 Mario Brunet

# Plan for Success on Drilling Jobs

A few years ago, I received a call from a contractor asking for help mitigating a situation with a governmental transport agency in regards to monitoring downhole pressures as they were drilling under a six-lane highway crossing. They were asked to provide details on the drilling fluid they were using and the expected annular pressure while drilling. In order to do this, one must look at the functions of the drilling fluids, the properties of the drilling fluids (like viscosity and solids content), the volume of fluids being pumped, and the rate or speed of drilling.

During the drilling process, a contractor circulates drilling fluids through the bore. The drilling fluids have several functions that keep the hole open and stable in order to pull the pipe through with ease. The primary functions of a drilling fluid are:

- Keep the tooling, sonde and any other instrumentation cool
- Lubricate the hole
- Clean the hole by suspending and transporting cuttings to the surface
- Hold the hole open via a filter cake and positive hydrostatic pressure (control fluid loss)
- Reduce torque, especially associated with sticky soil
- Control subsurface pressure

A bentonite-based drilling fluid is typically chosen for HDD bores, since it is able to provide all the functions listed above. The concentration of the bentonite fluid is determined by the soil. The coarser the soil, the more bentonite is required to ensure minimum fluid loss. The amount of bentonite used can be decreased by adding in polymers to help reduce the fluid loss while keeping the concentration of bentonite down.

You may be wondering what this has to do with fluid volumes and downhole pressure? The answer is quite a bit, based on the properties of the fluid being used. The contractor needs to look at the primary properties of the fluid, which are:

- Viscosity
- Gel strength, or the ability of the fluid to suspend cuttings
- Protection against fluid loss

The higher the viscosity of the fluid, the higher the pump pressure required and the higher the downhole pressure. As the fluid is designed to suspend and transport cuttings, the amount of fresh fluid being pumped will directly affect the solids content of the fluids being displaced out of the hole. Lastly, the pressure of the drilling fluid, encapsulated by the filter cake against the formation, helps hold the hole open. The filter cake controls the fluid loss with positive pressure; however, it must be controlled in order to not exceed downhole pressure.

When volumes and pressures aren't properly calculated, slurry-related failures on HDD jobs can be dramatic. *Source: CETCO Drilling Products photos*

## FLUID VOLUME

There is a simple formula that can be used to calculate soil volumes in a given bore path:

(bit or reamer size in inches)$^2$ ÷ 24.5 = gallons of soil per linear foot

Using a 5-inch bit as an example:

$5^2 \div 24.5 = 1.02$ gal./ft.

Therefore, looking at this example, we know that we need to move 1.02 gallons of soil per linear foot of bore. In order to do this, enough drilling fluids need to be pumped downhole in order to produce a flowable slurry. As mentioned earlier, the viscosity and solids content must be controlled in order to keep the downhole pressure manageable. In fact, a ratio of 2:1 to 3:1 of fluids per gallon of soil is needed in sand, and in clay the ratio may be up to 5:1. For example, if drilling in sand, a 2:1 ratio will be required as a minimum to produce a flowable slurry that will carry the cuttings out of the borehole. In this example, roughly 2-gallons of drilling fluid will need to be pumped per linear foot. As the diameter of the borehole increases, the amount of fluid required increased dramatically. For example, the calculation for a bore done by a 10-inch reamer is:

$10^2 \div 24.5 = 4.08$ gal./ft.

Without taking into account any pilot or pre-ream, the volume of soils we need to remove is 4.08 gal./ft. Therefore, in sand, we need to pump a minimum of 8.16 gal./ft. of drilling fluids to effectively displace the cuttings.

When pulling a pipe through the borehole, it is essential that the proper volume of slurry is pumped and also that there is sufficient annular space to allow for flow of the slurry. The volume of the fluid will keep the viscosity and solids content low and the slurry flowable. Without creating a flowable slurry, circulation will be lost and pressure in the borehole will increase rapidly, resulting in either a break-off or stuck pipe and/or inadvertent returns at the surface.

## DOWNHOLE PRESSURES

This now brings us to downhole pressures. The calculations of recommended downhole pressures are only as good as the geotechnical reports the contractor has. Often the engineering documents will recommend an annular pressure not to be exceeded. There is also software available that can produce this data. It is common that the available geotechnical soil reports were taken from the entry pit and the exit pit or nearby, but not necessarily along the entire planned bore path. Therefore, there can be unknown ground formations along the bore that the contractor may be unaware of unless he or she has drilled in the same area before.

A quick way to calculate downhole pressures is:

mud weight in pounds x 0.052 psi/ft. x depth in feet = hydrostatic pressure

In this equation, 0.052 is a unit conversion factor. It means that hydrostatic pressure (P), the result of the equation, is expressed in units of psi.

At a depth of 60 feet, with clean mud being an estimated 8.5 lbs./gal., the estimated pressure would be:

$8.5 \times 0.052 \times 60 = 26.6$ psi

The contractor I mentioned at the beginning of this column wanted some assistance to maintain downhole pressure in order to not cause formation damage while drilling under the roadway. The reality is that, in order to do this, the contractor needs to fully understand and ensure the following: the drilling fluid's functions and properties match the soil type; flow rate requirements are understood; and the speed of the drilling is known and monitored, all while keeping circulation constant.

A small- to medium-sized HDD driller has some options to understand the downhole pressure while drilling. On critical pullbacks, there is special instrumentation that can be installed between

For contractors, understanding fluid requirements can mean the difference between success and failure.

A heavy slurry may be required in some formations, but it increases pressures downhole.

the reamer and the pullback string. This instrumentation can provide real-time annular pressure readings. The speed of the drilling and volume of fluids can be regulated to keep pressure consistent and below a pre-determined value. Another option is for the driller to continually measure the mud weight of the fluid returns at the exit pit. The weight of the returns can be an indicator of the downhole pressure. The higher the mud weight, the higher the annular pressure.

Spending the time to understand the fluids required, the volume and speed of drilling, and the resultant pressure can make the difference between success and failure. This knowledge results in bores completed on time and on budget. Keep on turning to the right!

There are many nuances to any drilling project. It is always good to get these down on paper to make sure you don't forget them. Boost your odds for success. Utilize drilling fluids as a tool to avoid trouble instead of an aid to get you out of trouble! ND

Mario Brunet is technical sales manager for CETCO Drilling Products, a Mineral Technologies company. For more Drilling Fluids columns, visit www.nationaldriller.com/drillingfluids.