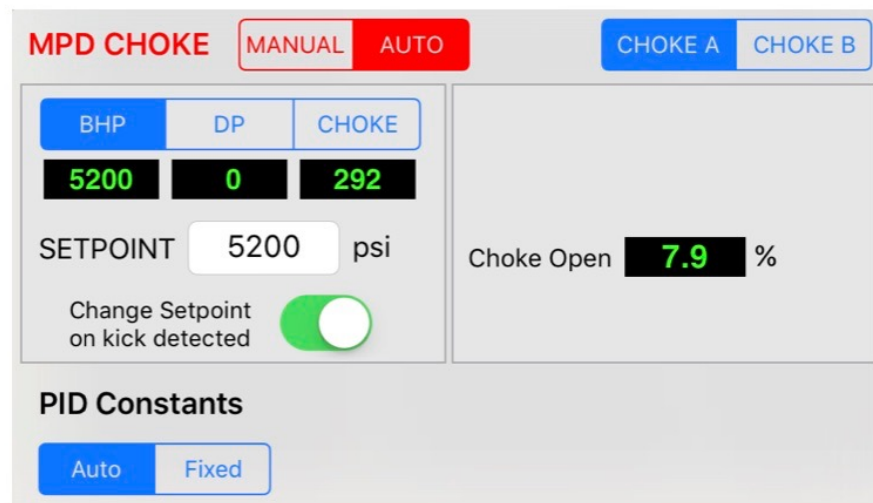
Use the right frame on choke panel:

1. Set the Choke Rate using the Slow/Fast buttons.
2. Close/Open choke to control pressures.
3. Select choke A or B.



## MPD Choke in Auto Mode

1. Select Pressures at Bottom (BHP), Drillpipe (DP) or Choke
2. Input the SETPOINT for the parameter selected
3. Set MPD Choke to AUTO



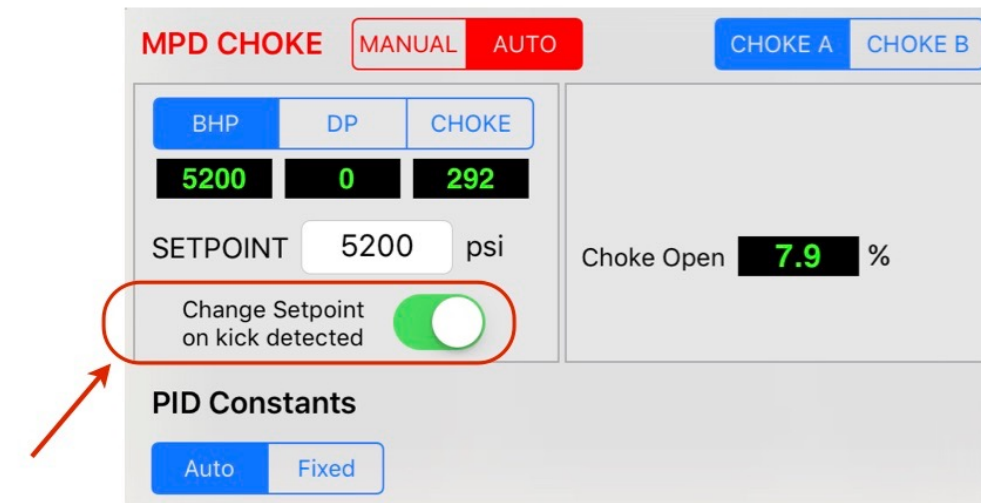
The panel shows the MPD Choke control interface. At the top, there are tabs for 'MANUAL' and 'AUTO', with 'AUTO' selected. Below this are buttons for 'CHOKE A' and 'CHOKE B'. The main display area shows three pressure readings: BHP (5200), DP (0), and CHOKE (292). Below these is a 'SETPOINT' input field set to 5200 psi. A toggle switch for 'Change Setpoint on kick detected' is turned on. The 'Choke Open' status is shown as 7.9%. At the bottom, there are 'PID Constants' buttons for 'Auto' and 'Fixed'.

Choke Rate parameter, Slow/Fast and Open/Close buttons unavailable in this mode.

**Change Setpoint on kick detected option** - Set for the automatic system to change the setpoint until to stabilize the influx from formation into wellbore. The MPD System uses the Coriolis mass flow meter to provide high accuracy and stability real-time measurements of density, viscosity, mass flow, temperature and volumetric flow to hydraulic model.

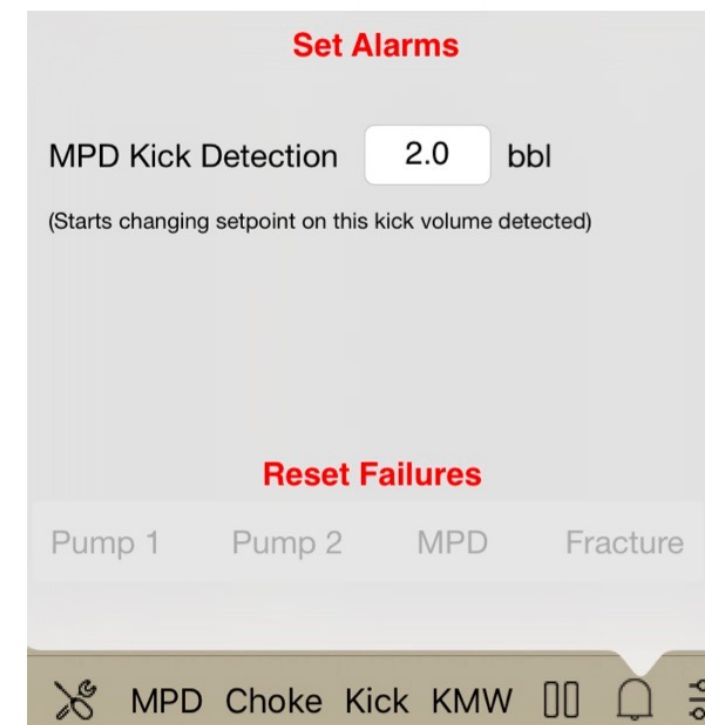
## MPD Kick Detection

Input the kick volume to start the changing the setpoint automatically if this option is enabled on choke panel.



This panel is identical to the one above, but with a red circle and an arrow pointing to the 'Change Setpoint on kick detected' toggle switch, which is turned on. The 'SETPOINT' is 5200 psi and 'Choke Open' is 7.9%.

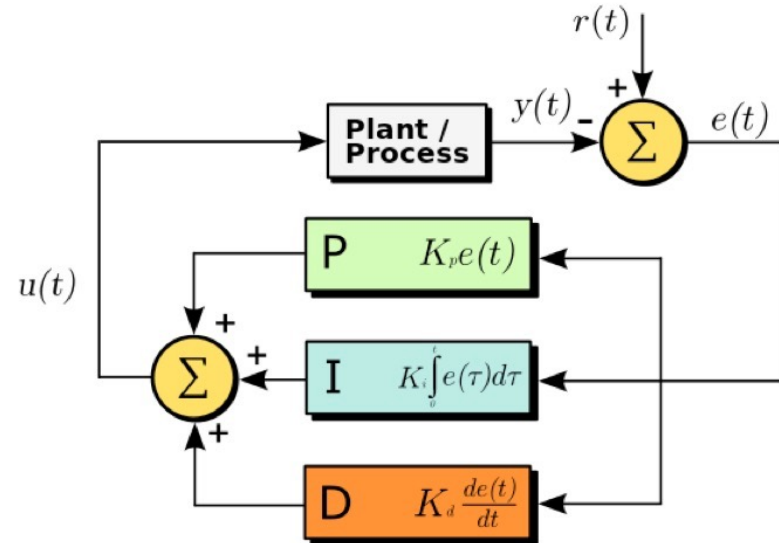
Default is 2.0 bbl



The screen is titled 'Set Alarms'. It shows 'MPD Kick Detection' set to 2.0 bbl, with a note: '(Starts changing setpoint on this kick volume detected)'. Below this is a 'Reset Failures' section with buttons for 'Pump 1', 'Pump 2', 'MPD', and 'Fracture'. At the bottom, there is a status bar with icons for 'MPD Choke Kick KMW' and other system indicators.



## PID CONTROLLER



The automatic MPD calculates the PID constants based in the hydraulic flow model for **current value vs setpoint** of the parameter selected. The values of constants also may be fixed manually on the choke panel:

**PID Constants**

0.1
0.05
0.01
Set Default

Auto
Fixed

**P**
0.100
**I**
0.000
**D**
0.100

The range of values for PID constants in this simulator:

$$K_p = 0.1 - 0.01$$

$$K_i = 0.1 - 0.01$$

$$K_d = 0.1 \text{ to } 0.01$$

## CHOKE OPEN PERCENT (%)

When the choke A reaches 100% open, the choke percent is also 100% and will change to 50% including the choke B.

**MPD CHOKE**

MANUAL
AUTO

CHOKE A
CHOKE B

BHP
DP
CHOKE

4731
3128
16

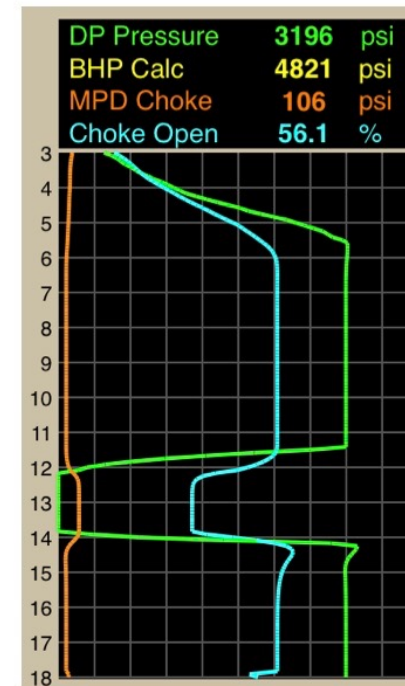
SETPOINT

4680

psi

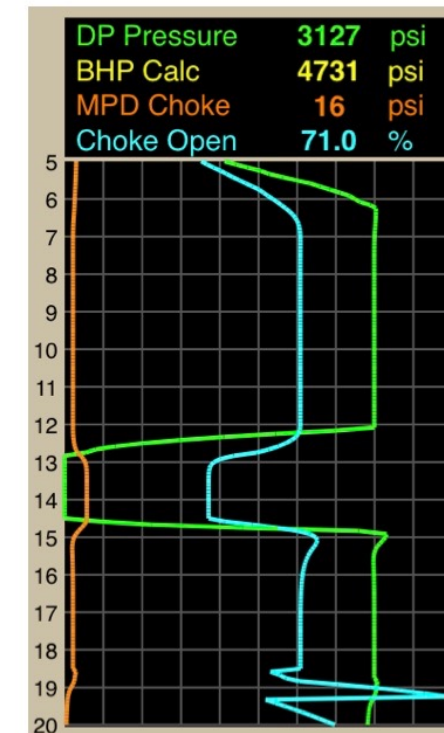
Change Setpoint on kick detected
☐

Choke Open 41.9 %



Choke A = 56.1%

Choke B = 0%



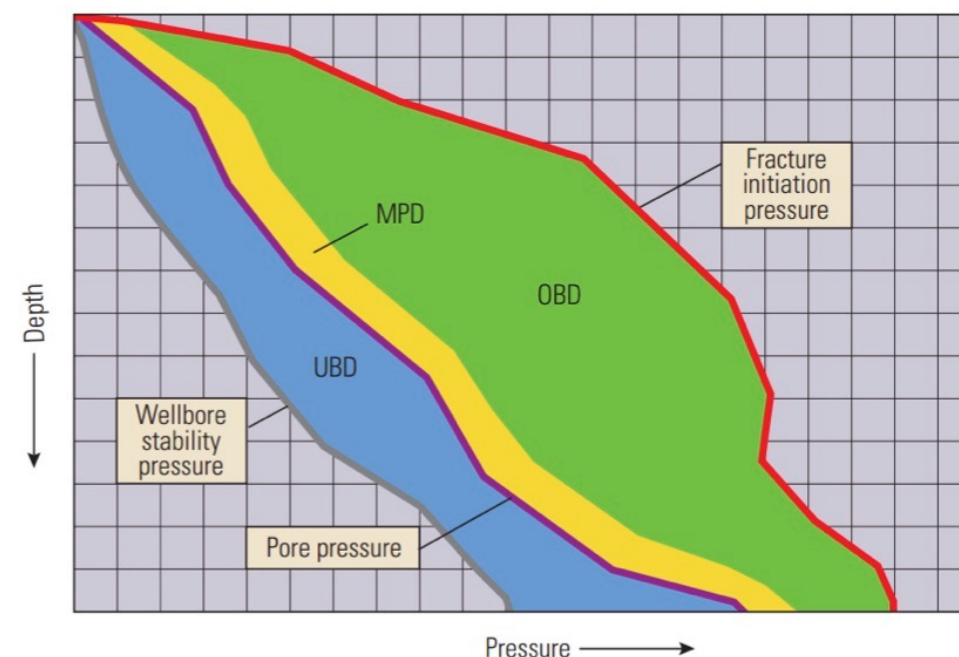
Choke A = 100%

Choke B = 41.9%

## CHAPTER 13

# BackPressure

This simulator provides the backpressure by BackPressure Pump (BPP), Rig Pump Diverter (RPD) and Riser Booster Pump on deepwater operations.



On conventional drilling, the **bottom hole pressure** can be calculated by:

$$\text{BHP} = \text{Hydrostatic} + \text{Annulus Friction}$$

In special situations, it is necessary an additional pressure to maintain the BHP in the safety range of ECD to drilling operations. But, during drillpipe connections for example, a pumps-off event is necessary.

The MPD system provides a **Surface BackPressure** as your the most important parameter.

$$\text{BHP} = \text{Hydrostatic} + \text{Annulus Friction} + \text{BackPressure}$$



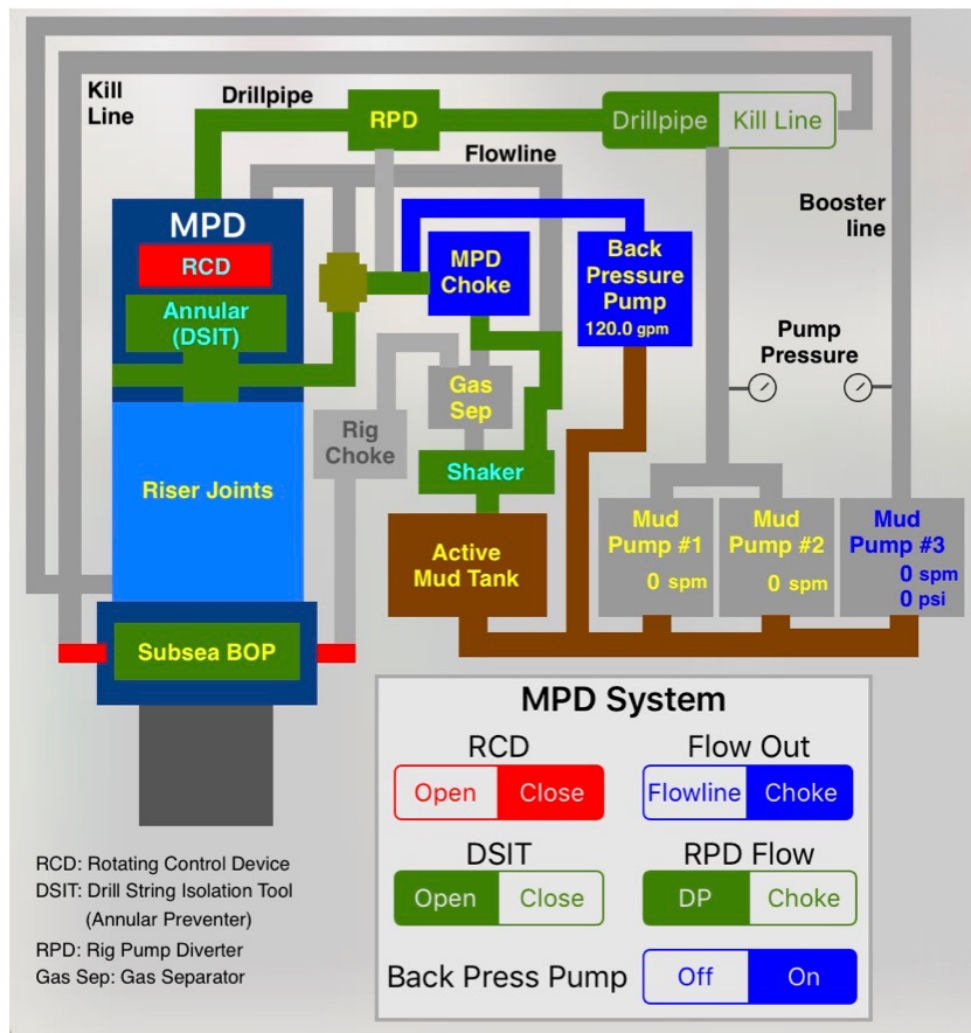


## BackPressure Pump - BPP

In this simulator, the BPP starts, when is ON and MPD in Auto Choke, if **Flow In DP** is less than 120 gpm.

The Maximum BPP Flow Rate is 120 gpm.

Set MPD system (RCD Close, Flow Out to Choke, BPP On)



Select Choke Option and set Setpoint = 300 psi

Set MPD Choke to AUTO.

**MPD CHOKES**
MANUAL
AUTO
CHOKES A
CHOKES B

BHP

DP

CHOKES

5208

0

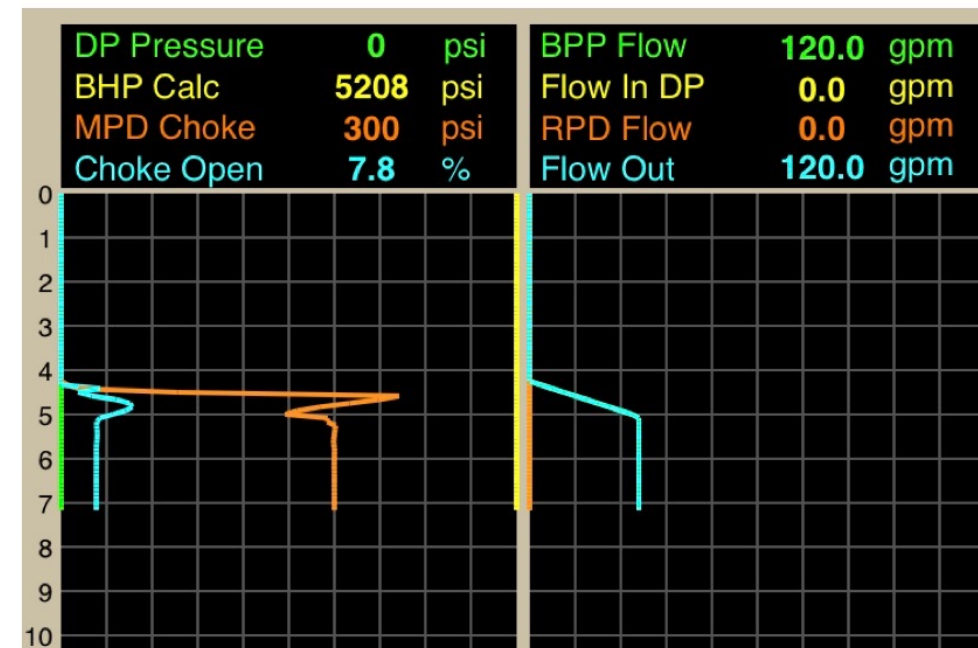
300

SETPOINT
300
psi

Change Setpoint on kick detected
☐

Choke Open
7.8
%

BPP Starts until 120 gpm

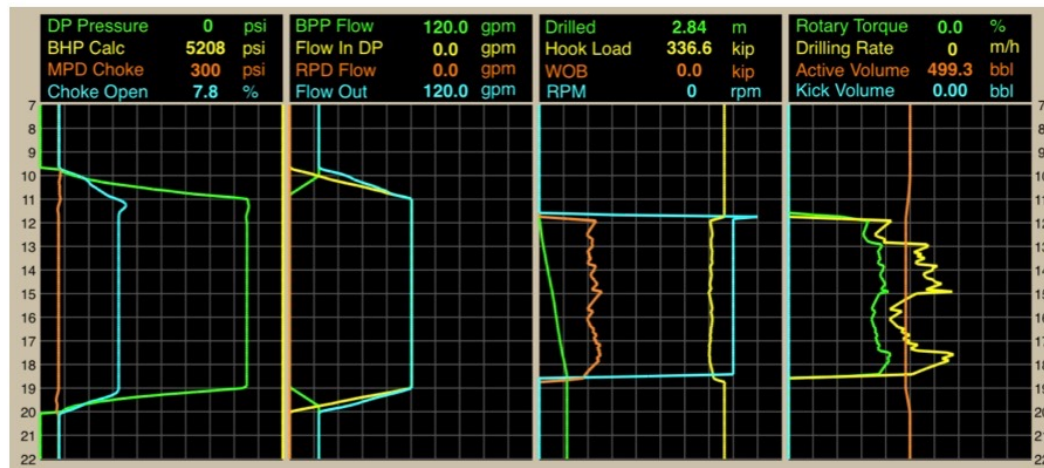


## Drillpipe Connection with BackPressure Pump

After BPP with 120 spm and auto choke ok maintaining set-point at choke = 300 psi:

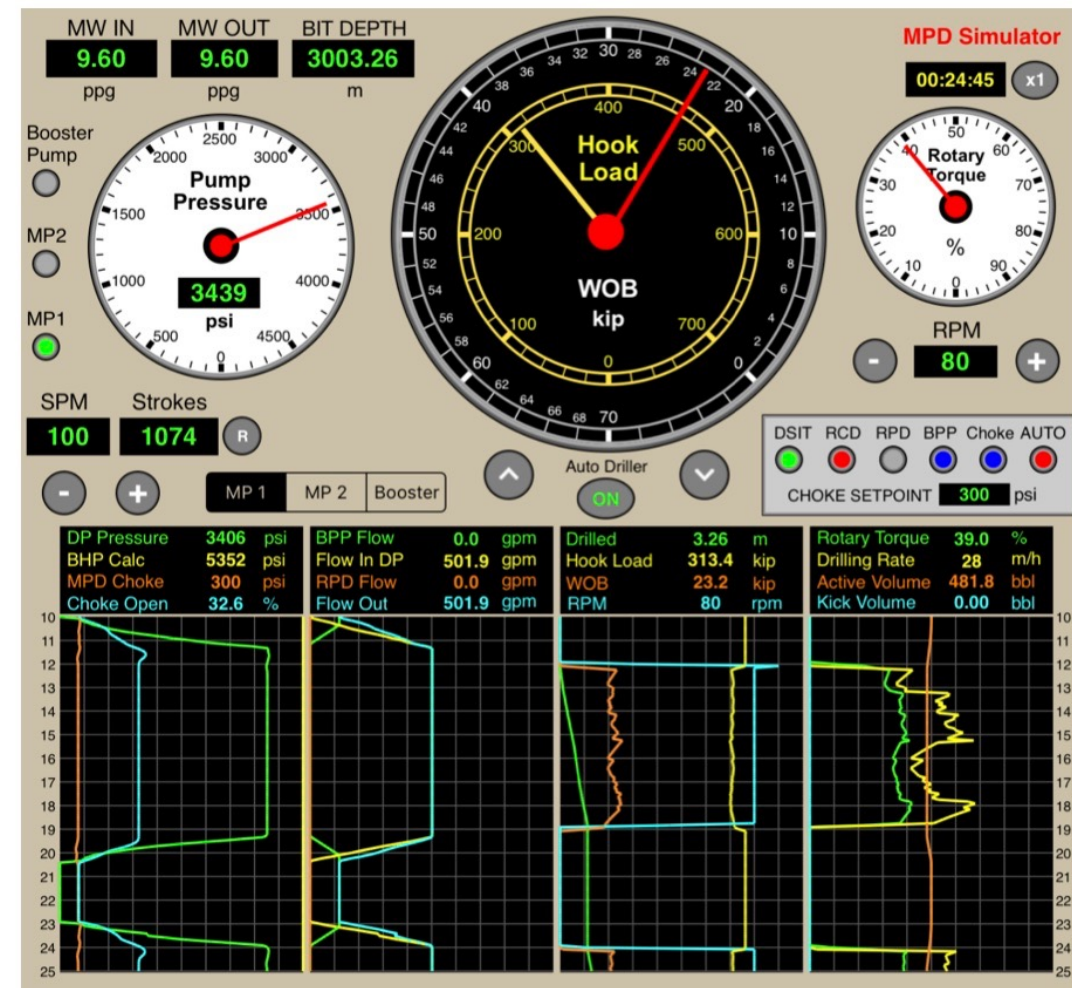
1. Start Mud Pump 1 until SPM=100 (Slowly)
2. Start drillstring rotation to 80 rpm
3. set Weight on Bit to 25 kips
4. Drilling until 3 m (or 10 ft)
5. Stop rotation, shift up drillstring until WOB = 0
6. Decrement mud pump speed slowly until spm = 0

BPP starts until 120 spm again and backpressure = 300 psi.



Restart Drilling again:

1. Start mud pump 1 until 100 spm.
2. Start drillstring rotation to 80 rpm
3. set Weight on Bit to 25 kips



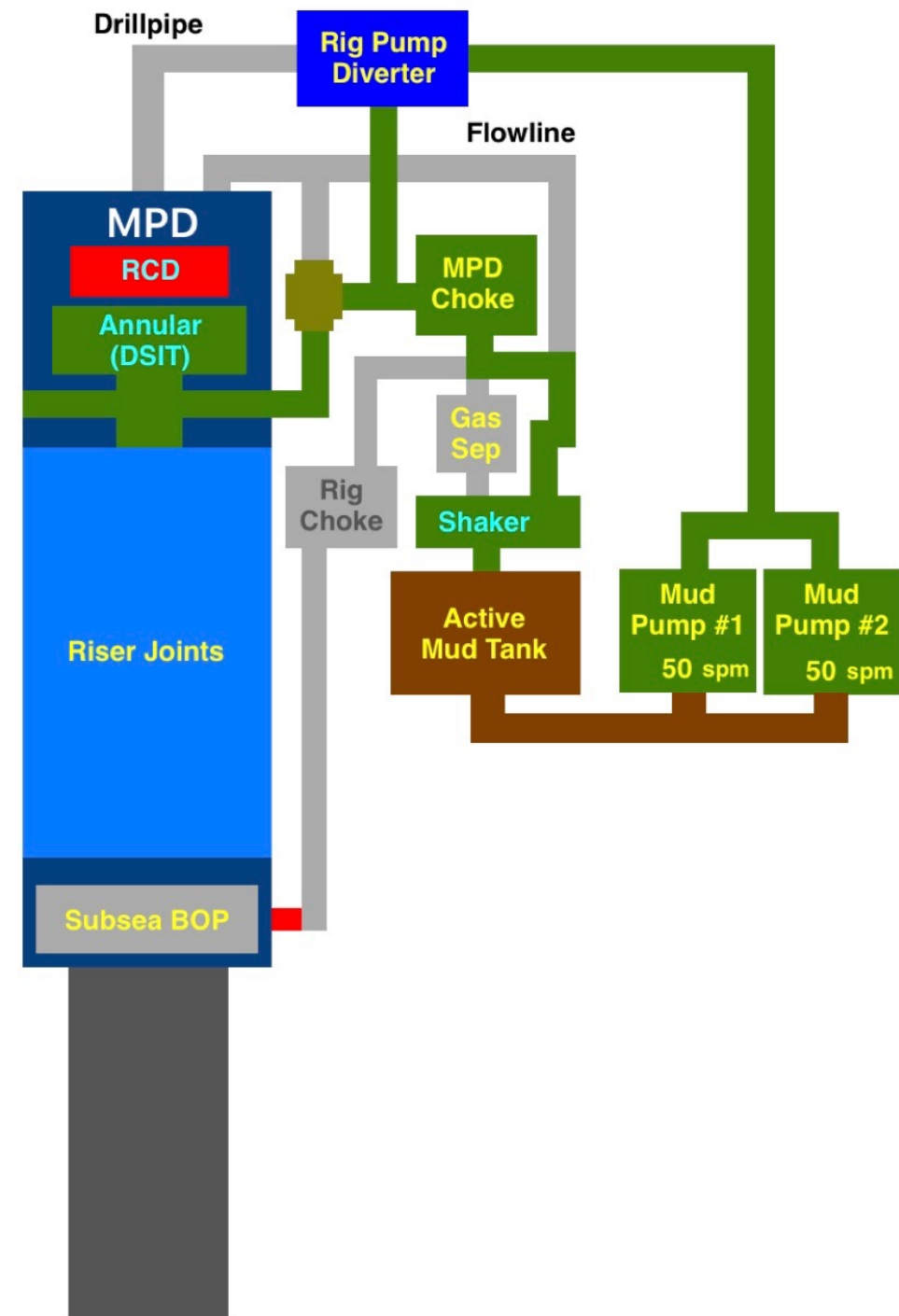


## CHAPTER 15

# Rig Pump Diverter

Rig Pump Diverter is a necessary component of the MPD System to supply and maintain BackPressure during drill pipe connections using the flow provided by the mud pumps of the rig.

RPD has several advantages over the BackPressure Pump.



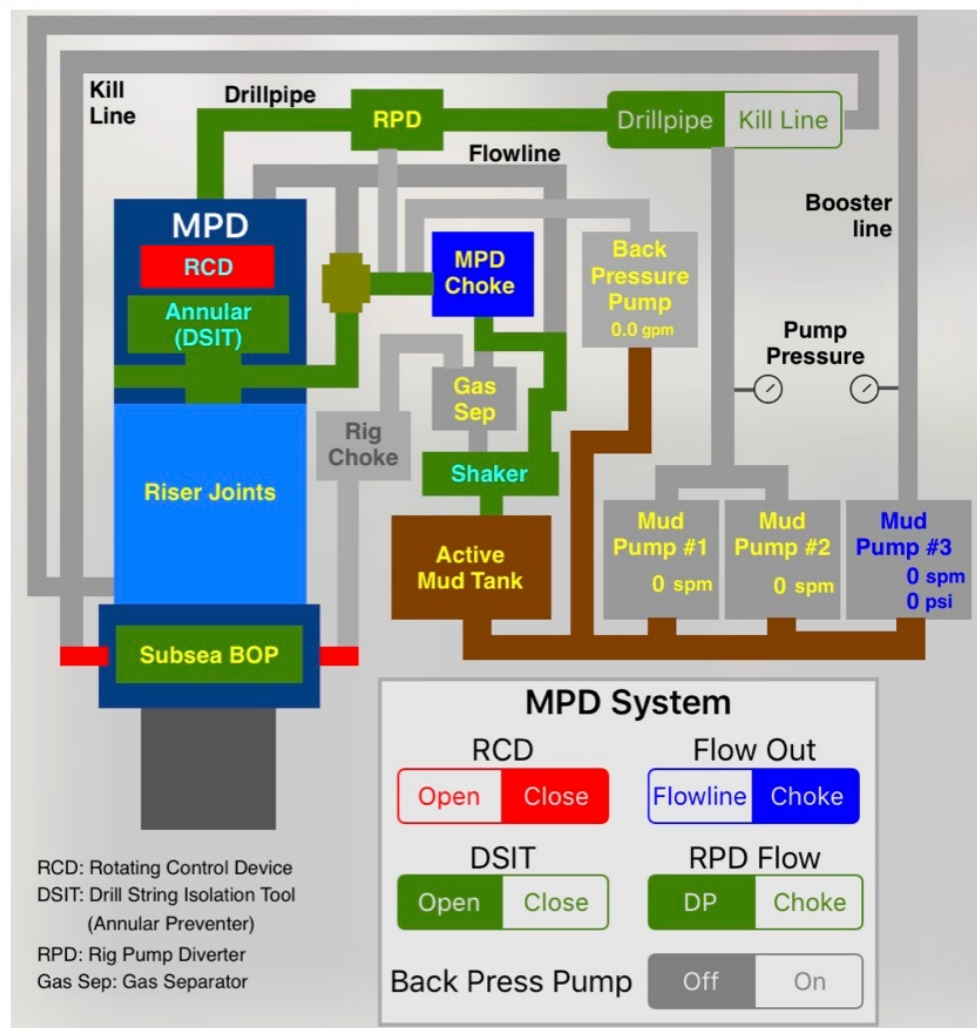


## Rig Pump Diverter - RPD

In this simulator, the RPD starts when the **Choke option** is selected and the flow of the mud pumps is fully deviated to the MPD Choke.

Set RPD Flow to **DP option** to the flow into drillpipe.

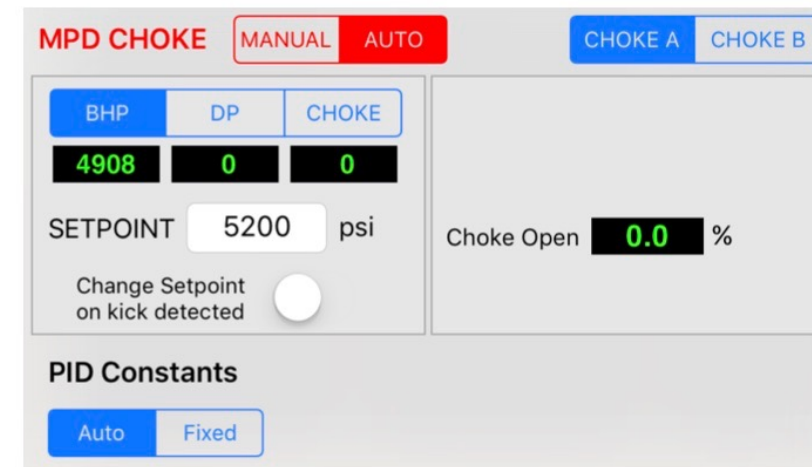
Set the MPD system (RCD Close and Flow Out to Choke) and maintain RPD FLOW to **DP option** in this moment.



## Drilling with CBHP - Constant Bottom Hole Pressure

Select BHP Option and set Setpoint = 5200 psi

Set MPD Choke to AUTO and PID Constants to AUTO.



**MPD CHOKE** MANUAL AUTO CHOKE A CHOKE B

BHP DP CHOKE

4908 0 0

SETPOINT 5200 psi

Choke Open 0.0 %

Change Setpoint on kick detected

**PID Constants**

Auto Fixed

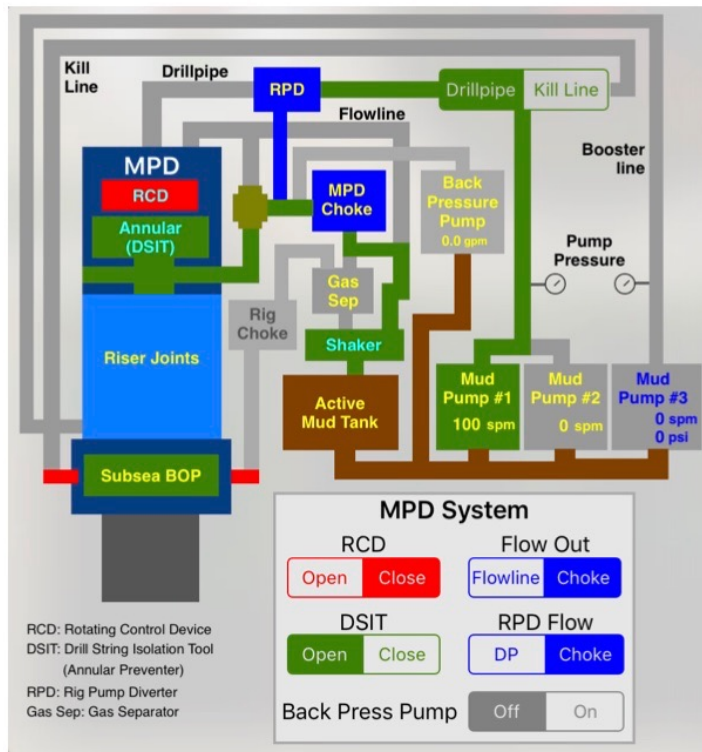
1. Start Mud Pump 1 until SPM=100
2. Start drillstring rotation to 80 rpm
3. Set Weight on Bit to 25 kips
4. Set Auto Driller to ON (optional)
5. Drilling until 2 m (or 7 ft)



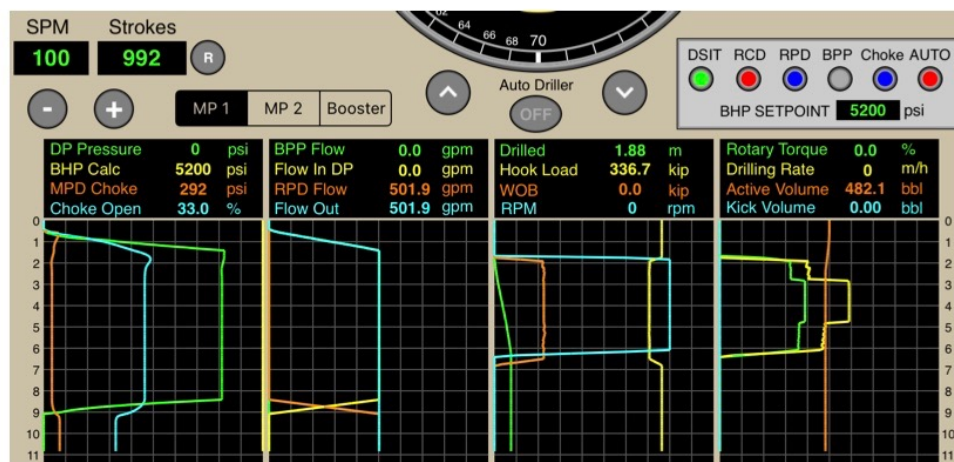


## Drillpipe Connection with Rig Pump Diverter

1. Stop rotation, shift up drillstring until WOB = 0
2. Open MPD view and set RPD to CHOKE option.

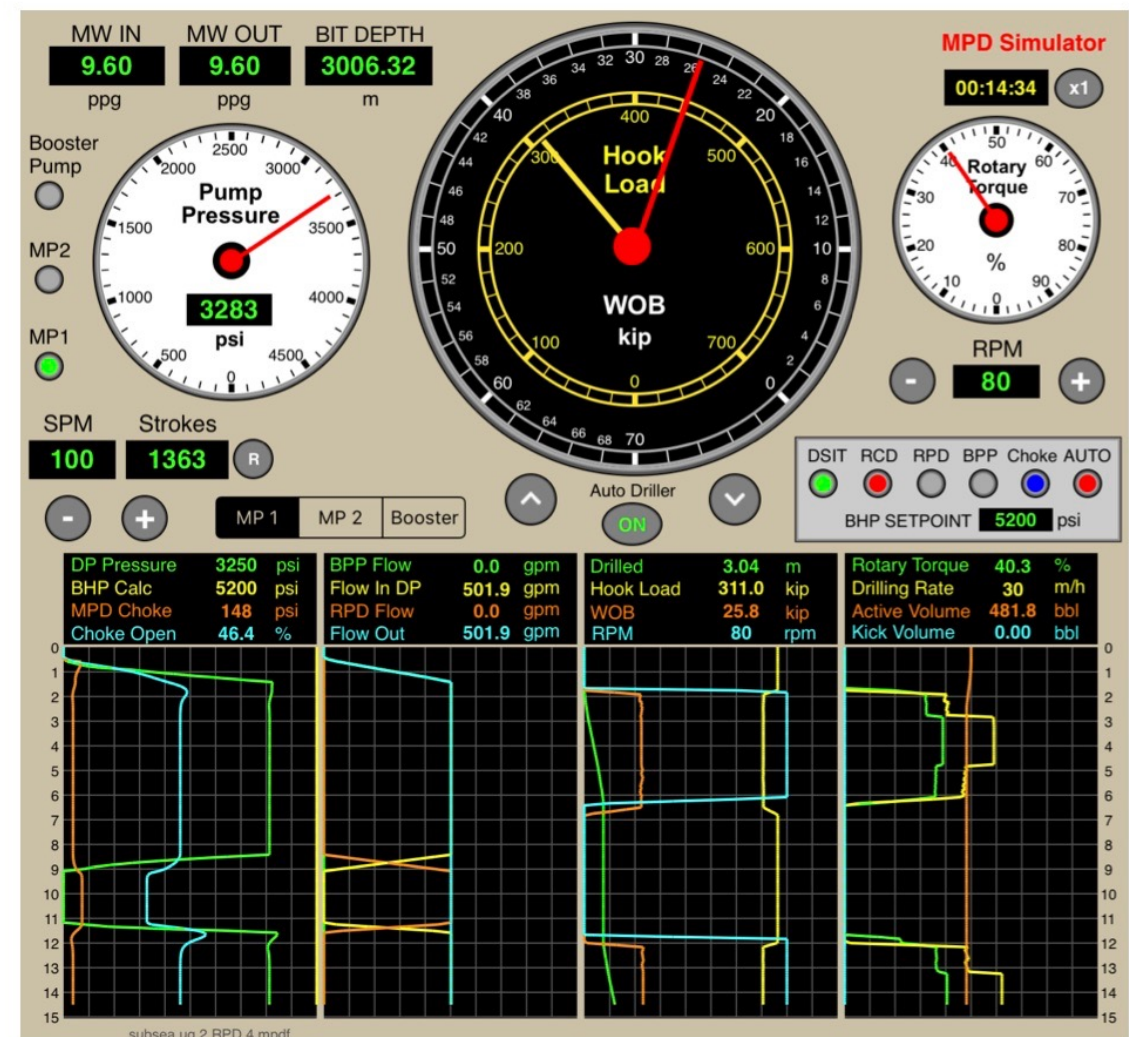


3. Close MPD view and wait for flow to choke completed.



## Restart Drilling again:

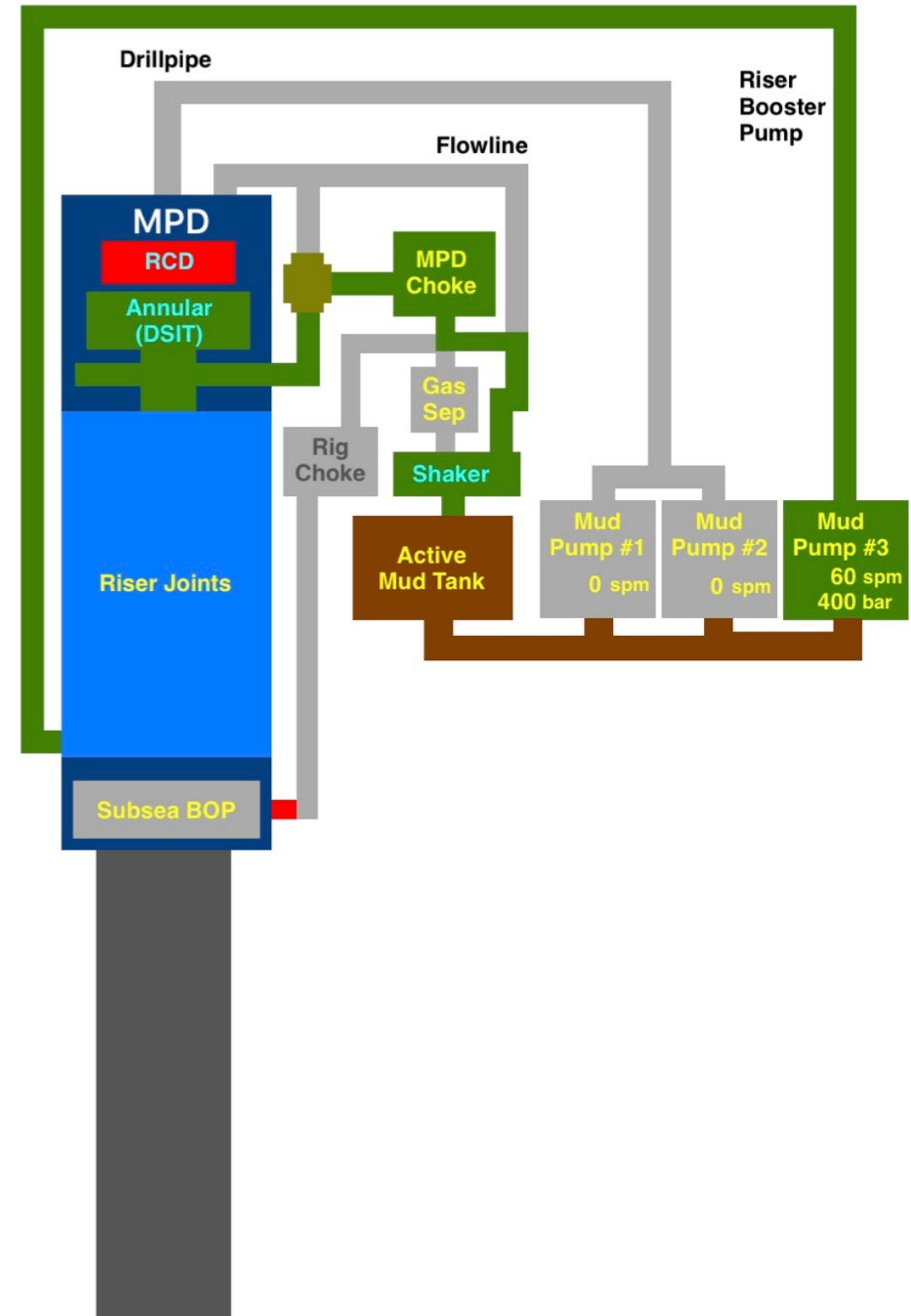
1. Open MPD view and set RPD to DP option
2. Close MPD view and wait for flow to DP completed.
3. Start drillstring rotation to 80 rpm
4. Set Weight on Bit to 25 kips
5. Set Auto Driller to ON (optional)



## CHAPTER 16

# BackPressure With Riser Booster Pump

On deepwater it is possible to supply and maintain BackPressure during drill pipe connections using the flow provided by the riser booster pump.

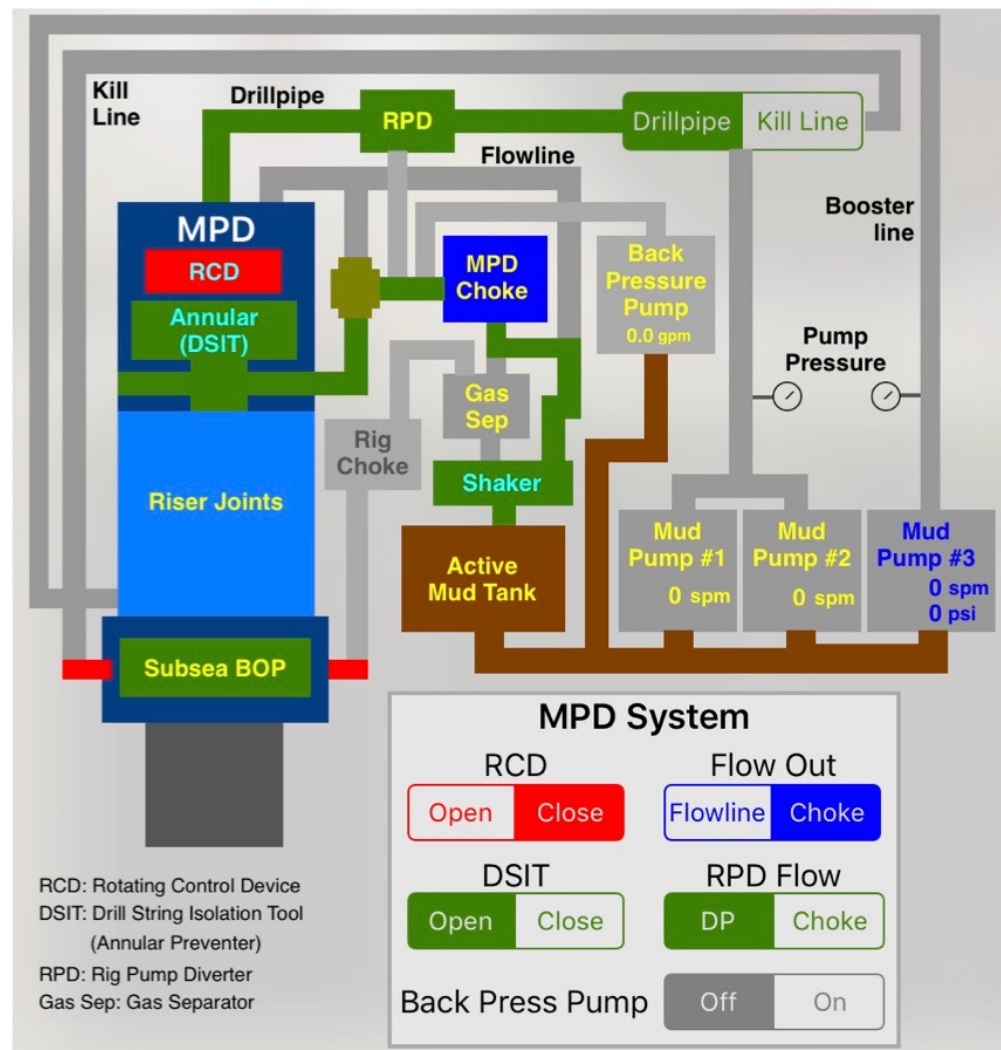




## Riser Booster Pump

In this simulator, the Riser Booster Pump is started by the driller normally on deepwater operations.

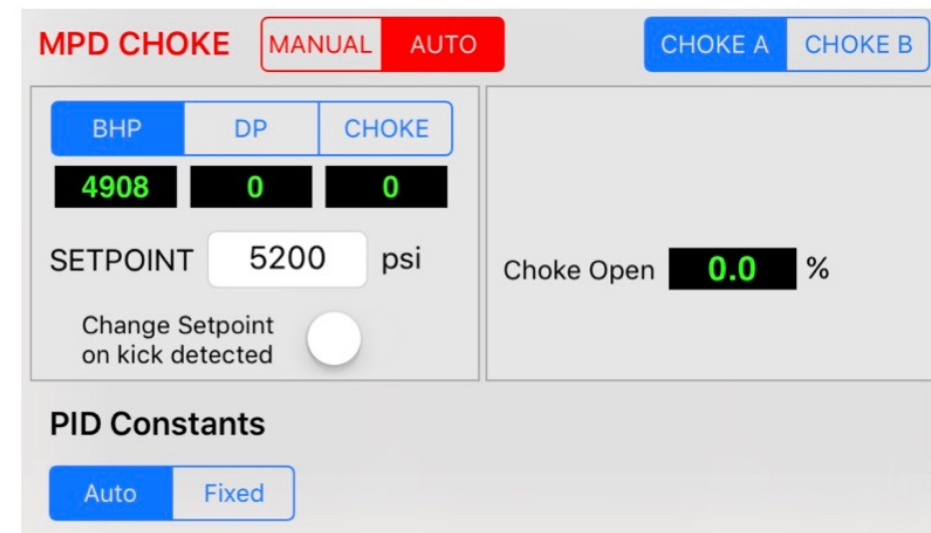
Set the MPD system (RCD Close and Flow Out to Choke)



## Drilling with CBHP - Constant Bottom Hole Pressure

Select BHP Option and set Setpoint = 5200 psi

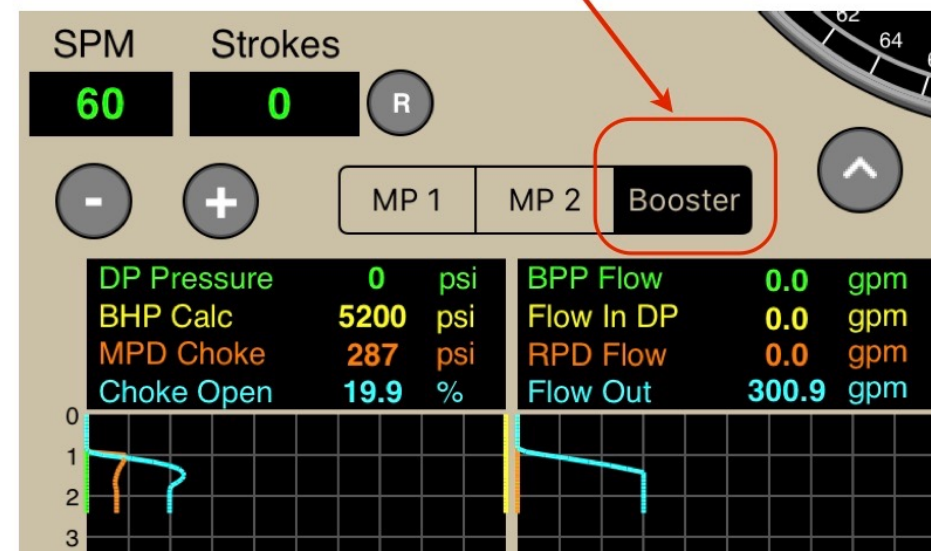
Set MPD Choke to AUTO and PID Constants to AUTO.



The MPD Choke control panel shows the following settings:

- MPD CHOKE:** MANUAL (red), AUTO (red)
- CHOKE A:** CHOKE A (blue), CHOKE B (blue)
- BHP:** 4908
- DP:** 0
- CHOKE:** 0
- SETPOINT:** 5200 psi
- Change Setpoint on kick detected:** (toggle switch)
- Choke Open:** 0.0 %
- PID Constants:** Auto (blue), Fixed (blue)

1. Select Riser Booster Pump
2. Increment speed until 60 SPM



The MPD System control panel shows the following settings:

- SPM:** 60
- Strokes:** 0
- R:** (toggle switch)
- MP 1:** (toggle switch)
- MP 2:** (toggle switch)
- Booster:** (toggle switch, highlighted with a red circle and arrow)
- DP Pressure:** 0 psi
- BHP Calc:** 5200 psi
- MPD Choke:** 287 psi
- Choke Open:** 19.9 %
- BPP Flow:** 0.0 gpm
- Flow In DP:** 0.0 gpm
- RPD Flow:** 0.0 gpm
- Flow Out:** 300.9 gpm

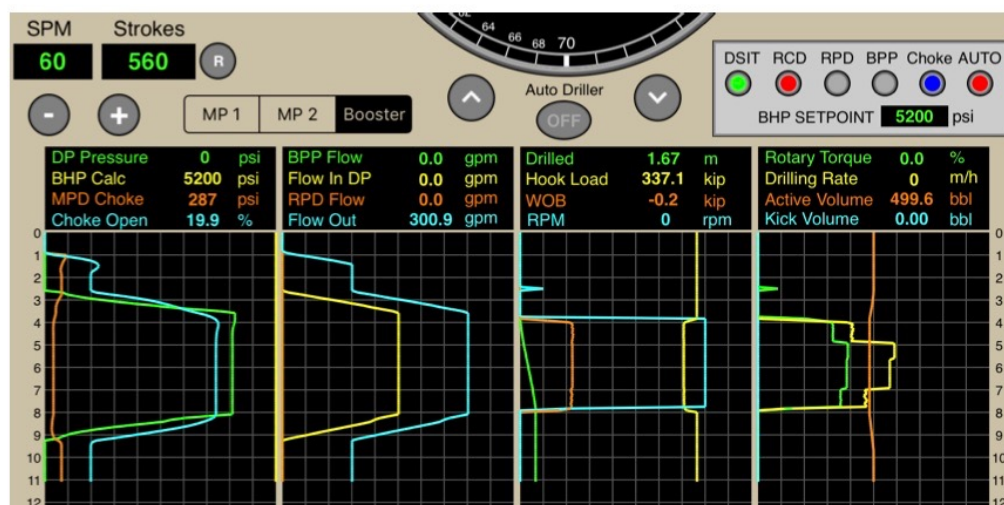


1. Start Mud Pump 1 until SPM=100
2. Start drillstring rotation to 80 rpm
3. Set Weight on Bit to 25 kips
4. Set Auto Driller to ON (optional)
5. Drilling until 2 m (or 7 ft)



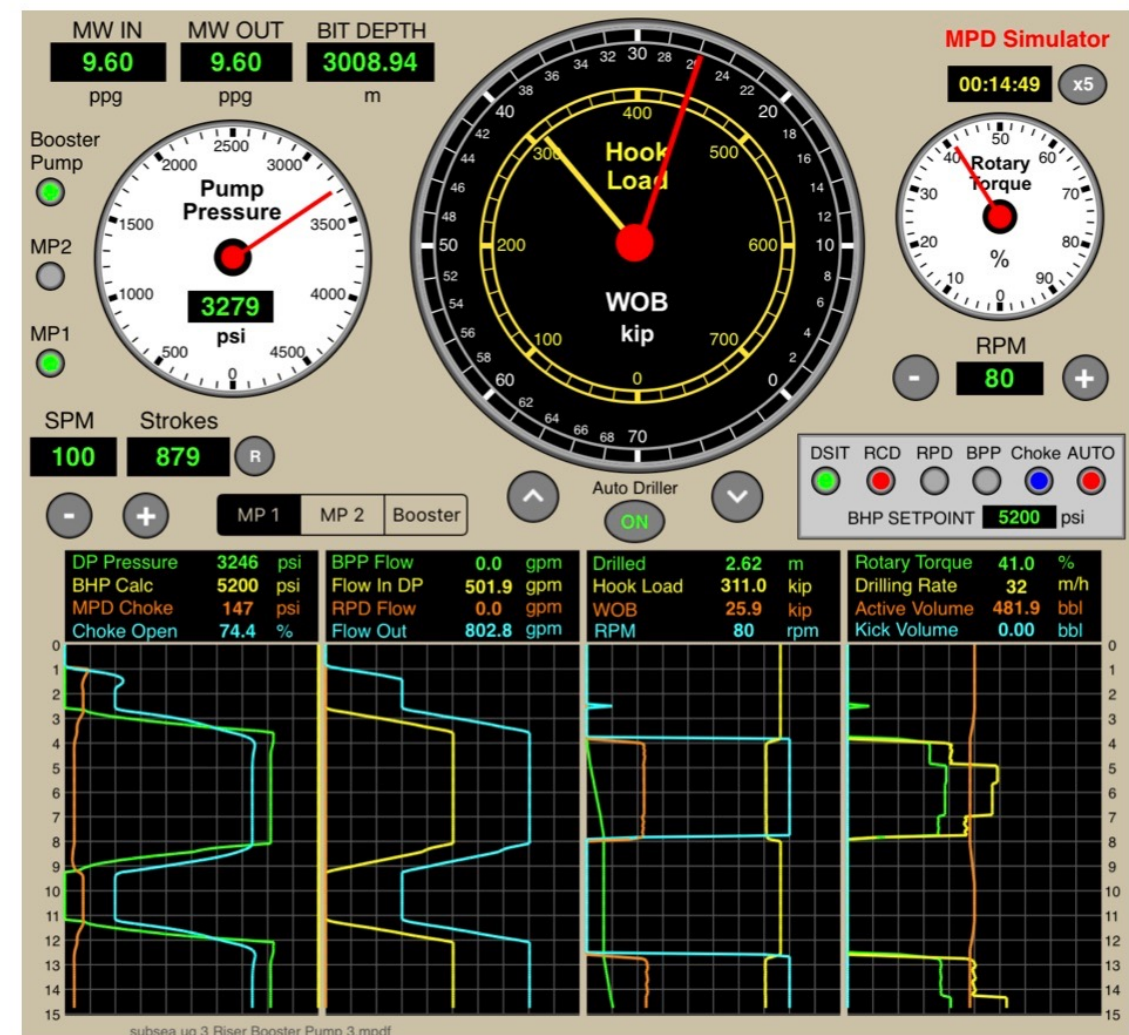
### Drillpipe Connection with Riser Booster Pump

1. Stop rotation, shift up drillstring until WOB = 0
2. Decrement Mud Pump 1 speed slowly until SPM = 0



### Restart Drilling again:

1. Start Mud Pump 1 until SPM=100
2. Set drillstring rotation to 80 rpm
3. Set Weight on Bit to 25 kips
4. Set Auto Driller to ON (optional)







## CHAPTER 17

# Kill Mud Weight

Calculate the kill mud weight based on kick informations and equal to the formation equivalent density.

## Set the Kill Mud Weight

Tap on toolbar button: KMW

**Kill Mud Weight** Disabled Enabled

Total Volume injected in the drillstring  bbl

Total Volume injected in the kill line  bbl

Kill Mud Weight  ppg Set

1. Select Enable Option
2. Input the Kill Mud Weight
3. Tap on “**Set**” button

Note:

The total volume injected into the drillstring. Normally equal to ZERO in this moment.

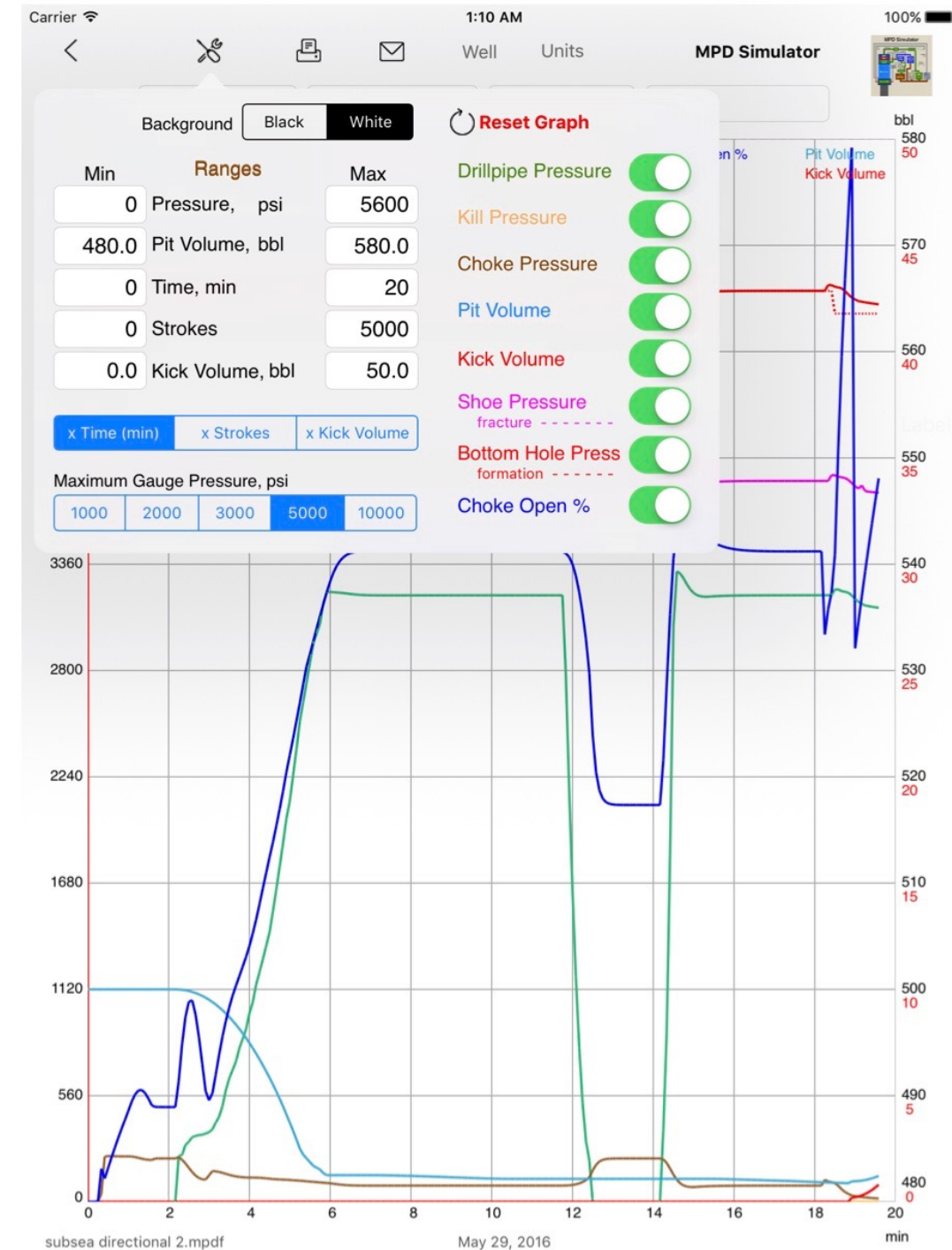


## CHAPTER 18

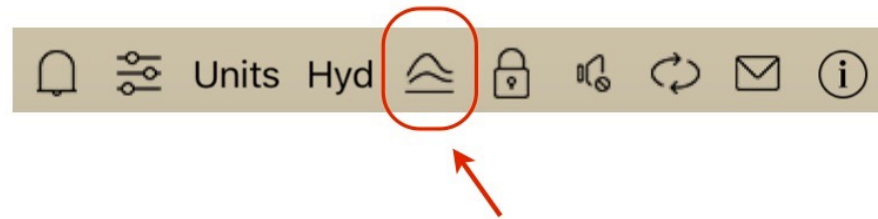
# Graph

This simulator provides a graph for analysis of the parameters:

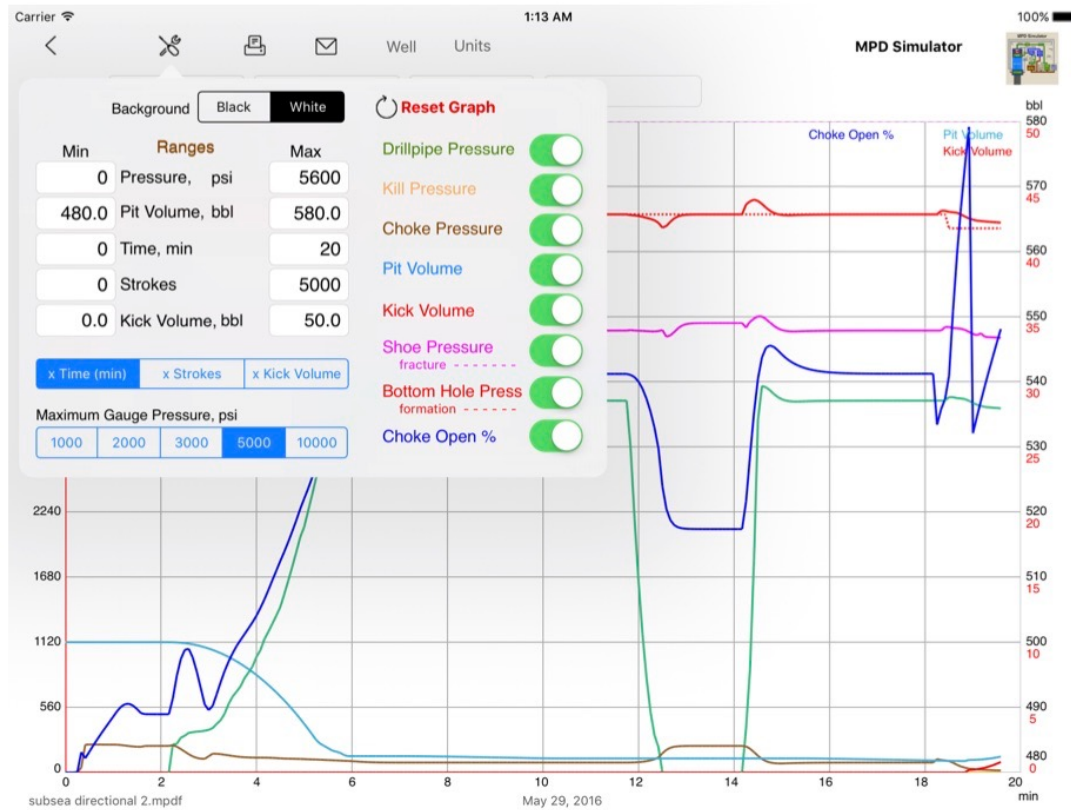
- Drill pipe Pressure
- Kill Pressure
- Choke Pressure (Well Head Pressure)
- Pit Volume
- Kick Volume
- Shoe Pressure
- Bottom Hole Pressure
- Choke Open %



Tap on toolbar button to open graph view



iPad on Horizontal position



Plot Options:

Background		Black	White
Min	Ranges	Max	
0	Pressure, psi	5600	
480.0	Pit Volume, bbl	580.0	
0	Time, min	20	
0	Strokes	2000	
0.0	Kick Volume, bbl	50.0	



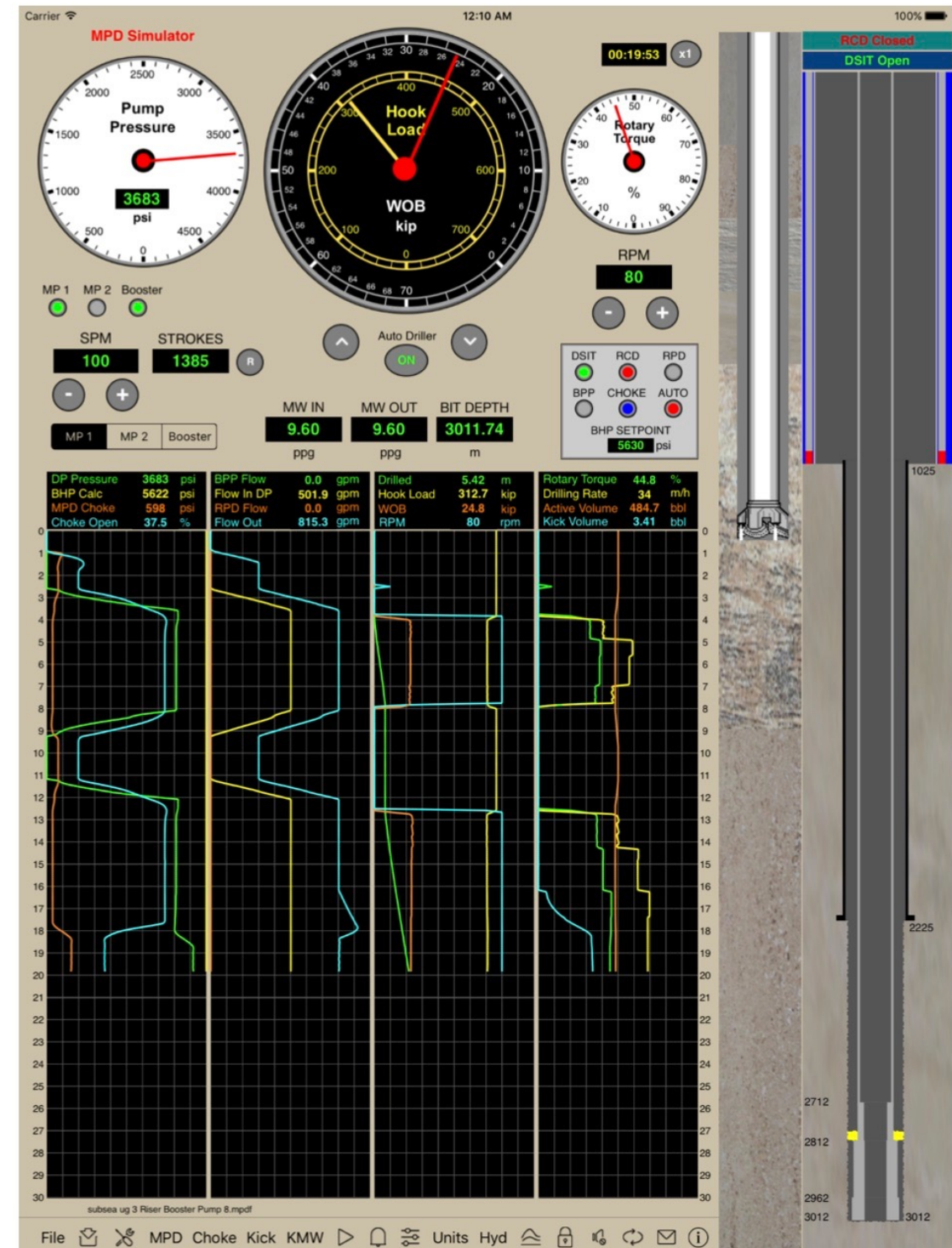


## CHAPTER 19

# Dynamic Well Control

This application provides practical simulations of the Dynamic Well Control on the Managed Pressure Drilling (MPD) operations in the oil field services.

With Managed Pressure Drilling (MPD), when kicks occur, they are typically smaller, contained more quickly, and, in some cases, they may be circulated out through MPD equipment without drilling or circulation interruption.





## Drilling with riser booster pump

Set the MPD Kick Detection at Alarms popup view.

The MPD Controller starts changing the setpoint on this kick volume detected:

Set Alarms

MPD Kick Detection  bbl  
 (Starts changing setpoint on this kick volume detected)

Set option to change setpoint automatically on influx detected on MPD Choke panel:

MPD CHOKE

MANUAL
AUTO

CHOKE A
CHOKE B

BHP
DP
CHOKE

5200
3261
147

SETPOINT  psi

Change Setpoint  
on kick detected
 

☒

**PID Constants**  

Auto
Fixed

Choke Open 74.4 %

Set the pore equivalent density to 10.75 ppg and fluid density to 2 ppg (gas)

Kick

Permeability  mD

Soft  % Hard

Pore Equiv. Density  ppg

Fluid Density  ppg

It is possible to hide this information with code. This is an useful resource for well control schools.

Kick

Permeability  mD

Soft  % Hard

Pore Equiv. Density  ppg

Fluid Density  ppg

Code

.....

Show Kick Informations

☐

**Codes:**  
☐

admin

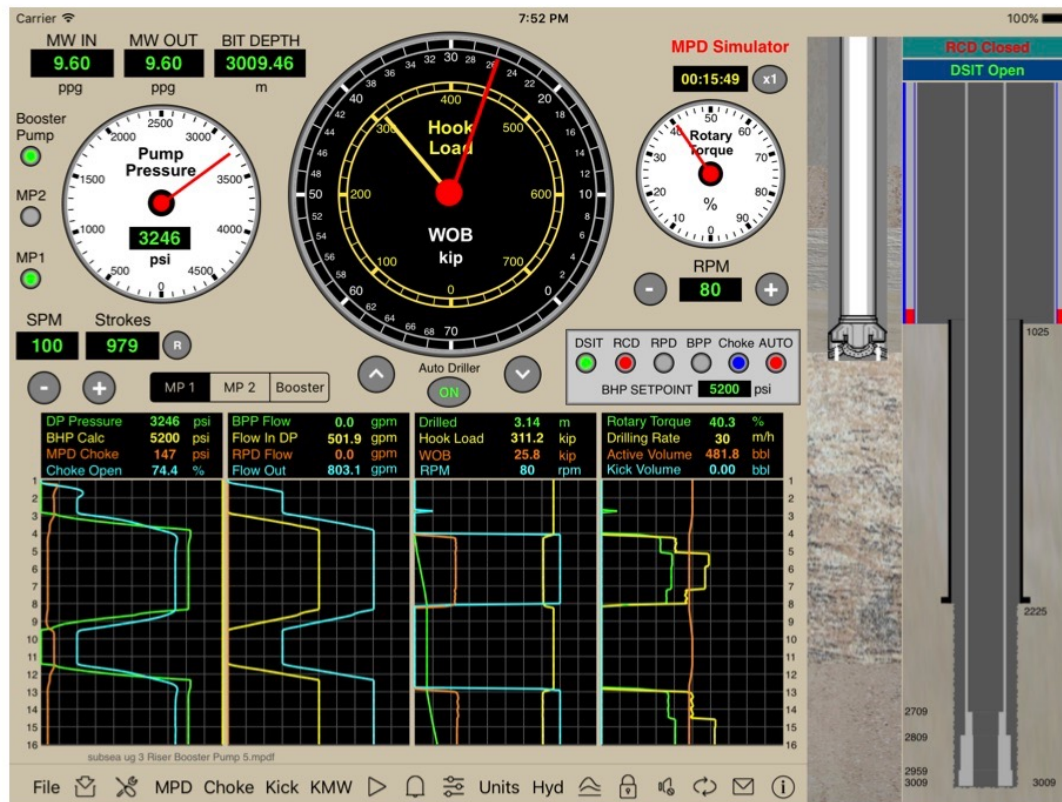
instructor

student

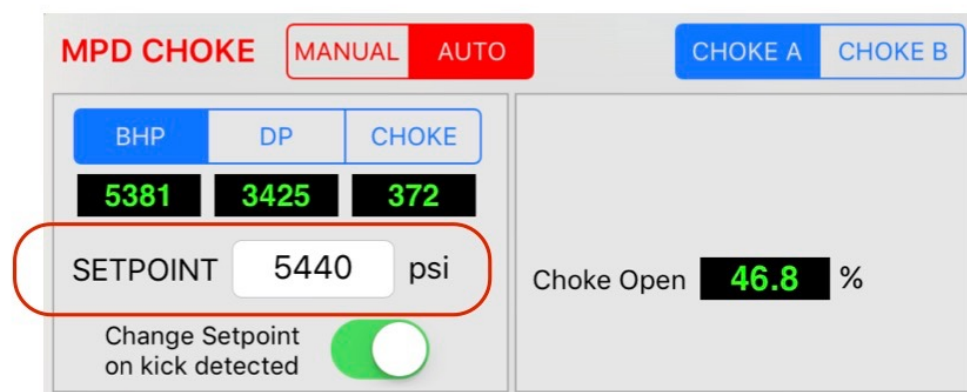
Note: These codes are non-cryptographed

subsea ug 3 Riser Boos

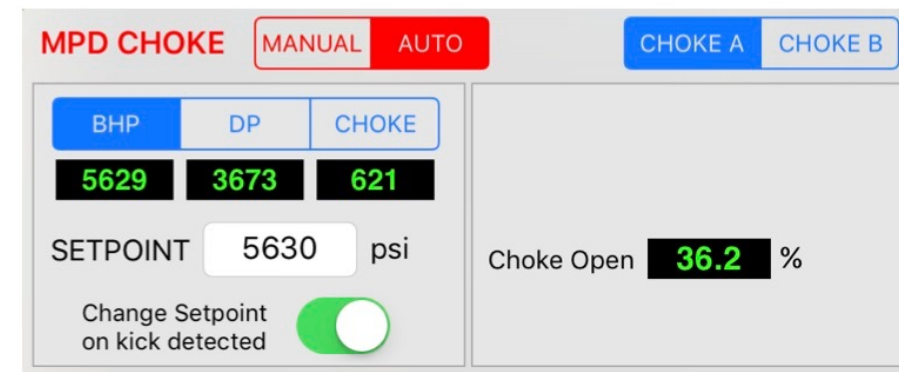
Now drilling until kick detection



On kick volume = 2.0 bbl, the MPD Controller starts changing the setpoint:



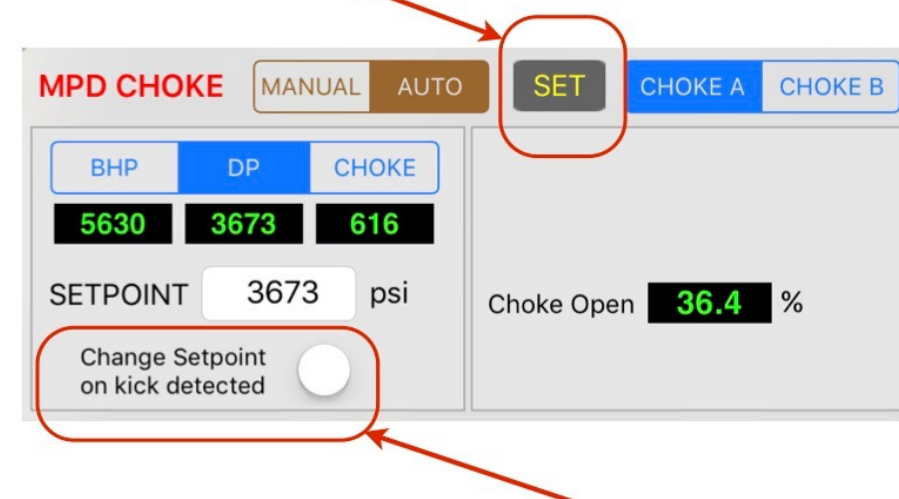
And stop on the influx stabilization.



New BHP Setpoint = 5630 psi, DP Pressure = 3673 psi

For dynamic well control, after stabilization of pressures, set DP Pressure to Setpoint:

Note: Disable setpoint option, select DP, input setpoint and tap on SET button.

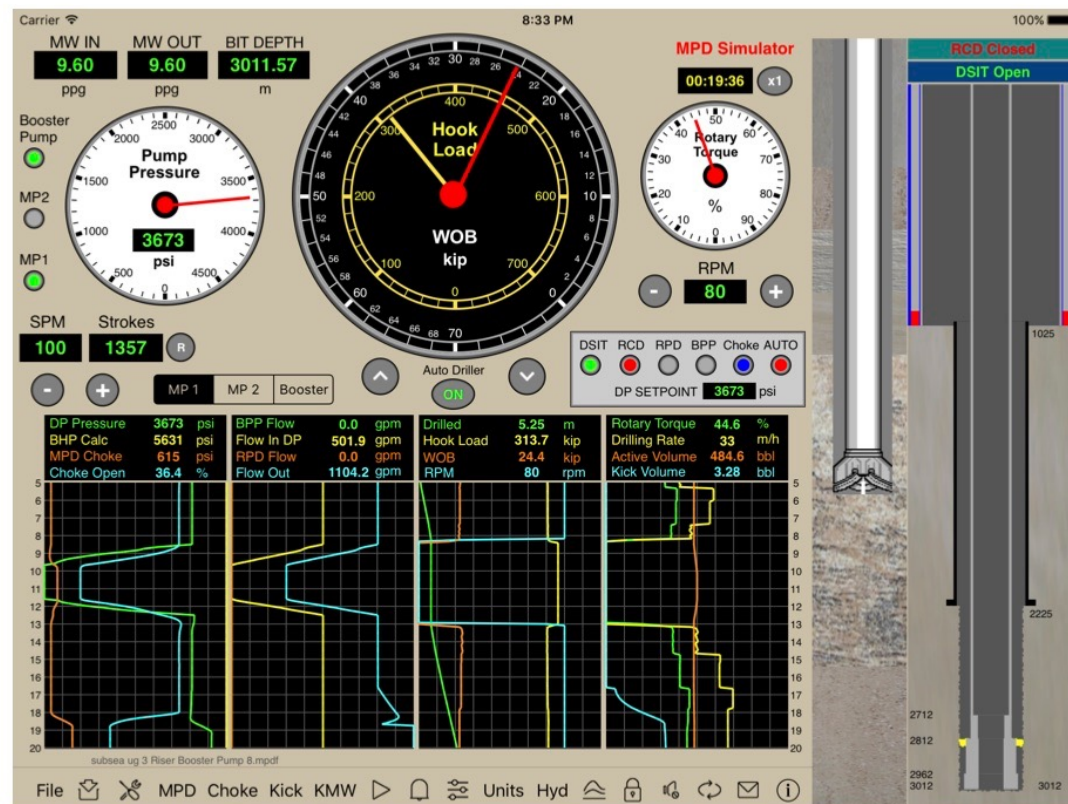




Note that in these dynamic conditions, the Pore Pressure can NOT be accurately calculated. An approximate value would be:

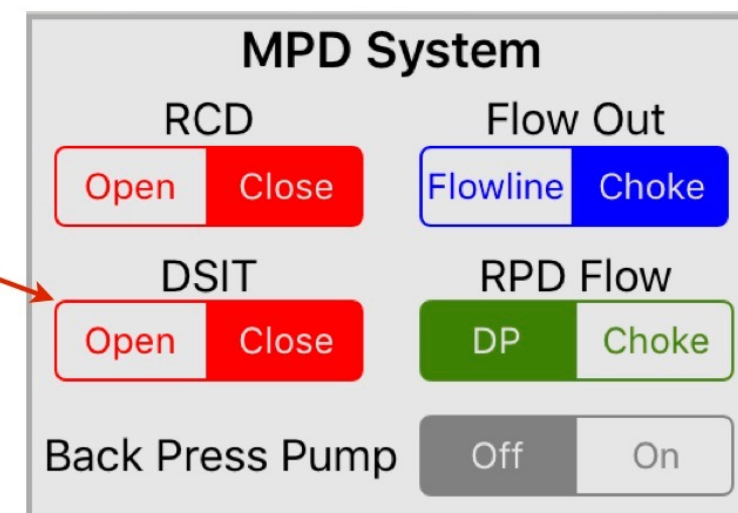
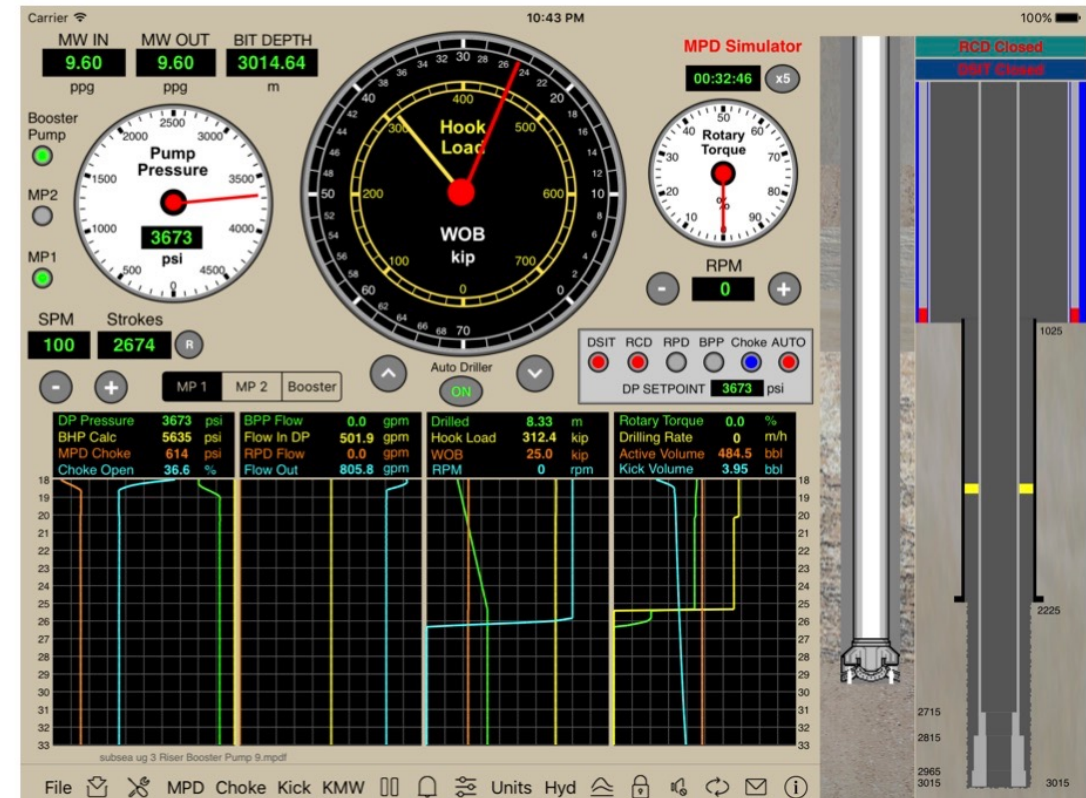
Pore Pressure = stabilized BHP - Annular friction.

Still, there is a possible error on final setpoint due delay on MPD Controller to reach the new setpoint.

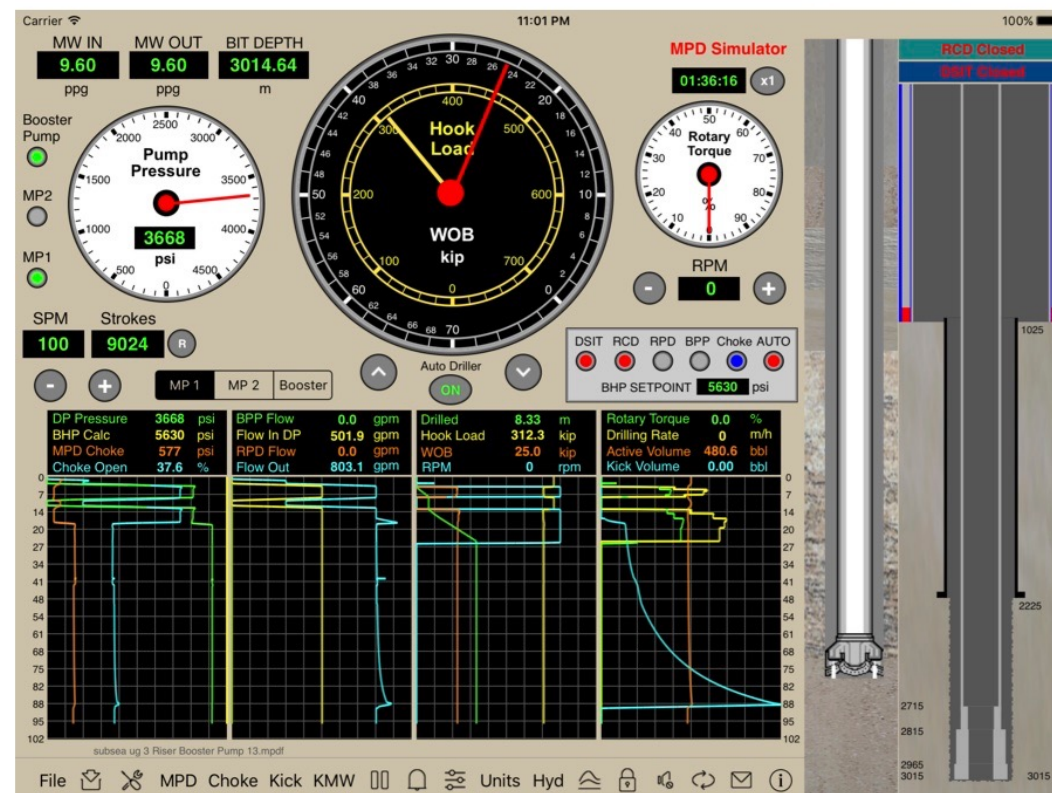
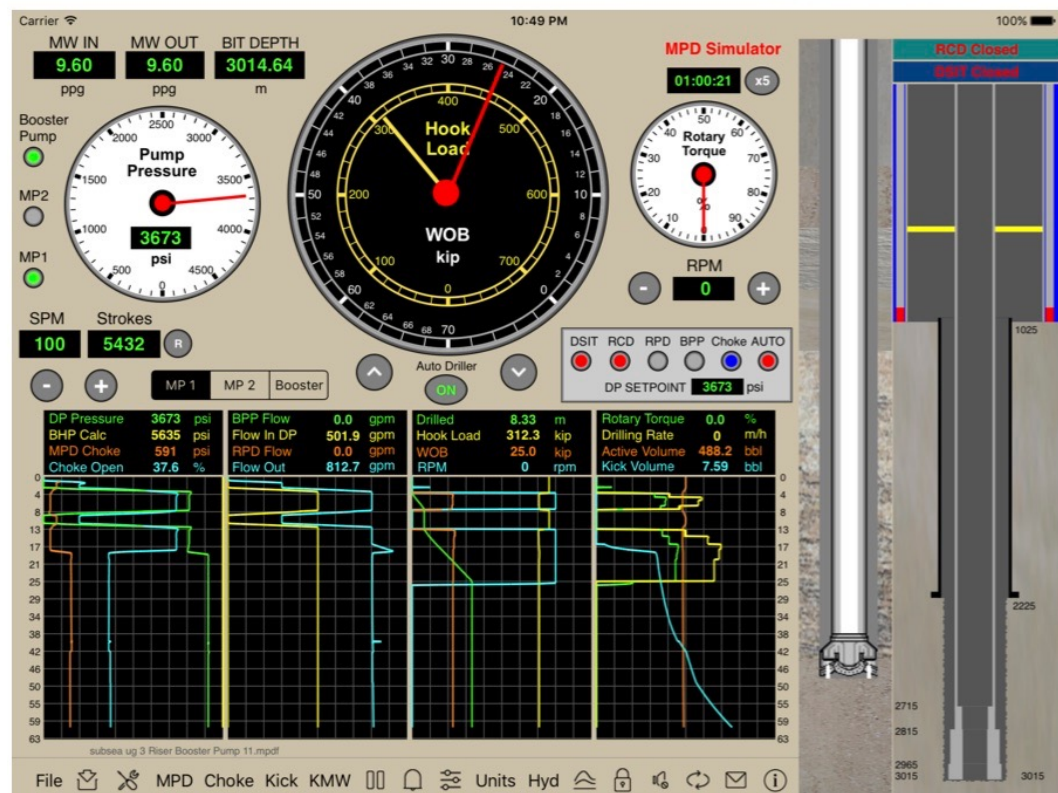
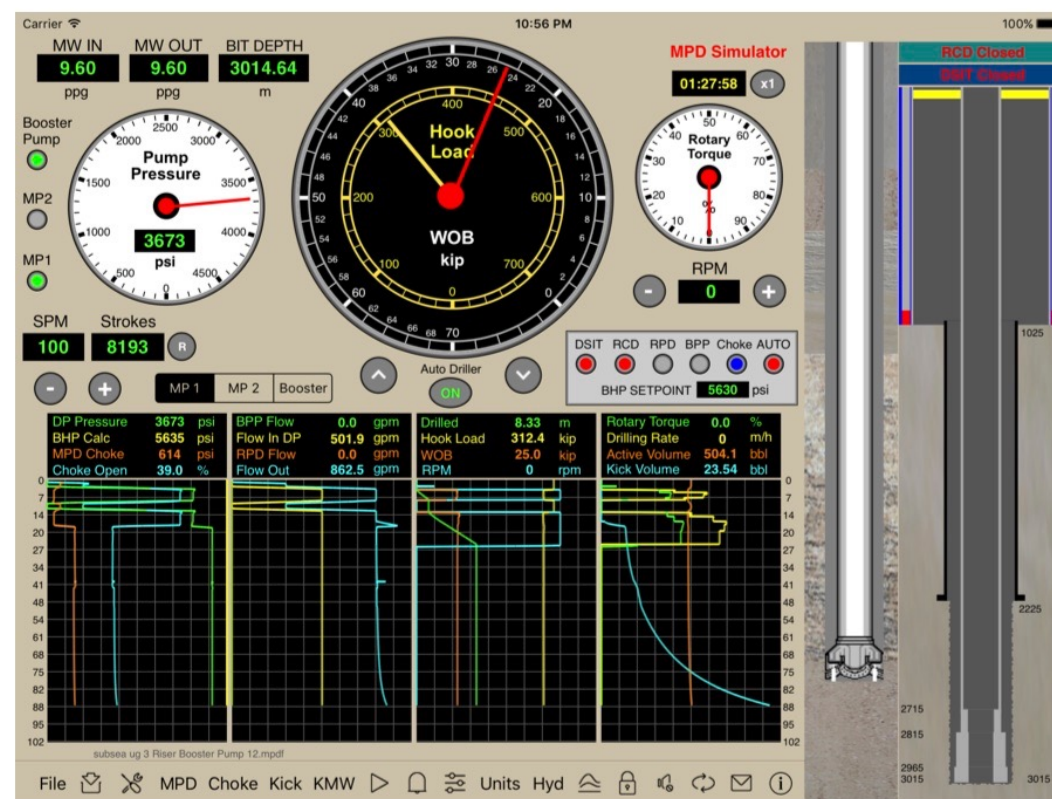
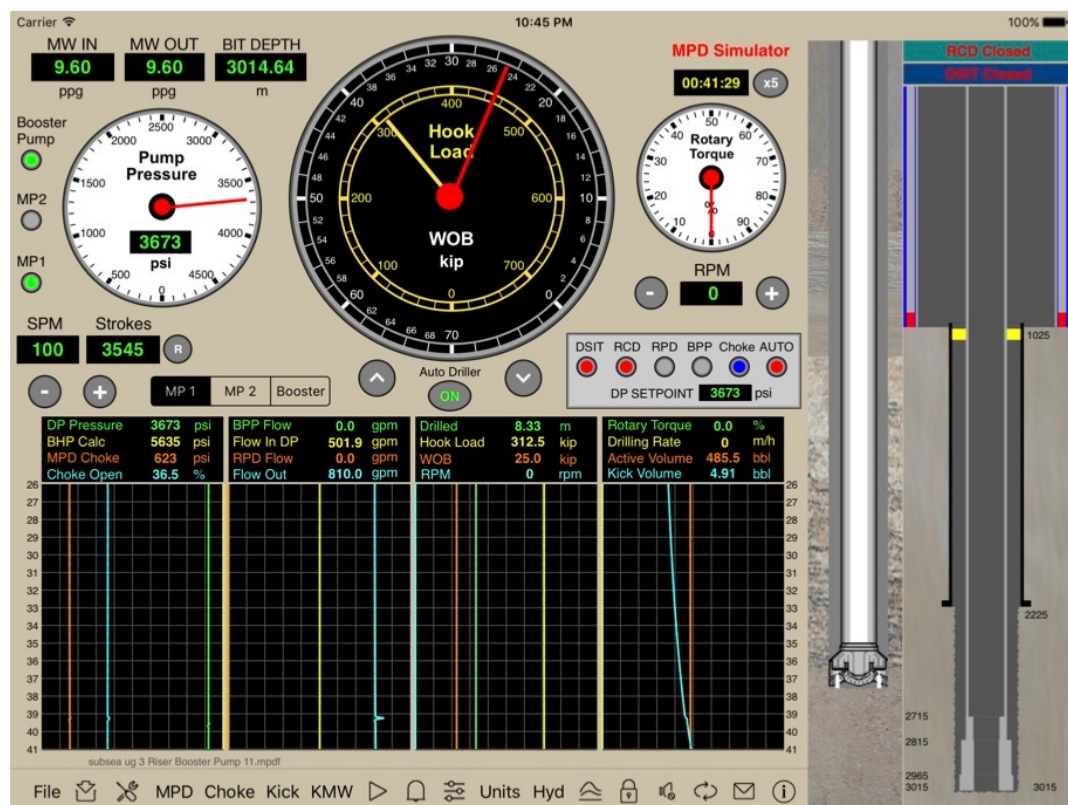


It is possible to continue the drilling during well control, but it is recommended stop the drilling and close the DSIT (Annular preventer). Let's go with the dynamic well control here for education purposes. This simulator drills 11 m (36 ft) only.

Stopping the drilling and closing the DSIT - Annular Preventer.









Kick Out at surface.

The MPD system has as advantage to continue the drilling with the original mud maintaining a surface backpressure at MPD Choke.

For educational purposes in this user guide, let's to replace the original mud with a new mud with the kill mud weight.

In this well, the hydraulic model calculated the BHP = 5630 psi and annular friction = 145 psi.

Pore Pressure = stabilized BHP - Annular friction (approx.)

Set KMW = Pore Density + safety margin = 10.8 ppg

Kill Mud Weight

Total Volume injected in the drillstring

bbl

Total Volume injected in the kill line

bbl

Kill Mud Weight

ppg

Reset total volume injected to ZERO.

SET CHOKE PRESSURE = CURRENT VALUE = 577 psi

MPD CHOKE

BHP

DP

CHOKE

5630

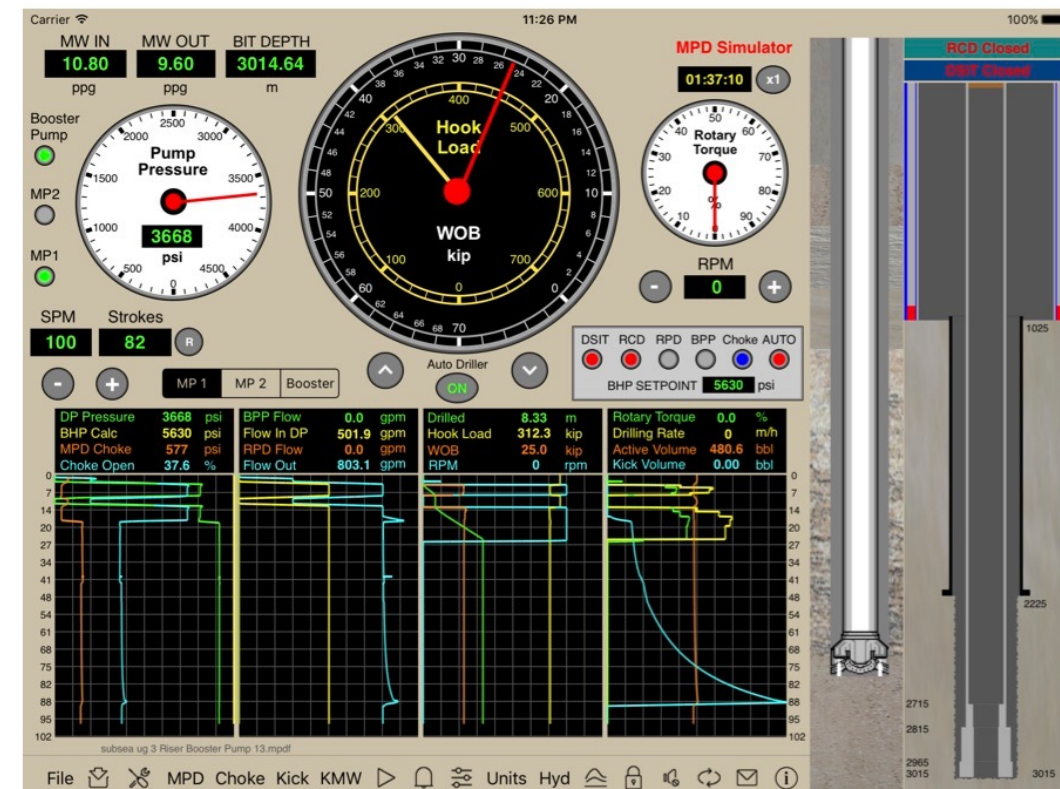
3651

577

SETPOINT  psi

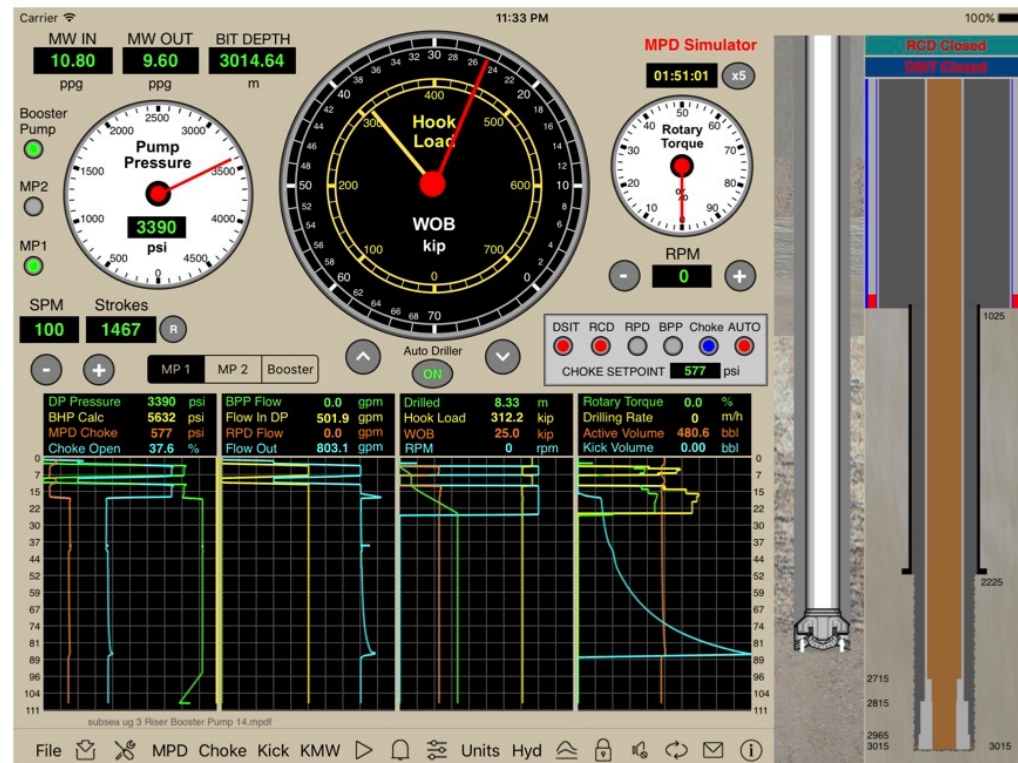
Choke Open 37.6 %

After 80 strokes (surface connections), the kill mud reaches the DP.

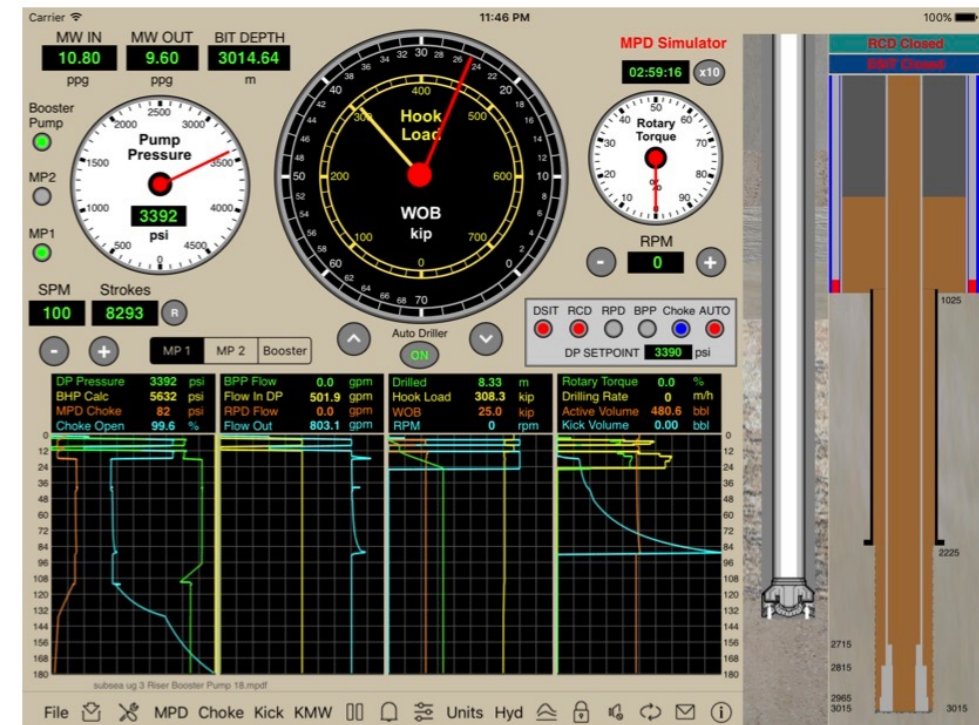




Kill Mud reaches the drill bit:

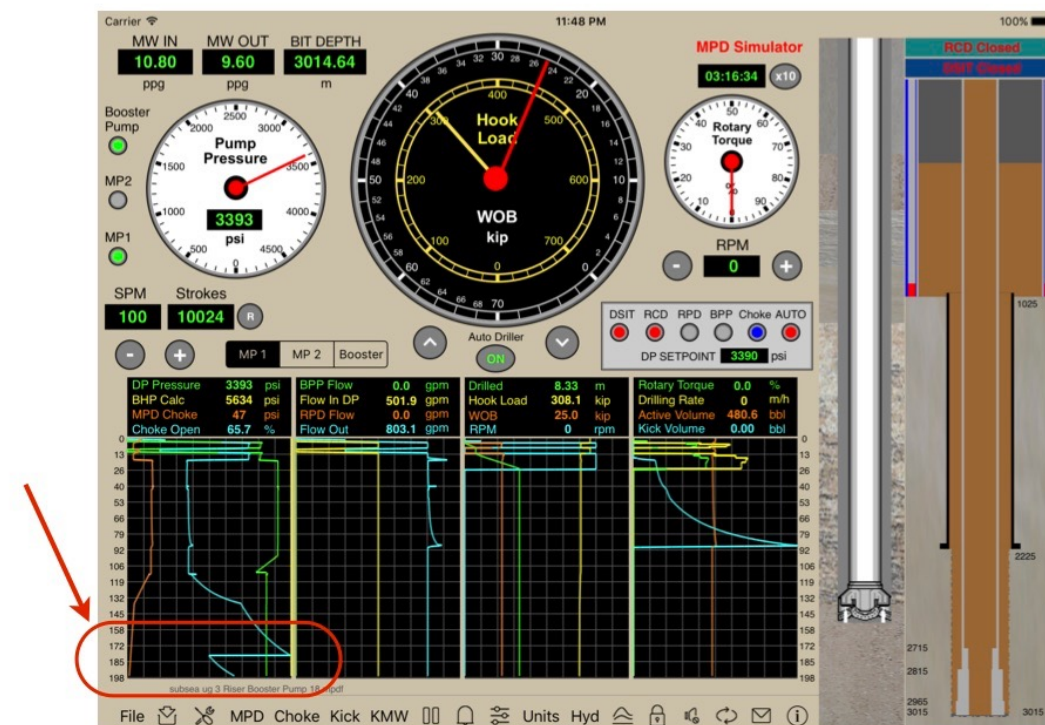
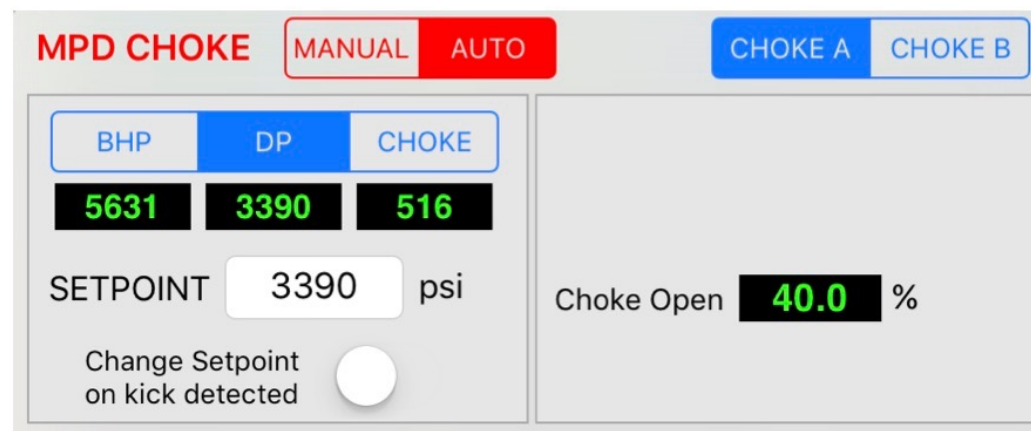


MPD Choke A fully open (100%).



MPD Controller open the MPD Choke B in parallel Choke A.

Change the Setpoint to DP = current value = 3390 psi





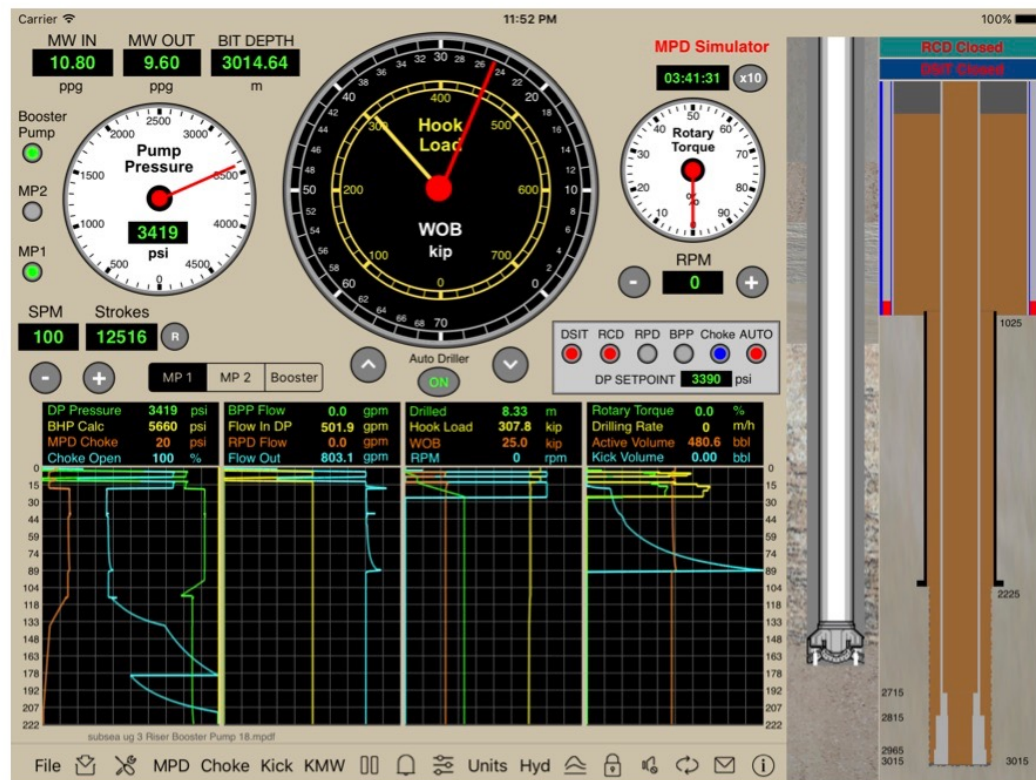
With MPD chokes A and B in parallel:

$$(\text{choke A } 100\% + \text{choke B } x\%)$$

$$\text{Choke Open Percent} = \frac{\text{choke A } 100\% + \text{choke B } 100\%}{\text{choke A } 100\% + \text{choke B } 100\%} \times 100$$

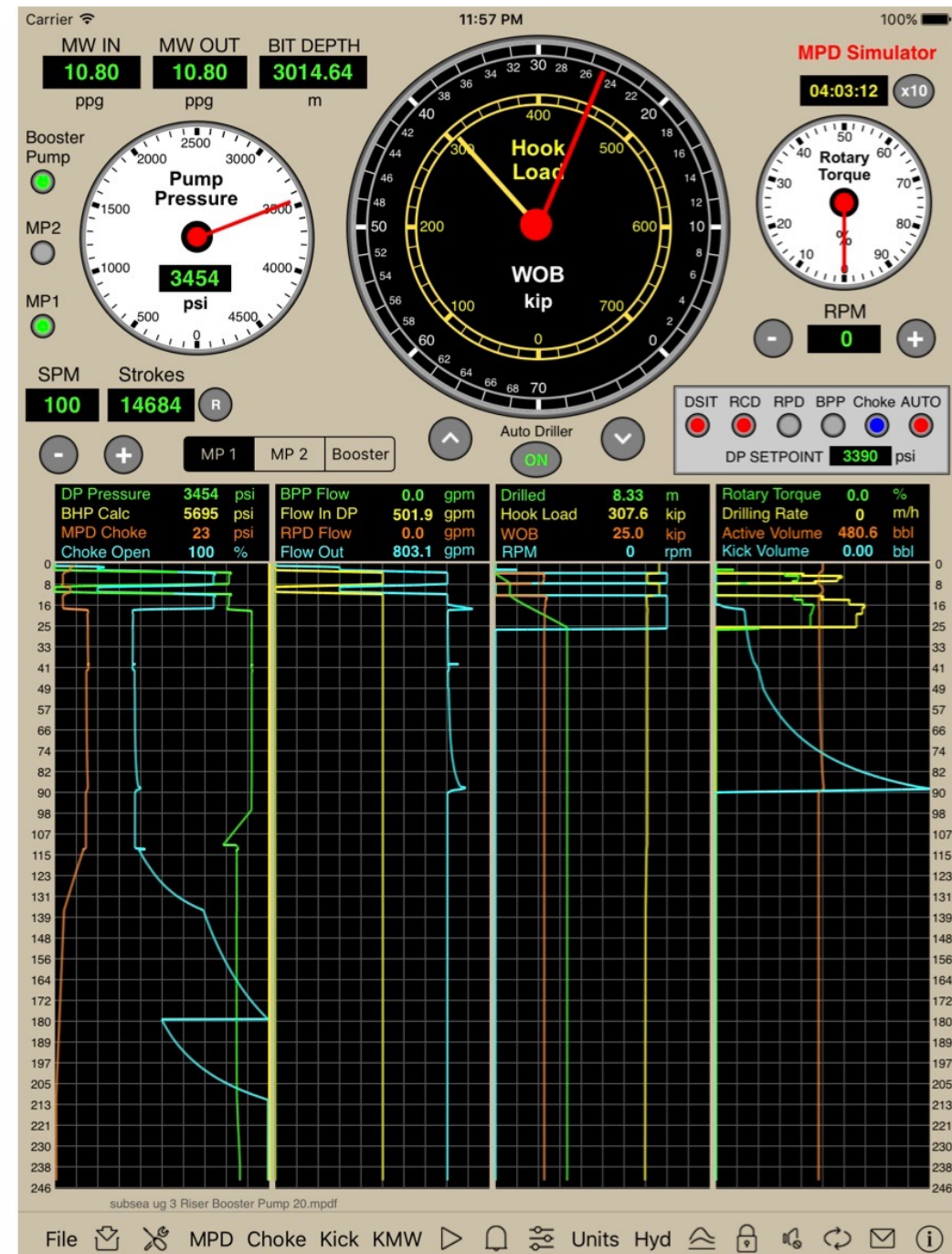
**After 30 minutes:**

Choke B also fully open (100%). BHP increases.

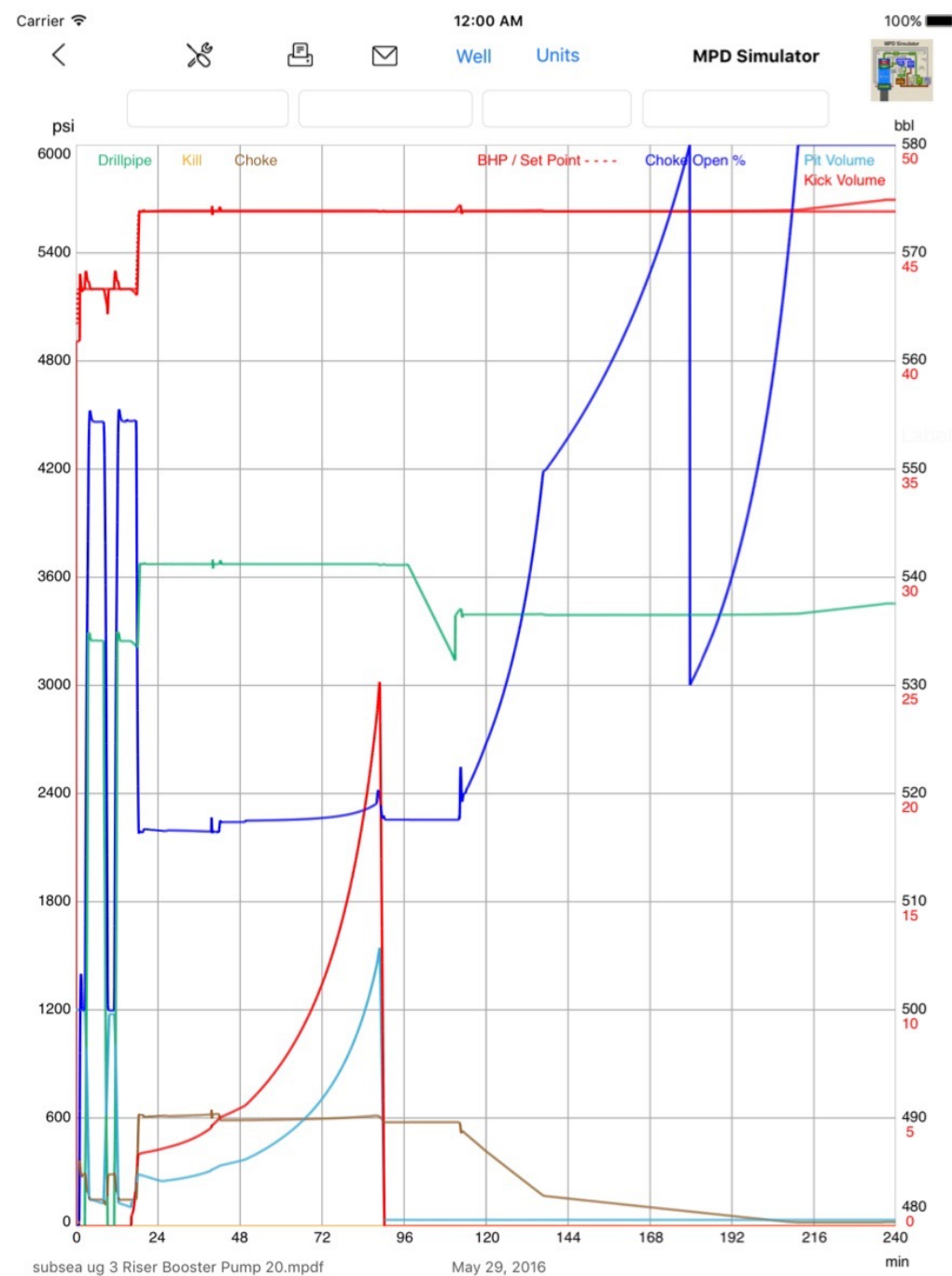
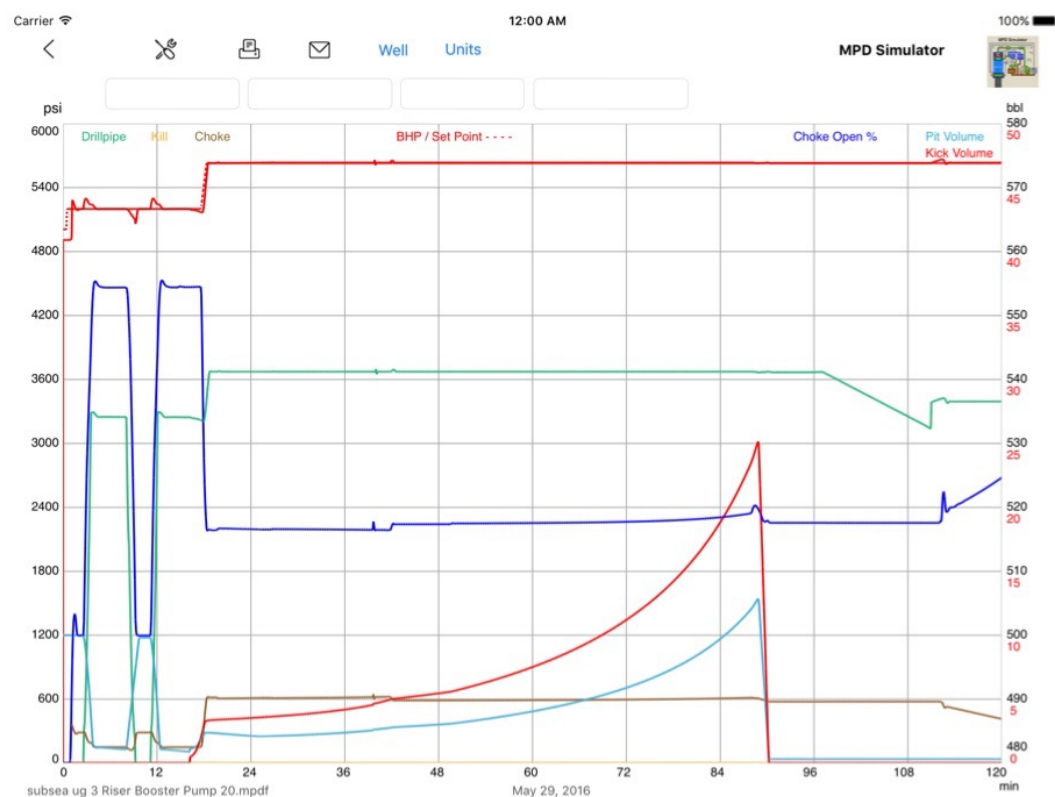
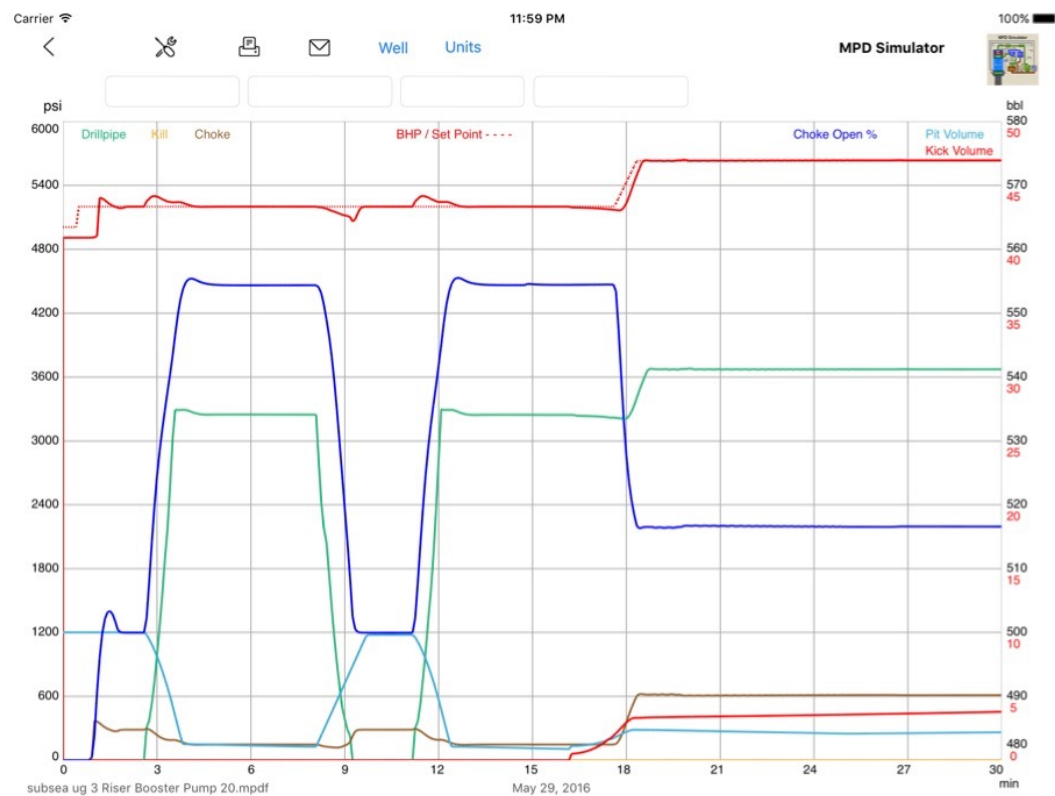


For deepwater operations with MPD, it is recommended MPD Chokes with maximum diameter > 2 inches.

Maybe chokes with diameters 3 and 6 inches.









[www.wellcontrol.com.br](http://www.wellcontrol.com.br)



**MPD Simulator**

# About

This app was developed based on our experience. There is no comparison with any other software.

Our goal was to create a low-cost application with the help of experts to share with drilling engineers, technicians, drillers, students and teachers of drilling engineering.

There is no intention to replace the professional softwares.

You can contribute with suggestions for improvements, correcting the translation to english, reporting bugs and spreading it to your friends.

Please visit our support url and see other applications for Oil & Gas for iPhone, iPod Touch, iPhone and Mac.

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