INTERNATIONAL SOCIETY FOR TRENCHLESS TECHNOLOGY	**TRENCHLESS TECHNOLOGIES RESOURCE CENTRE**	
	TRENCHLESS TECHNOLOGY GUIDELINES	SECOND EDITION
	SPOIL HANDLING AND LUBRICATION FLUIDS	NEW GUIDELINES JUNE 2005

1 OVERVIEW

Boring and Drilling Fluids, known widely as Slurries or Muds, and lubrication fluids to most seem to be the dirty side of their respective operations. Although water can be used on its own, most fluids are based on a mixture of water and bentonite (a very fine type of clay with thixotropic properties, meaning that it remains fluid as long as it is being pumped or agitated, but forms a gel if allowed to stand). These fluids have a vital role to play in both microtunnelling operations and in the HDD boring sector for a variety of different and sometimes similar reasons. The mud/slurry is not always bentonite based. Over many years several synthetic polymers and other natural additives have been developed and/or brought into use that mimic or compliment the use of bentionite in the fluid mixture or give specific properties to the fluid that are called for due to ground or other site variations on individual projects.

Various bentonite types and additives are available for boring and drilling fluid formulation. (picture courtesy of Baroid Industrial Products)

2 APPLICATIONS

A. PIPEJACKING AND MICROTUNNELLING

The main purpose of bore slurry in the microtunnelling sector is often two-fold. First, in the correct mixture, a slurry can provide face support during the excavation process, ensuring that the face remains open and that there is no loss of ground that might cause problems for the operator in terms of machine control or subsidence at surface, should too much ground be removed by the tunnelling system. Second, the slurry can act as the spoil

transport and removal medium, taking excavated spoil away from the face at a rate suited to the advance capabilities of the tunnelling system.

More often in recent years, the volume of slurry used per project has been reduced by the introduction of slurry recycling plant that removes spoil from a circulating slurry, reconditions it to the specifications required and returns it to the face for reuse.
There is third application for slurry in the pipejacking and microtunnellng field at that is its use as a lubricant. The fine clay base of most slurries makes it an excellent material for reducing friction loses between the pipe being jacked and the surrounding ground and it is often injected into the annulus between pipe and ground specifically for this purpose (see below).

A typical microtunnelling spoil separation and fluid recycling set-up.
(picture courtesy of Derrick Corporation)

B. HORIZONTAL DIRECTIONAL DRILLING

In HDD operations the drilling fluid, or Mud as it is more commonly known, has a variety of functions depending on the circumstances in which it is used. These include: To lubricate and/or cool the cutting head and reduce wear; To soften the ground so that it is easier to drill through; To convey excavated material in suspension back to the launch pit; To stabilise the bore during pilot hole boring and prior to and during backreaming; To lubricate and support the product pipe during backreaming and insertion; and To power downhole mud motors for drilling through hard ground. The mud formulation is varied according the job, or jobs, it has to do.

These muds are, more often than not, recycled through spoil cleaning system to reduce the quantity required per project as with pipejacking and microtunnelling.

A typical HDD fluid recycling set-up. (picture courtesy of Kem-Tron Inc)

C. MUDS AS LUBRICANTS

The two greatest forces that need to be overcome in jacking a pipe are the weight of the pipe string and the friction between the surface of the pipe and the ground as the pipe moves through the bore, similarly for the weight of a pipe string being pulled in during an HDD operation. Friction increases with pipe diameter, as a greater surface area of pipe is presented to the internal surface of the bore. The problem of friction is most commonly addressed by using pipe of the smallest acceptable diameter, and by lubrication. In the earliest days of pipejacking it was sometimes left to brute force to overcome the total resistance by simply installing a larger capacity jacking frame. This could lead to early pipe failures as the maximum load bearing capacity of the pipes was exceeded in difficult conditions. Similarly early HDD bores sometimes failed because the use of simple pulling force on a pipe caused failure as friction loads rose above the level of the tensile strength of the pipe material.

The introduction of lubrication using a bentonite mud or combination bentonite/polymer mixture can overcome most of the loading problems. The mud mixture is designed to work efficiently in the expected ground conditions. A simple formulation can be used where the lubricant will not be absorbed or drain away into the surrounding ground. In more difficult conditions, where loss of lubricant can be expected or where ground pressures are likely to be high, the lubricant can be modified to reduce loss and to assist in providing ground support throughout the duration of a pipejack or pipe pull-in. For pipe jacking, the lubricant is conveyed by pipes installed within the main pipe string, and is injected through ports drilled through the pipe wall, often pre-drilled during the pipe manufacture as man entry is not permitted in many cases with microtunnelling operations. Each injection port may be fed by a separate lubrication line. Injection is controlled either manually from the operator's station, or by means of a computer-monitored system through a central distribution manifold. The latter system is increasingly popular, and allows measured amounts of specific lubricants to be added at the correct position, at an optimum pressure along the pipe string as the ground varies and the pipe string moves forward. Computer monitoring often increases the efficiency of lubrication by minimising over-lubrication at any one point, bearing in mind that lubricants can be expensive. On smaller diameter, often shallower, pipejacks or microtunnels this can be a significant advantage as it minimises surface heave or loss of lubricant through cracks to the surface.

For HDD the lubrication comes simply from the flow of mud through the bore as pipe pull-in occurs. The formulation is vital here to ensure bore stability, pipe support and lubrication.

On many projects the use of the correct lubrication materials and techniques can bring about a considerable reduction in jacking/pull-in loads and ground support problems. It may also allow the use of a smaller jacking frame or drill rig, thus minimising the size of the drive shaft or start pit and helping to reduce the overall cost of the project. Using modern lubricants and installation techniques, it may be possible to install up to 1,000 metres of pipeline in a single drive.

3 SPOIL REMOVAL/GROUND SUPPORT IN MICROTUNNELLING

Although used sometimes in Pipejcking operations, slurries are more often found in microtunnelling systems. For microtunnelling specific properties may be required for either face support or spoil removal but often the systems work in a very similar way to those used for HDD, just on a larger scale. So to save repetition see below for more detailed coverage. The only real difference between microtunnelling slurries and HDD fluids is the carrying capacity. Microtunnelling tends to produce larger spoil pieces and so requires greater carrying capacity, so systems tend to be larger and more powerful to move the ultimately heavier fluids around the recycling system. Volumes used also tend to be high so recycling is often the only economic solution. Most microtunnelling slurry circuits also operate in closed circuit with both feed and return flows passing through a pipeline system. In HDD an open circuit may be used where conditions and pumping arrangements allow.

4 BORING FLUIDS FOR HDD

There are two aspects of HDD drilling fluids that should be considered, the mixture and handling of the fluid in operation. In some circumstances HDD fluids can be used in open circuit where no cleaning or collection for recycling is done, but environmental pressures in recent years have seen their use in this manner almost disappear. The expense of using fluids only once has also helped to reduce this type of use, as it has on the increasingly frequent larger diameter bores where usage volumes can become very high.

A. Mixtures

The formulation of drilling/boring fluids is a complex science in its own right, and one which plays a major part in the success of projects. Most manufacturers of drilling machines have their own recommendations on the most suitable fluids for particular applications, and advice is also available from the manufacturers of the materials. This is an area where specialist guidance should be sought, especially when dealing with difficult ground conditions. To assume that simply throwing bentonite mud at a problem will solve it is a situation to be avoided – seek advice – this cannot be stressed heavily enough!

B. Handling

The design of mixing, pumping, filtration and recycling plant is also a major consideration, especially for large-scale projects, and again advice should be sought from experienced contractors or manufacturers.

In short, most systems rely on a combination of agitators or stirring devices or venturi jets to mix the bentonite/polymer/water and any other additives together in the mixing tanks.

Normally these mixtures have to be agitated for a length of time to allow full 'hydration' of the solid particle with the water. Once mixed, an arrangement of slurry pumps passes the fluid from the mixer tanks to storage tanks where they are continuously agitated to maintain the fluids characteristics. When required the fluid is then passed into the boring system using special 'slurry' pumps, normally by pumping down the hollow drill rod to the cutting head (or through a circulating pipeline within a microtunneller system). The fluid then passes through the head, cooling it if necessary, picking up spoil from the face of the bore and returning to the launch area by passing along the annulus between the drill rod and the bore wall. If designed to do so, the properties of the fluid will help support the bore wall and/or form a fluid 'skin' at the bore wall preventing loss of fluid into the surrounding ground.

For both HDD and microtunnelling, on return to surface the fluid is collected and passed through a specially designed spoil separation system comprising a series of mesh sieves and hydrocyclone solids separators that remove the larger particles from the fluid down to the designed size cut-off. The fluid, if necessary, is checked and re-formulated to its required specification and returned to the storage tanks for re-use down hole.

Many countries have over the past few years introduced regulation as to the use and disposal of boring and drilling fluids and users should make themselves fully aware of these local requirements. Environmental controls are increasingly a part of the fluid industry's major activities.

5 SUMMARY

1. Fluids have a vital role to play in both Microtunnelling and HDD operations in terms of bore maintenance, ground support and spoil removal.
2. The design of a fluid and maintenance of it operating specification can mean the difference between success or failure of a project.
3. Design of fluid is very specialised for many circumstances and advice should be sought at an early stage from machine manufacturers or fluid specialists.
4. Similarly for fluid handling – these systems are very complex and need to be set up properly to achieve their best efficiency – expert advice should be sought.
5. New regulations are appearing in many parts of the world – make yourself aware of your local responsibilities in respect of fluids and their disposal.