OTC 16621

Managed Pressure Drilling Applications Index

Ian C. Coker, Texas A&M

Abstract

Managed Pressure Drilling (MPD™) uses existing underbalanced technology to transform a well operation into one where the pressure can be precisely managed, whatever it is, in relation to the pore pressure of the surrounding rock. MPD may apply to underbalanced, near balanced or overbalanced drilling operations. This makes it possible for operators to increase the range of fields considered economic, which could be very advantageous for the industry, considering that presently over 50% of prospective offshore hydrocarbon formations are economically undrillable using conventional overbalanced drilling methods.

This paper describes and explains the Applications Indexes, that align certain UBD equipment required to nullify or eliminate a number of conventional overbalanced drilling barriers or obstacles, i.e., loss circulation, slow Rate of Penetration (ROP), narrow fracture to pore pressure margins, excessive casing programs, shallow geo hazards, extended reach issues, etc.

Introduction

Though these applications of UBD methods to MPD are being recognized throughout the industry, they are not formalized into suitable reference documents. To address this shortfall a Managed Pressure Drilling Applications Index (MPDAI) has been developed which provides a cross-reference matrix format to indicate the specific tools and methods best applicable to each of the drilling obstacles that may be encountered in a marine drilling environment. Four Applications Indexes have been developed to guide users of MPD technology for offshore drilling applications in:

- Rigs with a surface BOP stacks.
- Rigs with a subsea BOP stacks.
- Riserless drilling of top holes in deep water.
- Emerging variations of MPD such as dual gradient deep water drilling and slim riser deep water drilling with a surface BOP stack.

Defining Managed Pressure Drilling

This accepted industry definition of MPD was addressed at the Managed Pressure Drilling Forum 2004:

"Managed Pressure Drilling has been characterized as "Walking the Line." This adaptive drilling technique precisely controls the annular fluid pressure profile within a wellbore. The concept of containment practiced in MPD allows drilling of what might otherwise be economically unattainable prospects. MPD allows faster corrective action to deal with observed pressure variations. The purpose of MPD is to both ascertain the downhole pressure environment limits and manage the annular hydraulic pressure profile to fit within that window. MPD is a tool, which will, in comparison with conventional drilling, mitigate the risks and costs associated with drilling wells within narrow, downhole environmental limits by proactively managing the annular hydraulic pressure profile.

MPD may be accomplished by many means including combinations of backpressure, variable fluid density, fluid rheology, circulating friction, and hole geometry. Containment used in this context means that MPD is focused not on creating a pressure draw down across formations, which may produce hazardous flow products, but instead to contain any flow incidental to the operation."[1]

Importance of MPD offshore. It is important, almost vital, that MPD become widely and comfortably used in the offshore market. This technology can, and will, lead to many current offshore resources becoming available. Some industry professionals would quote figures that as much as 70% of current offshore hydrocarbon resources are economically undrillable using conventional drilling methods. With the techniques and equipment that are addressed in the index more and more of these offshore resources will become available in an economic sense. Therein lies the importance of MPD, without this technology much of the world resources will be neglected.

An in Depth Look at the Indices

The MPDAI consists of four indices each applies to a different offshore drilling atmosphere. The intent behind the MPDAI was to keep fairly general outlook. Every drilling drilling program is completely and utterly unique. The index is not a tool catered to every drilling program, but simply a reference tool to be used for applied learning and to assist the industry in building a knowledge base for MPD.

In order to use the Applications Indexes' you must first determine the type of well that the problem will apply to. For

Riserless Drilling refer to the Riserless Drilling index, and for Emerging Technologies refer to the Emerging Technologies index, and so on. On the index, in the left column is a list of some typical problems encountered when drilling conventionally offshore. Horizontally across the top is listed the tools that would apply. One would find the conventional problem in the left column and trace across until there is an X in the space, then trace directly upwards or downwards to see the equipment that may assist in fixing the problem.

In each box with an obstacle or tool there are detailed definitions, used to expand the industry knowledge base of conventional drilling obstacles, and specialized MPD equipment. Some industry professionals will not have encountered, or simply have knowledge of all of the obstacles in the index; therefore the definitions will give them the vital knowledge to avoid the problem before they are forced to experience it. The same will apply to the specialized tools listed. Some may not have experience, or knowledge of all of the tools listed, with this newfound knowledge a driller may decide to use these tools to make adjustments he never thought possible in the particular drilling program. This yet again stresses the utter importance of the MPDAI.

Riserless Drilling. This particular index applies to a drilling program in shallow water without a riser, specifically drilling top holes. Riserless drilling in comparison with the other drilling program types carries has less risk involved, but none the less MPD can apply in many ways. The main focus in this section would be shallow hazards, and well instability. With MPD these shallow flows (i.e. gas, water, etc.) can be contained safely. MPD can also have great benefits for a program that is forced to drill in a narrow fracture/pore gradient margin; allowing the driller to lay less strings of casing, as well as each string reaching further. Refer to Figure A-1 for index.

Other Rig Structures. There are far too many problems to address in text. Refer to Tables A-2 through A-4. Notice the main focus of the MPDAI is, as the name would lead to you believe, pressure management. All of the equipment/drilling techniques addressed in the MPDAI all deal with some sort of pressure control, whether it be a rotation control device to shut off the well, or in different matter of speaking the Continuous Circulation System used to add pipe without stopping circulation.

The Compilation

During the formation of the MPDAI it was noted that other technology could be used to further assist in the learning process. There are five sections the entire MPD Applications Compilation, though none have completely finalized. The intent here is to spark interest and allow individuals to take the MPDAI to the next level. The five sections include: The MPDAI, an Emerging Technologies Listing, A Navigable User-Interface, Visio Stencils, and an extensive bibliography.

The Emerging Technologies Listing. This is simply a text document listing and describing some of the emerging technologies considered in the Emerging Technologies portion of the MPDAI. Each technology is listed with a brief definition as well as a list of special tools and techniques required to fulfill the particular technology.

The User-Interface. The User-Interface is a graphical and navigable edition of the MPDAI. A user can 'surf' through at while looking at definitions of obstacles and the tools used to nullify them. There are also some graphics included to increase familiarity with these tools and techniques. Refer to Figure A-1.

Fig. A-1: A Screen Shot of the User-Interface

Visio Stencils. The Visio stencils are included to build a simple 'personally ideal' MPD rig. The stencils will allow the user to learn in a graphical way, in the case visual learning is preferred. Having a relative knowledge of, "What pieces fit where", will smooth the learning process and allow the user to fulfill every aspect of the MPD reference documents.

Extensive Reference List. In the instance one would want to know where to look for more information, there is a bibliography with over 70 sources to give a user the ability for further self-enrichment.

Conclusions

An abundant amount of hydro-carbon resources are offshore, yet considerable amounts are either too risky or uneconomic to drill with conventional drilling technology. With MPD these resources will become readily available, economically and safely. The only shortfall of MPD was that there were no suitable reference documents to assist in achieving these MPD goals. With the MPD Applications Index, as well as the other pieces of the Compilation, this shortfall will void and the industry will be able to open the door to what was thought to be unattainable.

Acknowledgements

Special thanks are due to Weatherford International for allowing me the opportunity to do this project and give me the gateway to present at the conference. In particular a great level of gratitude is due to Don Hannegan and William Bland, for their great contribution to this project and great encouragement. Special thanks to all who helped from ConocoPhillips, Varco, and Texas A&M University. Most of all gratitude is due to Oliver Coker for his incredible moral support and copious amounts of technical knowledge.

References

1. "Managed Pressure Drilling Forum 2004", PennWell www.managedpressure.com , January 27-29, 2004, Moody Gardens, Galveston, TX.

2. Table A-1

Riserless Drilling Top Holes																			
	Specialized Equipment	Surface Rotating Control Device (RCD)	External Riser RCD	Marine Diverter RCD	Sub-Sea RCD	Internal Riser RCD	Nitrogen Generation Systems	Choke Manifold	Surface Separator	Flare Line and Stack	Continuous Circulation System	Down hole Isolation Valve	Non-Return Valve (Drill String Isolation Device)	Top Hole Drilling Package	Flow Modeling	ECD Reduction Tool	Down hole Pressure Monitoring	Foam Drilling	Drilling With Casing
Conventional Drilling Obstacles																			
Narrow Pore/Fracture Gradient Margins					X		X	X			X			X	X	X	X		X
Heavy Viscous Mud Cost (Environmental Considerations)								X			X	X		X					X
Excessive Casing Program											X			X		X			X
Poor Cement Jobs					X														
Well Bore Instability					X		X	X	X		X			X		X			X
Shallow Gas Kicks					X		X	X	X	X	X	X		X					
Shallow Water Flow Hazards					X			X	X					X	X				X
Shallow Geo-Hazards					X			X	X	X				X					X
Underground Blowouts					X						X	X		X					X
		Surface Rotating Control Device (RCD)	External Riser RCD	Marine Diverter RCD	Sub-Sea RCD	Internal Riser RCD	Nitrogen Generation Systems	Choke Manifold	Separator	Flare Line and Stack	Continuous Circulation Device	Down hole Isolation Valve	Non-Return Valve (Drill String Isolation Device)	Top Hole Drilling Package	Flow Modeling	ECD Reduction Tool	Down hole Pressure Monitoring	Foam Drilling	Drilling With Casing

Table A-2

Shallow Water - Jack Up / Platform / Barge Mounted (Surface BOP)																			
	Specialized Equipment	Surface Rotating Control Device (RCD)	External Riser RCD	Marine Diverter RCD	Sub-Sea RCD	Internal Riser RCD	Nitrogen Generation Systems	Choke Manifold	Surface Separator	Flare Line and Stack	Continuous Circulation Device	Down hole Isolation Valve	Non-Return Valve (Drill String Isolation Device)	Top Hole Drilling Package	Flow Modeling	ECD Reduction Tool	Down hole Pressure Monitoring	Foam Drilling	Drilling With Casing
Conventional Drilling Obstacles																			
Lost Circulation (Excessive Mud Cost)		X		X		X	X	X	X	X	X	X	X		X			X	X
Differentially Stuck Pipe		X		X		X	X	X	X	X	X		X		X			X	X
Slow ROP / Short Bit Life		X		X		X	X	X	X	X	X						X		
Narrow Pore/Fracture Gradient Margins		X				X	X	X			X		X		X	X	X	X	x
Shallow Gas Kicks		X		X				X	X	X	X	X	X		X				
Excessive Casing Program		X				X	X				X					X	X	X	X
Poor Cement Jobs							X				X								
Well Bore Instability		X		X		X	X	X			X		X		X			X	X
Shallow Geo-Hazards		X		X				X	X	X									
Shallow Water Flow Hazards		X		X				X	X						X				X
Skin Damage (Grossly Over-Balanced)		X		X		X	X				X		X		X			X	
Underground Blowouts		X		X		X	X	X			X	X			X			X	
Ballooning						X	X				X								X
High-Temperature High-Pressure		X		X			X	X	X	X		X	X		X		X		
Extended Reach Issues (i.e. Hole Cleaning, High Torque)		X				X	X	X			X				X			X	
Flat Time Circulation Out Kicks		X		X		X	X	X	X	X	X	X			X				X
		Surface Rotating Control Device (RCD)	External Riser RCD	Marine Diverter RCD	Sub-Sea RCD	Internal Riser RCD	Nitrogen Generation Systems	Choke Manifold	Separator	Flare Line and Stack	Continuous Circulation Device	Down hole Isolation Valve	Non-Return Valve (Drill String Isolation Device)	Top Hole Drilling Package	Flow Modeling	ECD Reduction Tool	Down hole Pressure Monitoring	Foam Drilling	Drilling With Casing

Table A-3

Deep Water - Drill ships / Moored Semi Submersibles / etc. (Sub-Sea BOP)																		
	Specialized Equipment	Surface Rotating Control Device (RCD)	External Riser RCD	Marine Diverter RCD	Sub-Sea RCD	Internal Riser RCD	Nitrogen Generation Systems	Choke Manifold	Separator	Flare Line and Stack	Continuous Circulation Device	Down hole Isolation Valve	Non-Return Valve (Drill String Isolation Device)	Top Hole Drilling Package	Flow Modeling	ECD Reduction Tool	Down hole Pressure Monitoring	Foam Drilling	Drilling With Liners
Conventional Drilling Obstacles																			
Lost Circulation (Excessive Mud Cost)			X			X	X	X	X	X	X	X			X	X	X	X	X
Differentially Stuck Pipe			X			X	X	X	X	X	X				X	X	X	X	X
Slow ROP / Short Bit Life			X			X	X	X	X	X	X				X	X	X	X	
Narrow Pore/Fracture Gradient Margins			X			X	X	X		X	X				X	X			x
Shallow Gas Kicks			X				X	X	X	X	X	X							
Excessive Casing Program			X			X	X	X	X	X	X				X	X	X		X
Poor Cement Jobs			X																
Well Bore Instability			X			X	X	X	X		X	X	X		X	X	X	X	X
Shallow Geo-Hazards			X				X	X	X			X			X		X		
Skin Damage (Grossly Over-Balanced)			X			X	X				X				X	X	X	X	X
Underground Blowouts			X			X	X	X			X	X			X		X	X	
RSR Gas Burping			X			X						X							
Ballooning			X			X	X	X	X		X	X							X
High-Temperature High-Pressure			X				X	X	X	X		X	X		X		X		
Extended Reach Issues (i.e. Hole Cleaning, High Torque)			X			X	X	X	X		X				X	X		X	
Flat Time Circulating Out Kicks			X			X	X	X	X	X	X	X	X		X	X	X		X
		Surface Rotating Control Device (RCD)	External Riser RCD	Marine Diverter RCD	Sub-Sea RCD	Internal Riser RCD	Nitrogen Generation Systems	Choke Manifold	Separator	Flare Line and Stack	Continuous Circulation Device	Down hole Isolation Valve	Non-Return Valve (Drill String Isolation Device)	Top Hole Drilling Package	Flow Modeling	ECD Reduction Tool	Down hole Pressure Monitoring	Foam Drilling	Drilling With Liners

Table A-4

Emerging Technologies (i.e. Dual Gradient, Slim Riser (Surface BOP), Pressurized MudCap, Drilling with Casing, Nitrogen Gas Lift)																				
	Specialized Equipment	Surface Rotating Control Device (RCD)	External Riser RCD	Marine Diverter RCD	Sub-Sea RCD	Internal Riser RCD	Nitrogen Generation Systems	Choke Manifold	Separator	Flare Line and Stack	Continuous Circulation Device	Down hole Isolation Valve	Non-Return Valve (Drill String Isolation Device)	Top Hole Drilling Package	Flow Modeling	ECD Reduction Tool	Down hole Pressure Monitoring	Foam Drilling	Drilling With Casing	Drilling With Liners
Conventional Drilling Obstacles																				
Lost Circulation (Excessive Mud Cost)			X	X	X	X	X				X	X		X	X	X	X	X	X	X
Differentially Stuck Pipe			X		X	X	X	X			X			X	X	X		X	X	X
Slow ROP / Short Bit Life			X			X	X	X			X			X		X		X		
Narrow Pore/Fracture Gradient Margins			X		X	X	X				X			X	X	X	X	X	X	X
Shallow Gas Kicks			X			X	X	X	X	X	X	X	X	X	X			X	X	
Excessive Casing Program			X		X	X					X			X	X	X			X	X
Poor Cement Jobs					X		X							X	X			X		
Well Bore Instability			X		X	X		X			X			X	X	X	X		X	X
Shallow Geo-Hazards			X		X				X					X	X			X	X	
Skin Damage (Grossly Over-Balanced)			X		X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Underground Blowouts			X		X	X	X				X	X		X	X		X	X	X	X
RSR Gas Burping			X			X						X							X	X
Ballooning			X			X	X		X		X			X	X	X		X	X	X
High-Temperature High-Pressure			X					X	X	X		X	X		X				X	X
Extended Reach Issues (i.e. Hole Cleaning, High Torque)			X			X	X		X		X	X		X	X	X		X		
Flat Time Circulating Out Kicks			X			X		X	X		X	X		X			X	X	X	X
		Surface Rotating Control Device (RCD)	External Riser RCD	Marine Diverter RCD	Sub-Sea RCD	Internal Riser RCD	Nitrogen Generation Systems	Choke Manifold	Separator	Flare Line and Stack	Continuous Circulation Device	Down hole Isolation Valve	Non-Return Valve (Drill String Isolation Device)	Top Hole Drilling Package	Flow Modeling	ECD Reduction Tool	Down hole Pressure Monitoring	Foam Drilling	Drilling With Casing	Drilling With Liners