

Comparative risk using MPD techniques

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DRILLING FOR OIL and gas in any environment entails risk. There are risks of not hitting pay, getting stuck, taking a kick, having an oil spill, falling down on the rig floor, tripping down a set of stairs, even getting a bad meal in the galley.

Some of the events associated with these risks have more serious consequences and have a more profound impact on drilling operations than others. Each incident carries with it the components of severity, occurrence and detection. Since time is money, the consequences are typically measured in terms of money and safety.

$$\text{Risk} = \text{Severity} \times \text{Frequency of Occurrence} \times \text{Ability to Detect}$$

$$\text{Risk\$} = \text{\$Consequences} \times \text{Frequency of Occurrence} \times \text{Exposure}$$

In very broad terms, risk is the known chance that an event will occur. Uncertainty is knowing an event will occur, but not knowing when, or how or where that event might occur.

Reliability engineers and risk analysts are often able to assign a number based on probability that an event will occur. As an example, risk analysts routinely use actuarial tables to help determine risk before assessing the premium to be charged for an insurance policy based on the costs for a defined risk. Reliability engineering not only deals with risks but also addresses the issue of uncertainty through the use of statistical tools that help to predict the occurrence and magnitude of an event based on historical data.

Since Spindletop, we have primarily been drilling wells with rotary drilling tools and drilling mud in an open container. For more than a hundred years, the industry has known that some of the drilling risks to ultimately produce oil and gas include getting differentially stuck, losing circulation, taking kicks

Application Category

Category	Description
A	Managed Pressure Drilling (MPD) Drilling with returns to surface using an equivalent mudweight that is maintained at or above the open-hole pore pressure.
B	Underbalanced Operations (UBO) Performing operations with returns to surface using an equivalent mudweight that is maintained below the open-hole pore pressure.
C	Mud Cap Drilling Drilling with a variable-length annular fluid column that is maintained above a formation that is taking injected fluid and drilled cuttings without returns to surface.

Fluid Systems

	Fluid	Description
1	Gas	Gas as the fluid medium. No liquid intentionally added.
2	Mist	Fluid medium with liquid entrained in a continuous gaseous phase. Typical mist systems have less than 2.5% liquid content.
3	Foam	Two-phase fluid medium with a continuous liquid phase generated from the addition of liquid, surfactant and gas. Typical foam range from 55% to 97.5% gas.
4	Gasified Liquid	Fluid medium with a gas entrained in a liquid phase.
5	Liquid	Fluid medium with a single liquid phase.

and watching too many of those kicks turn into uncontrolled blowouts. Those are known risks to drilling operations. While we know these events will occur

(risk), we don't exactly know when, where or how the event will present itself (uncertainty). Managed Pressure Drilling (MPD) utilizes a variety of techniques to

Risk Levels

Generally, risk increases with operational complexity and potential well productivity. The examples provided are for guidance only.

Level	Description
0	<p>Performance enhancement only; no hydrocarbon containing zones.</p> <ul style="list-style-type: none"> • Air drilling for ROP enhancement.
1	<p>Well incapable of natural flow to surface. Well is inherently stable and is a low-risk from a well-control point of view.</p> <ul style="list-style-type: none"> • Sub-normally pressured oil wells.
2	<p>Well is capable of natural flow to surface but can be controlled using conventional well kill methods. Catastrophic equipment failure may have limited consequences.</p> <ul style="list-style-type: none"> • Abnormally pressured water zones. • Low flow rate oil or gas wells. • Depleted gas wells.
3	<p>Geothermal and non-hydrocarbon bearing formations. Maximum anticipated shut-in pressure (MASP) is less than UBO/MPD equipment pressure rating.</p> <ul style="list-style-type: none"> • Includes geothermal wells with H₂S present.
4	<p>Hydrocarbon bearing formation. Maximum anticipated shut-in pressure is less than UBO/MPD equipment operating pressure rating. Catastrophic equipment failure will likely have immediate serious consequences.</p> <ul style="list-style-type: none"> • High pressure and/or high flow potential reservoir. • Sour oil and gas wells. • Offshore environments. • Simultaneous drilling and production operations.
5	<p>Maximum anticipated surface pressure exceeds UBO/MPD equipment operating pressure rating. Catastrophic equipment failure will likely have immediate serious consequences.</p> <ul style="list-style-type: none"> • Any well where Maximum Anticipated Surface Pressure (MASP) is greater than UBO/MPD equipment pressure rating.

minimize risk through control of the exposed bottomhole pressure profile.

The IADC Underbalanced Operations and Managed Pressure Drilling Committee continues to promote the safe use of these technologies and has defined Managed Pressure Drilling as:

... an adaptive drilling process used to precisely control the annular pressure

profile throughout the wellbore. The objectives are to ascertain the downhole pressure environment limits and to manage the annular hydraulic pressure profile accordingly.

While there are many others, one common form of MPD is to create a closed system utilizing a rotating control device and a drilling choke to restrict and con-

trol the exposed wellbore pressure profile and a casing pump to provide back pressure when required.

Managed Pressure Drilling is not necessarily a new or novel technique. We actually practice facets of MPD while circulating out a kick or while decreasing mud density to manage differential sticking or lost circulation. Managed Pressure

Drilling is just an extension of the Driller's Method of circulating out a kick. The primary difference is that you are making hole while controlling the open wellbore pressure profile by this or other means.

Because the wellbore is virtually a closed system, changes in wellbore pressure are typically more easily observed, thus reducing the kick magnitude (risk) to more manageable levels so that drilling can continue under most circumstances.

By controlling the wellbore pressure profile, the risks of differential sticking and lost circulation diminish in frequency and magnitude. By reducing these drilling risks, non-productive time (NPT) can be significantly reduced, thereby reducing safety incidents and costs associated with these risks.

The IADC Underbalanced Operations and Managed Pressure Drilling Committee has also devised a well classification system to generally describe the overall risk, application category and fluid system used in underbalanced operations

(UBO) and managed pressure drilling (MPD).

Wells are classified according to:

Risk Level Application Fluid System
(0 to 5) (A, B or C) (1 to 5)

This classification system provides a framework for defining minimum equipment requirements, specialized procedures and safety management practices.

For more information, refer to the IADC UBO HSE Planning Guidelines and other related documents: http://www.iadc.org/committees/underbalanced/Documents/IADC_HSE-Planning_FINAL.pdf.


More information on the Managed Pressure Drilling also can be found at <http://www.iadc.org/committees/underbalanced/index.html>.

Risk assessment studies are currently being devised to evaluate the hypothesis that Managed Pressure Drilling provides an equal or greater degree of protection, safety, or performance com-

pared with the Conventional Drilling Process. This can be done by analyzing safety and operational incidents in terms of severity, occurrence and detection. To evaluate the comparative risk, hard numbers will be computed based on actual historical data. Risk assessment computational tools such as Fault Tree Analysis, Failure Modes and Effects Analysis, and Weibull Analysis will help to provide some insight that should determine which drilling process affords a greater safety margin and less NPT.

Prospective participants in this study include operators, drilling contractors, service companies, equipment manufacturers, regulators and other interested parties. Virtually all of the data compiled for this study is expected to have an invaluable impact on drilling operations whether they are land-based or offshore applications.

More information regarding this project can be found at <http://www.dea.main.com/projects/status/155.html> or by sending e-mail to ken.malloy@mohreng.com. ■

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