Driller's Method vs Wait and Weight Method: One offers distinct well control advantages

By Rana S Roy, Conroy James Nini, Paul Sonnemann, Berton Thomas Gillis, Chevron

THE TWO WIDELY used constant bottomhole circulating methods are the Driller's Method and the Wait and Weight (W&W) Method. Well control experts are often strongly opinionated on selecting the better method to circulate an influx out of the wellbore. The purpose of this article is to highlight the major advantages and disadvantages of the two methods.

The basic principle of both methods is to keep bottomhole pressure (BHP) constant at or, preferably, slightly above the formation pressure.

The Driller's Method requires two circulations. During the first circulation, the influx is circulated out with the original mud weight. Constant BHP is maintained by holding circulating drill pipe pressure constant through the first circulation. If the original mud weight is insufficient to balance the formation pressure, the well is killed by circulating a heavier mud (kill mud) in a second circulation.

To hold constant BHP during the second circulation, one of two procedures is employed. Casing pressure is held constant while pumping kill mud from surface to bit, and drill pipe pressure is held constant thereafter until kill mud is observed returning to the surface. Alternately, during second circulation, a drill pipe pressure schedule can be calculated and followed while pumping kill mud from surface to bit, and drill pipe pressure is held constant thereafter.

The W&W Method involves only one circulation. The influx is circulated out, and the kill mud is pumped in one circulation. While pumping kill mud from surface to bit, a drill pipe pressure schedule has to be calculated and followed. The drill pipe pressure is held constant thereafter until kill mud is observed returning to the surface.

The W&W Method is sometimes called the Engineer's Method because it involves more calculations compared with the Driller's Method. There is a widespread misconception that the Driller's Method is preferred only because it is simple. We will discuss various reasons why the Driller's Method could be better for circulating an influx in many or even most wells drilled.

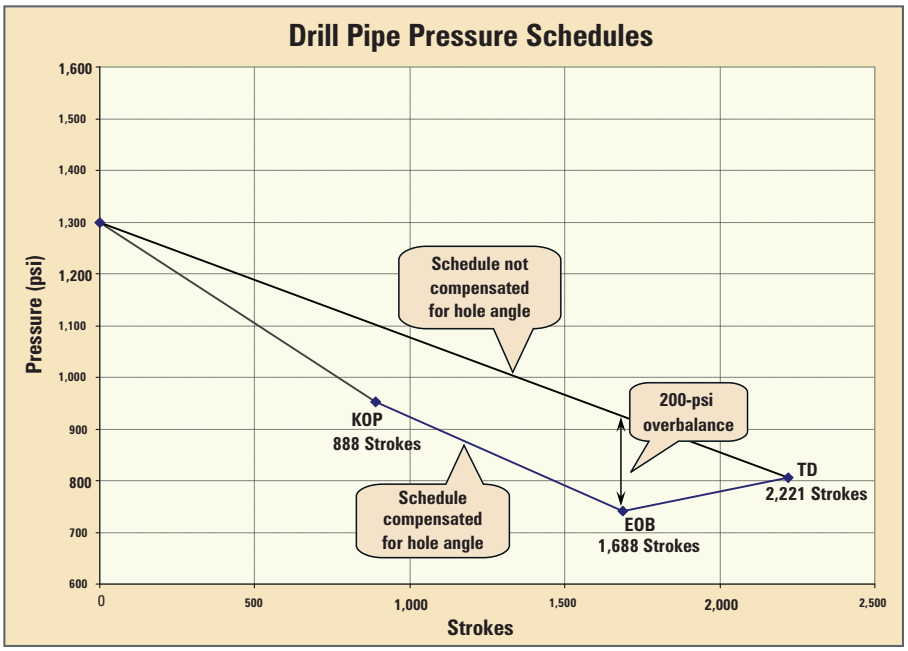

Figure 1: In a deviated hole/tapered drill string scenario, the drill pipe pressure schedule under the Wait and Weight Method becomes harder to calculate than in a vertical wellbore. In this case, if rig personnel do not correctly compensate for hole deviation, there will be a 200-psi overbalance that could be detrimental to weak formations.

Any drilling organization or company can adopt a policy of recommending just one well control method so that everybody in the organization can be competent in at least one method. This may help in avoiding confusion in the field and promote understanding of how to efficiently circulate a kick out of the wellbore without creating major well control problems.

There is a shortage of experienced personnel in the drilling industry, and ensuring competency in one method could lead to fewer disasters. We have to keep in mind, however, that even experienced personnel do not routinely kill wells. They may kill only a few wells in their entire career. We can achieve operational excellence by ensuring their competence in one method. It may be better to use a good method expertly than a slightly better method inexpertly.

COMPARISON

We will compare the advantages and disadvantages of the two methods under specific conditions. The different applications are various types of wells and their geometry.

Deviated hole / tapered drill string: The drill pipe pressure schedule for the W&W Method is fairly simple to calculate if the wellbore is vertical and there is one size of drill pipe. The schedule becomes complicated and difficult for rig personnel in complex deviated well geometries and/or with multiple sizes of drill pipe. If the proper drill pipe pressure schedule is not calculated while performing the W&W Method, BHP pressure may not be held constant.

Figure 1 shows two drill pipe pressure schedules for a horizontal well. The first schedule does not compensate for the hole deviation while the second one does. As per this example, if we do not compensate for hole deviation, we will have approximately a 200-psi overbalance when the kill mud gets to the end of build inside the drill string.

This overbalance of 200 psi could be detrimental to weak formations and could increase shoe and surface pressures. One often-mentioned advantages of the W&W Method is lower pressure at the casing shoe. But if a proper schedule is not calculated for the W&W Method, we

may expose the casing shoe or weak formations to higher pressures compared with the Driller's Method.

Hole problems: Many wells are drilled in areas with significant hole instability problems. If the drill string is kept static with no mud circulation, the drill string may get stuck in the hole due to pack-off problems. If it is decided to kill the well with the W&W Method, kill mud may have to be mixed before circulation can be established. This long period of non-circulation with little or no pipe movement may not be desirable in problematic hole sections.

The Driller's Method has some obvious advantages under these circumstances. Circulation can be started as soon as a stabilized shut-in casing pressure (SICP) and shut-in drill pipe pressure (SIDPP) are established. The first circulation of the Driller's Method is done with the original mud in the hole. If the method is understood and followed correctly, non-circulating time in the well is minimized, and any further hole problems may be minimized.

Fluid mixing capability of rigs: While we are building new rigs and modifying existing ones to drill wells more efficiently, a vast majority of wells are still drilled all over the world using older rigs with limited capabilities. Kill-weight mud may not be quickly prepared and/or pumped at a desired rate if the W&W Method is employed. The Driller's Method may be preferred under these circumstances to avoid excessive increase in surface and shoe pressures due to gas migration.

We acknowledge that on some rigs, kill mud can be mixed at a fast rate without problem. But simultaneous mixing and pumping of kill mud may make pit volume gain and loss difficult to track and lead to confusion, particularly in the event of complications.

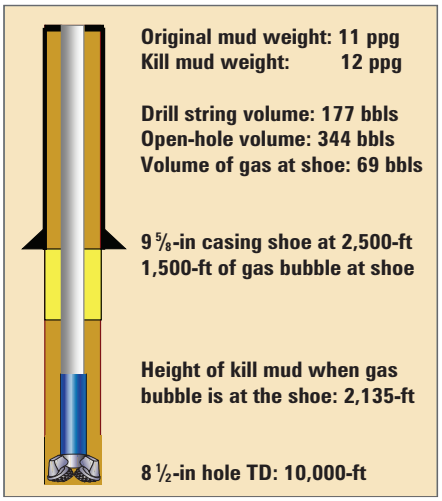

Figure 2: Even in a vertical well with a long open-hole section — conditions likely to favor the Wait & Weight Method — this example shows that a reduction of only 111 psi can be achieved under an extreme scenario.

Drilling in formations with ballooning potential: Ballooning is a phenomenon occasionally encountered in some formations. Ballooning can be defined as flowback from the well after shutting the pumps off, which is preceded by losses while the pumps were running. Losses in the well can be attributed to extra BHP due to equivalent circulation density (ECD).

After the pumps are shut down, the ECD does not exist anymore, resulting in a drop in BHP, and mud is forced back into the wellbore. It appears the well is flowing and is referred to as ballooning.

Ballooning is often misinterpreted as a kick. If it is decided to kill the well with the W&W Method, mud weight may be increased due to incorrect measurement of formation pressure. Due to the additional mud weight, BHP increases even further. This can induce more losses and worsen the ballooning problem.

For the above reasons, it is commonly recommended that the Driller's Method be followed in ballooning formations. Since the Driller's Method does not require any increase in mud weight during the first circulation, no additional BHP is exerted on the formation. After the first circulation of the Driller's Method, the situation can be assessed and further course of action can be decided (i.e., drilling ahead with no mud weight increase if ballooning continues).

Complications and friction changes during well control: While a well is being killed, complications may occur during the process. When killing a well with the W&W Method, if one or more of the bit nozzles plug while drill pipe pressure schedule is followed, the pressure schedule must be recalculated immediately.

The failure to notice the change and to recalculate the proper drill pipe pressure schedule may result in underbalance. On-the-spot recalculation of the drill pipe pressure schedule may be difficult for highly deviated wells and/or with tapered drill strings. Furthermore, when a kick is taken, it is normal that the rig crew become nervous. If any complications

arise while killing the well, rig personnel may panic and make poor decisions.

If the kick is circulated with the Driller's Method and one or more of the bit nozzles plug, the response by the choke operator is fairly simple. The circulating drill pipe pressure should be allowed to increase while temporarily holding casing pressure constant (as during start-up). After the drill pipe pressure stabilizes, the new circulating pressure should be held constant during the rest of the first circulation. If one or more nozzles plug during the second circulation of the Driller's Method while pumping kill mud from surface to bit, the simple response is to continue holding casing pressure constant until kill-weight mud is at the bit and then switch to hold whatever drill pipe pressure is shown on the pump gauge. Hence, if complications arise during well kill operations, it is easier to respond with the Driller's Method.

Deepwater wells: If gas kicks are taken in deepwater wells, there is a possibility of hydrate formation in the BOPs or choke/kill lines. The high-pressure and low-temperature conditions in deepwater are ideal for formation of hydrates when free water comes into contact with gas.

Possible long periods of non-circulation with the W&W Method will make conditions more favorable for hydrate formation due to cooling of mud. Hence, non-circulating times in deepwater wells with a gas influx should be minimized. By establishing circulation as soon as possible with the Driller's Method, the mud can be kept warm, and hydrate formation may be prevented.

Time to kill well: The W&W Method involves only one circulation while the Driller's Method involves two circulations. This sounds as if we can always save time by following the W&W Method. But other factors need to considered. If the time required to mix kill mud is significant, we may not save any time with the W&W Method. We may not be able to circulate all the influx out with just one circulation due to hole conditions, such as gas remaining in the high pockets of the well, poor hole cleaning and bad mud properties. Additional circulations are almost always required for complete removal of the influx and the addition of safety factors in the mud weight. Therefore, the time element may not be significant, and most experts agree that doing it right is more important than doing it faster.

Shoe Pressure: Maximum shoe pressure often occurs when the top of a gas influx is at the casing shoe. Pressure at the shoe can be lower with the W&W Method if kill mud gets into the annulus before the top of the bubble is at the shoe. But, for this to happen, the first criteria is that the drill string volume has to be less than the open-hole volume minus the bubble size at the shoe. If the drill string volume is more than the open-hole volume minus the bubble size at the shoe, then lower shoe pressure cannot occur with the W&W Method.

We also have to consider gas migration issues before determining whether the W&W Method will have an advantage over the Driller's Method with respect to maximum shoe pressures. There may be a significant amount of wait time to mix kill mud. During this time, gas may be migrating. Most methods used to control BHP before pumping involves application of a surface pressure safety factor. These can easily exceed the expected benefit that the early delivery of kill-weight mud to the open-hole annulus is intended to provide.

There is an often a good chance that a kick is not detected when the kick is at bottom. Many times, we may circulate or continue drilling with the influx before it is detected. At times, the gas may already be above the shoe due to delayed detection and gas migration, even before we start pumping kill mud.

Synthetic/oil-base mud (SOBM) is now routinely used to drill wells. Unlike in water-base mud (WBM), gas is soluble in SOBM. Kick detection with SOBM is not as simple as with WBM. The size and time of the kick may not be easily determined. Gas may stay in solution in SOBM, and the influx may not be detected until the gas is close to surface, often well above the shoe.

Due to the above reasons, only rarely can lower shoe pressures be achieved with the W&W Method compared with the Driller's Method. Only if all conditions are favorable will the W&W Method give us lower shoe pressures. Realistically, the chances are minimal and the magnitude of this effect is usually insignificant.

Figure 2 shows a vertical well with a long open-hole section to create conditions likely to favor the W&W Method. The hole configuration has been kept fairly simple, and we have considered a big influx of gas that expands to 1,500 ft just below the shoe for both methods. If we follow the W&W Method, as we can see from the calculation shown in the appendix, we achieve a maximum pressure reduction at the shoe of 111 psi.

The reduction of 111 psi in the shoe pressure will only exist when the influx is detected by the rig crew when the gas is at the bottom and the influx stays at the bottom without any migration while mixing kill mud (or is handled perfectly with volumetric control and no safety factors/working pressure margins).

We do not have to be an expert to realize that these conditions will probably not exist in any wellbore. Hence, even in the relatively extreme scenario like this, a 111-psi reduction in shoe pressure with the W&W Method is almost impossible to achieve. In many wells, we may not get any reduction in shoe pressures, and even if we get some reduction in pressures, it is probably not worth taking other risks with the W&W Method.

Maximum casing pressure at surface (PcMax) and peak gas flow rate: Maximum casing pressure during the circulation is observed when the top of the gas bubble gets to surface. This may be defined as PcMax. The gas flow rate through the mud gas separator is maximum at the same time when PcMax

is observed. Peak Gas Flow Rate must not exceed the gas-handling capacity of the mud-gas separator. PcMax and peak gas flow rate will be lower with the W&W Method if kill mud gets into the annulus before the top of the bubble gets to surface. If the W&W Method is followed, there is a good chance that kill mud will enter the annulus before the top of the bubble gets to surface, and we will likely have lower surface pressures compared with the Driller's Method.

Lower PcMax may be an advantage for the W&W Method when we drill HPHT wells where surface pressures could be a concern. The surface equipment may be exposed to high pressures and gas flow rates for a long time during well-killing operations in these wells.

However, for most of the regular wells we drill, PcMax and peak gas flow rates may not be a primary concern. In the examples in Figure 3, we calculate PcMax for kicks taken while drilling a regular well and an HPHT well. The large kicks modeled here have been selected to simulate worse-case scenarios. The PcMax calculation is explained in the Appendix.

As can be seen for the regular well example, the difference in PcMax is not significant between the Driller's and W&W methods. Even in case of a large kick in the HPHT well, the difference in surface pressures is only 335 psi.

	WELL 1 (regular well)	WELL 2 (HPHT well)
Well Depth (TVD/MD)	10,000-ft	22,000-ft
Hole Size	8.5-in	6-in
Previous Casing Size	9-5/8-in, 47 ppf	7-5/8-in, 26.4 ppf
Previous Casing Depth	6,000-ft	17,000-ft
LOT EMW	14 ppg	22 ppg
Drill Pipe	5-in, 19.5 ppf	4-in, 15.7 ppf
Current MW	12 ppg	19 ppg
SIDPP	500 psi	1,000 psi
SICP	1,000 psi	2,000 psi
Kick Volume	40 bbls	30 bbls
PcMax with Driller's Method	**1,674 psi**	**2,602 psi**
PcMax with W&W Method	**1,568 psi**	**2,267 psi**

Figure 3: This example calculates PcMax for a regular well and an HPHT well with large kicks. With the regular well, the difference in PcMax is not significant. Even in the HPHT well, the surface pressure difference is only 335 psi.

CONCLUSION

The Driller's Method does offer some distinct advantages over the W&W Method. The W&W Method may be advantageous to achieve lower shoe and surface pressures in some cases. However, these advantages are often exaggerated and, in reality, we may not see a significant reduction in maximum shoe and surface pressures. Due to gas migration and hole geometry, many times shoe pressure may not be lower at all with the W&W Method. Application of the W&W Method may even give us higher shoe pressures if the drill pipe pressure schedule is not calculated and followed properly. Reduction in PcMax may not be significant even in deep HPHT wells.

The W&W Method may be difficult to follow properly in complex, deviated wells and/or with tapered drill strings. The Driller's Method is a preferred method when hole problems are significant and any long non-circulation times could further compound the problems. Hydrates concern in deepwater wells may require limiting non-circulation times with possible gas influx in the well

Due to the low experience level of current drilling personnel, limited field practice with well control methods by a majority of experienced personnel, exaggerated and often unachievable benefits, the W&W Method may not offer significant advantages. Additionally, certain conditions — ballooning, swabbed kicks, hydrate concerns in deepwater and hole stability problems — may dictate using only the Driller's Method. Due to all these reasons, the Driller's Method is a logical, simple, practical, adequate and often superior approach to kill majority of the wells we drill.

Appendix:

Shoe pressure reduction with the W&W Method compared with the Driller's Method:

Height of Kill Mud in the Annulus When Top of the Gas Is at the Casing Shoe = (Open-Hole Volume - Drill String Volume - Gas volume at shoe) / Annulus Capacity

*Pressure Reduction with the W&W Method = Height of Kill Mud in the Annulus * 0.052 * (Kill Mud Weight - Original Mud Weight)*

Calculation of PcMax in the Driller's Method:

PcMax = O + Q

O = SIDPP / 2

*Q = (O2 + K*M*N*P)1/2*

K = Reservoir Pressure

M = Initial Pit Volume Increase / Annulus Capacity Factor in bbls/ft Right Below Wellhead

*N = Difference in Mud Weight Gradient and Influx Gradient = MW*0.052 - Influx Gradient*

*P = Temperature and Compressibility Correction Factor (TZ) = 4.03-(0.38 * ln(K)*

Calculation of PcMax in the W&W Method:

PcMax = U + V

U = 0.052 G*Q / 2 / R*

*V = (U2 + K*M*N*P)1/2*

G = SIDPP / 0.052 / TVD

Q = Drill String Capacity in bbls/ft

R = Annulus capacity factor in bbls/ft right below wellhead

K = Reservoir Pressure

M = Initial Pit Volume Increase / Annulus Capacity Factor in bbls/ft Right Below Wellhead

*P = TZ = Temperature and Compressibility Correction Factor = 4.03-(0.38 * ln(K)*

*N = Difference in Mud Weight Gradient and Influx Gradient = MW*0.052 - Influx Gradient*