Managed pressure drilling — what's in a name?

Definition is secondary to technology's applications

Philip Frink, Blade Energy Partners

EXPERTS IN THE drilling industry are abuzz right now arguing over the definition of "managed pressure drilling (MPD)." As usual when a group of experts meet, significant time is consumed quarrelling about trivial nuances of language, not the substance or consequences of application.

For technical people, the definition of MPD recently adopted by the IADC Underbalanced Operations and Managed Pressure Committee will hopefully make sense:

"Managed Pressure Drilling (MPD) is 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."

In non-technical terms, the simplest yet most compelling definition of managed pressure drilling is "cheating Mother Nature." As most drillers learn on the first day of their careers, bottomhole pressure is normally maintained above pore pressure by simply controlling the density of the drilling fluid. When density gets too high, the formation begins to drink fluid and it's time to stop. Casing must be run to isolate the open hole before drilling can continue. This relationship is shown graphically in Figure 1.

The common objective of all currently known managed pressure drilling techniques is to stretch or eliminate casing points to allow drilling beyond conventional limits of depth or pressure variation. Mother Nature is thus cheated out of her desire of preventing wells from reaching their ultimate objective depth.

Figure 1: Equivalent mud weight graph

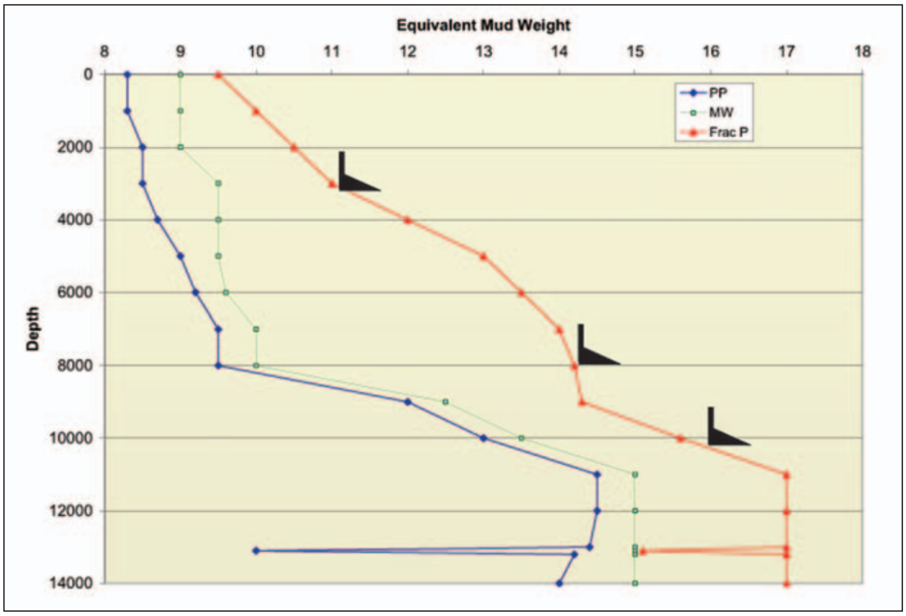
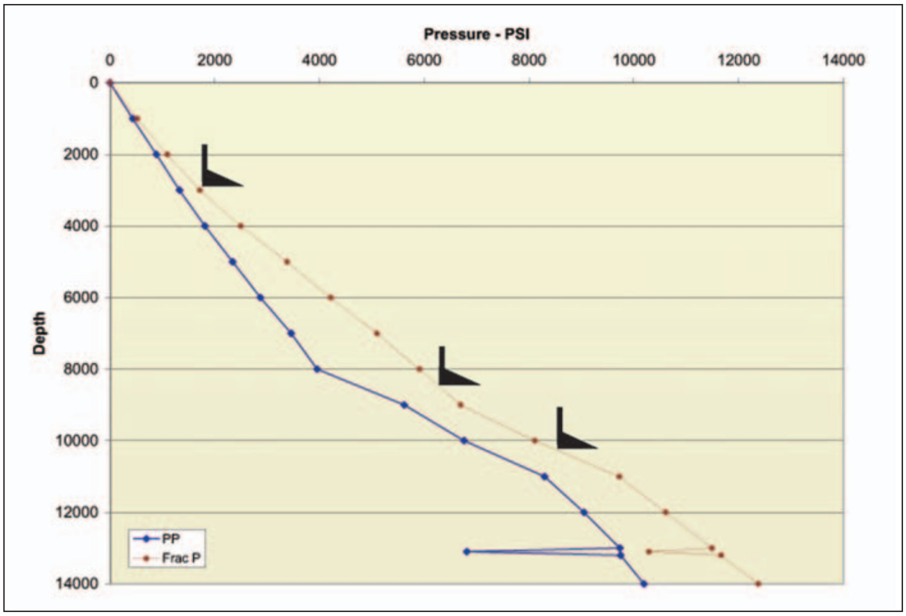


Figure 2: Pore Pressure vs Fracture Pressure Graph.



MPD EXAMPLES

Managed pressure drilling techniques cheat because they violate one of the following two assumptions used in conventional drilling:

• Mud returns to surface at atmospheric conditions (zero back pressure);

• Mud is circulated using energy supplied by drillpipe injection.

To understand the implication of violating these assumptions, it is useful to redraw the equivalent mud weight graph shown in Figure 1 on an absolute pressure scale as shown in Figure 2. The key challenge in the well illustrated by the figure is a pressure-depleted zone at 13,100 ft with associated lost circulation problems.

Figure 3 shows the effect of violating the first assumption by increasing surface pressure and reducing mud density. By applying this form of managed pressure, the slope of the fluid density pressure profile becomes more vertical. Because this line is more parallel with pore pressure and fracture pressure limits, drilling can proceed across the depleted zone at a lower pressure than a well drilled with a higher mud weight and no surface back pressure. In this case, MPD reduces the chance of losing returns and increases the chance of reaching TD.

Figure 4 shows the effect of using annular injection of fluid to reduce the effective density of the return mud column in a deepwater application. This can be accomplished either using downhole pumps to directly reduce pressures or annular injection of a lighter fluid or gas to reduce the density of the return mixture. In this variation of managed pressure drilling, a fluid density greater than static fracture pressure can be used to drill a longer interval as long as the fluid column does not fully extend to surface.

METHOD COMPLICATIONS

In addition to violating the circulation assumptions just described, MPD also violates the "kiss" principal normally applied to drilling operations. Proper design and contingency planning are needed to address the following potential MPD complications:

- **Well Control**

Because MPD allows drilling between narrow pore and fracture pressure limits, there is little margin for error when "walking the line." If bottomhole pressure falls below the pore pressure of a permeable zone, a kick will occur. If the kick contains a significant amount of gas, surface pressures while circulating the kick out may exceed the pressure rating of surface MPD equipment or subsurface openhole fracture limits, resulting in an underground blowout. Sensitive kick detection methods, comprehensive well control procedures and adequate kick processing equipment (separators, flare booms, etc), are critical elements of prudent MPD well design.

Figure 3: Open Hole Pressure Profile – MPD versus Conventional MW.

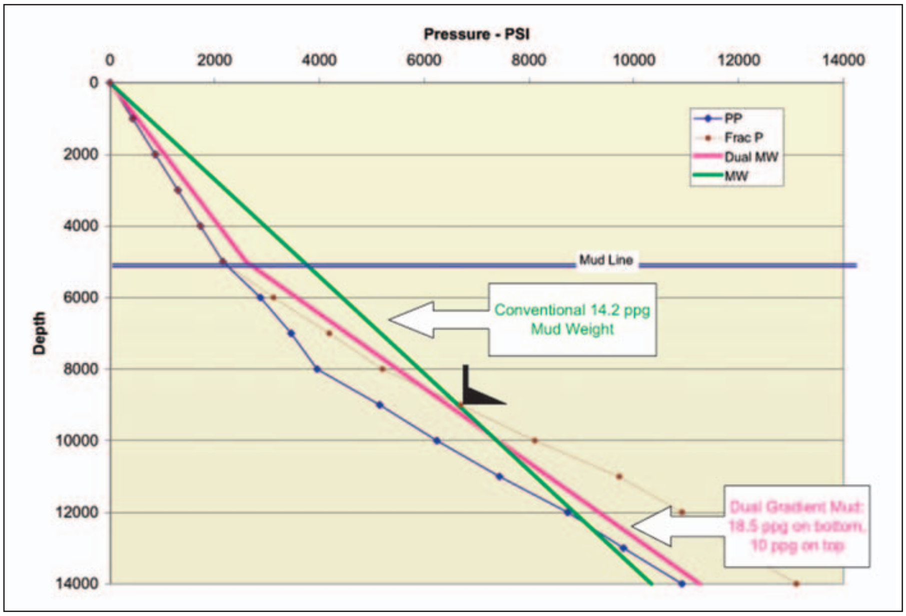
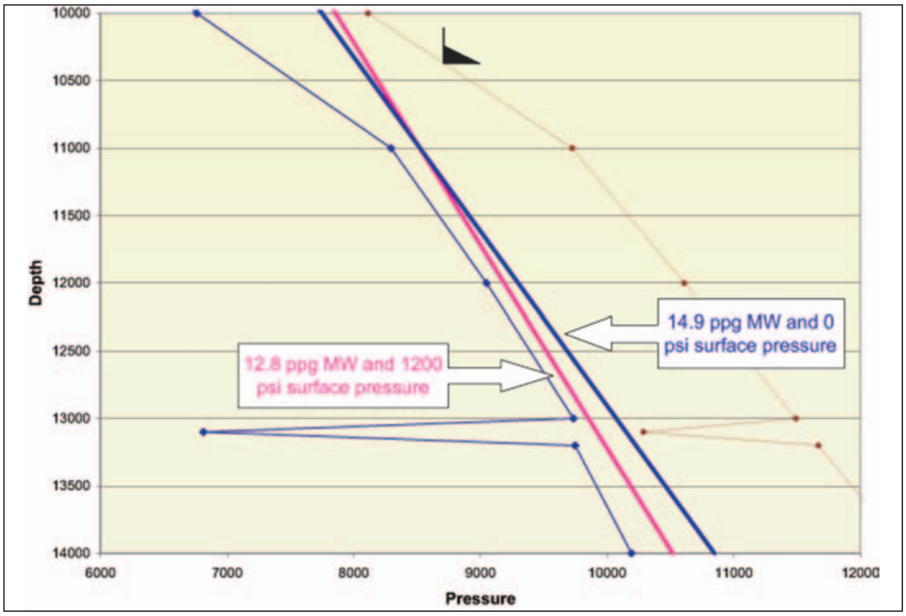


Figure 4: Effect of annular injection and heavier mud weights.



- **Pressure Transients**

In addition to mud density, secondary pressures caused by fluid friction and pipe movement must also be considered when managing annular pressure profiles within close tolerances. For fluid induced transients created when making DP connections, use of a continuous circulating device or temporarily increasing surface annular pressure can eliminate this pressure transient. When tripping pipe without circulation, density of the mud left in the well may need to be adjusted to statically overbalance the well without loosing returns.

- **Equipment reliability**

Because MPD relies on specialized equipment to maintain precise pressure control, the reliability of this equipment is extremely important. A Failure Modes & Effects Criticality Analysis (FMECA) analysis should be conducted for special-

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ized MPD equipment and processes. The approach to an FMECA is a well-established methodology, utilized within major hazard industries and is recognized by regulatory authorities.

The FMECA should be conducted in accordance with BS 5760-5: 1991 and IEC 60812 to identify the various failure modes, to identify the causes of each failure, to identify the effect of the failure on the overall performance of the MPD system, identify the symptoms of the failure, calculate the criticality of the failure and finally to determine what mitigation is available (or mitigation action is required) to prevent the failure.

Rig BOPs are typically adequate for secondary surface pressure control. Auxiliary pumps can be used to compensate for loss of primary injection capability. The sensitivities and consequences of varying surface pressures and flow rates should be included in pre-well design activities.

CONCLUSION

MPD is more complex than conventional drilling but should be considered as an option when it is impractical to drill using conventional means. MPD is an emerging technology that will likely improve in capability over time due to innovation and experience.

At the end of the day, the argument over the definition of MPD is secondary to what this technology can achieve if properly applied. It is a powerful weapon in the driller's arsenal to cheat Mother Nature. If you're going to cheat however, don't underestimate the complexity of the task or the consequences of poor planning if you get caught by her uncertain and vindictive nature.

References:

"Two Methods for Achieving Dual Gradient in Deep Water", Robert Herrmann and John Shaughnessy, SPE paper 67745, 2001 SPE Drilling Conference in Amsterdam, The Netherlands.

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SPE/IADC Managed Pressure Drilling & Underbalanced Operations Conference & Exhibition

More than 2 dozen presentations on MPD and UBO will be made over the 2-day event, to be held 28-29 March at Moody Gardens Hotel in Galveston. Conference sessions will explore topics such as the philosophy of MPD and UBO, case studies, designing MP/UB operations, equipment and tools, risk assessment, HSE, deepwater applications, perspectives on MPD/UBO and more.

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