MELFRED BORZALL

FROM THE FOUNDING MEMBERS OF HDD:

NEW HDD DRILLERS START HERE

A Beginner's Guide To The Fundamentals Of Horizontal Directional Drilling Operations, Tooling Selection, and Basic Soil Conditions

Horizontal directional drilling (HDD) is the trenchless method for installation of underground pipes, cables, and other utilities in areas where traditional excavation or trenching is not practical or minimizing ground disruption is necessary. HDD allows for major installations in areas that were previously unreachable and has become increasingly popular in recent decades. It is a complex process that requires specialized equipment and crew members with a level of proficiency. However, with the fast expansion of HDD drilling in today's world, HDD contractors are finding it harder to fill their crews with able-bodied drillers...let alone those with prior drilling experience who can prevent costly mistakes or liabilities.

The tooling and equipment selection required to complete these operations can be very complex. Different ground conditions, pipe materials and equipment capabilities mean specific tools need to be used for each and every HDD job. Choosing the wrong tools for the job can cost thousands of dollars in ruined equipment and decreased productivity. For a new driller who has zero or very little experience in HDD, understanding the fundamentals of the process is essential.

That's why we've applied our nearly-eight-decades of experience to create a comprehensive guide to help new drillers understand the basics of HDD drilling operations and tooling selection. In this guide we've included some background on the HDD Industry, an overview of HDD operations, and essential knowledge for utilizing the right tools and equipment under the most common ground conditions in order to maximize your production and profitability.

This guide can help those of you who are new to HDD get up to speed, limit some rookie mistakes, and quickly become the invaluable crew member your supervisor needs.

A SHORT HISTORY OF HDD

Horizontal Directional drilling began when Fred Melsheimer, the founder of Melfred Borzall, took those same principles and turned everything sideways. The first drill bits used in horizontal drilling, we called them "fishtail bits," were connected to a drill string and spun using an air motor held by two strong workers (they had to be!). At first these rudimentary practices could only complete narrow, two to three inch diameter, bores for short distances such as street to house installations. But as the practice grew, so did the vision for what was possible.

In order to drill larger diameter holes, drillers developed a process to ream out the existing hole by pulling a cutting tool, or reamer, back through the original pilot bore shot. Thus enlarging tools are now called backreamers. Along with cutting tools, more powerful hydraulic powered drilling machines (rigs) were created to facilitate longer and larger bores. This is when larger OEMs started to jump into the industry and you started to see Ditch Witch® & Vermeer® rigs.

Originally, when boring capabilities were fairly shallow, crews had to drill a series of potholes along the bore path in order to locate the drill rod manually along the intended path. But as location technology improved throughout the late 20th century, so did the ability for horizontal directional drillers to know the direction of the drill head without having to see it with their own eyes.

Over time, this meant less excavation was needed along the borepath. Utilizing cutting edge locating technology, eventually the first steerable drill heads and directional drill rigs were developed that enabled drillers to go further and deeper than ever before.

PART 1: AN OVERVIEW OF HDD OPERATIONS

In the course of just a few decades, horizontal drilling went from a dozen yards of boring to drilling under rivers and entire highway systems, with very minimal surface damage, sometimes for tens of thousands of feet. From then on, HDD innovation has mostly been aimed at improving the accuracy, speed, and capabilities of the entire HDD process by developing more durable equipment, better locating technology, and specialized tools for increased efficiency and profitability.

KNOW YOUR EQUIPMENT

1

DRILL RIG

This is the large machine that runs the entire string of connecting tooling for the jobsite operation.

2

LOCATING SYSTEM

This ensures the drill head is correctly moving along the planned bore path, avoiding existing underground utilities to arrive at the exit pit.

3

DRILLING FLUIDS

The "mud mix" is a complex mix of water and formulated additives that serve a number of important functions depending on the soil composition.

4

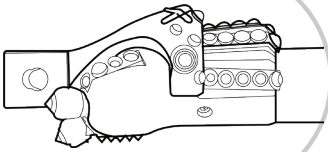
HDD VAC

Evacuates excess mud so it doesn't contaminate the area surrounding your jobsite. Also used to create potholes along the bore path.

5

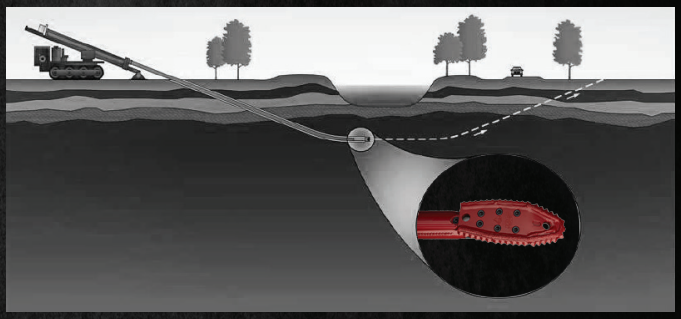
HDD TOOLING

Bits, blades, reamers, swivels, transmitter housings, pullers and other tools tailored to job and ground conditions.



PILOT BORE

The first part, once all the equipment is setup and the site is ready, is to create a "pilot bore," using a cutting bit or blade, between point A to point B. Normally these initial tools will bore a hole about 3- 8" in diameter. The bit follows a path, heading at an angle down to a predetermined depth starting at the intake pit and coming up at the exit pit. Sometimes the path follows the curve of a road or makes a slight turn to avoid existing underground utilities or other obstacles.



The rig operator works together with the locator to steer the bit along this path. During the bore, the rig works much like a conventional drill by spinning the drill to cut a straight line through the present soil conditions. The rig operator is able to steer the drill by stopping the rotation and allowing the angled face design of the directional bit or blade to push against the hard surface of the ground ahead of it, which changes its direction.

Mounted just behind the drill is a solid cylinder with a cavity inside that holds the radio transmitter. It is called the transmitter housing. This transmitter sends a signal with information downhole, to a receiver that is held by the locator walking at the surface along the bore path. The locator can determine where the drill bit is, how deep it is, the direction it's headed, and how fast it's progressing. The locator radios or signals this information to the rig operator allowing for necessary adjustments and "steering" along the intended path.

The pilot bore is complete when the drill bit reaches the designated exit position...leaving a nice, clean hole.

PULLBACK

The second part of the process, called "pullback," both enlarges the pilot bore to a slightly larger size than the finished product pipe using a tool called the backreamer, and at the same time pulls the product pipe through the bore where it will remain and become a useful piece of infrastructure for years to come. To begin this step in the process, the crew detaches the drill and the housing assembly from the starter rod or drill rod, and attaches the appropriate reamer. In standard HDD pullback, a swivel is then attached behind the reamer, and after that, they attach the product pipe.

In most HDD drilling, pull back is powered by the same drill rig. The reamer spins and cuts a wider hole along the bore path. The swivel acts to stop the spinning motion so that the product pipe can be pulled smoothly into place along the bore path. During both parts of this process, both the pilot bore and pullback, drill fluid or "mud" is pumped through the tools into the borehole in order to cool the equipment, lubricate the process, carry soil cuttings out of the hole and stabilize the borehole. Different mixtures of fluid are used depending on the soil conditions and several other factors. The vac is used to suck up fluid as it exits the bore hole and into a separator which separates the drilling fluid from the soil cuttings produced during the bore.

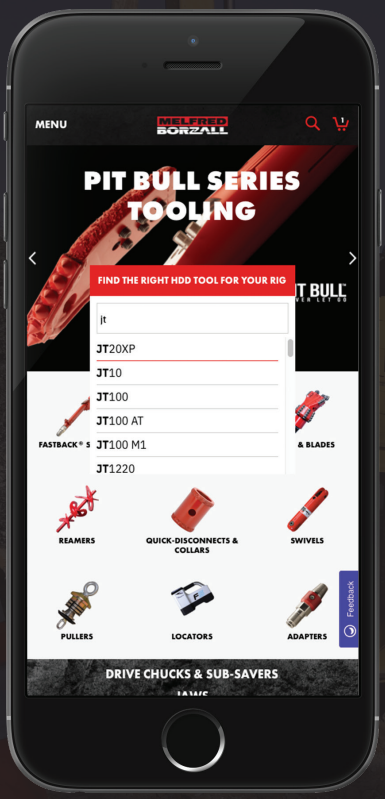
PART 2

Each of the steps we have covered has a detailed selection of tooling, equipment and fluid additives is required depending on the specific conditions of the intended bore. The list of available equipment and materials out there is extensive, with tools designed to meet every condition imaginable. This section will provide an overview of the most common factors and conditions that can affect tooling and fluid additive selection - and how to approach them smartly..

MELFRED BORZALL

DRILL RIGS

As HDD capabilities have grown over the last several decades, so have the amount of available different HDD tools and equipment that are built for specific types of projects. The drill rig is one of the biggest pieces of equipment on a bore, and not all drill rigs will work for different conditions. The simplest way to think of drill rig selection is, first to look at the rig's thrust and pullback force, measured in push/pull pounds force, and second to look at the rig's rotational torque, measured in ft per lbs. In general, drill rigs with more thrust are intended for drilling longer distances and higher rotational torque on a drill rig indicates its ability to ream out larger diameter holes.



While the basic concept of these HDD drill rigs works the same, there are slight differences you will encounter based on the project and the type of rig best equipped to do that job. Drill rig operators receive special training either through drill rig manufacturers, or independent HDD focused organizations.

Drill rig selection is a highly specialized process. But it's important for beginners to understand that different size drill rigs require different kinds of tooling such as bits, blades, reamers and their associated attachments. When selecting these tools for the job, make sure you are selecting tools that are intended for use with the type of drill rig on your job.

We understand that you probably have an existing rig and you are not changing your rig for every job, so you will likely need to primarily focus on what size tooling and operations fit your existing rig. We'll jump into that next.

3 IMPORTANT FACTORS

1. THE CUT

The cutting action of your bits, blades and reamers needs to achieve two things. First you need to be able to cut a hole through the ground, and second, the tools need to render the cuttings in such a way that they can be efficiently and adequately carried out of the bore to leave clear passage for the product pipe.

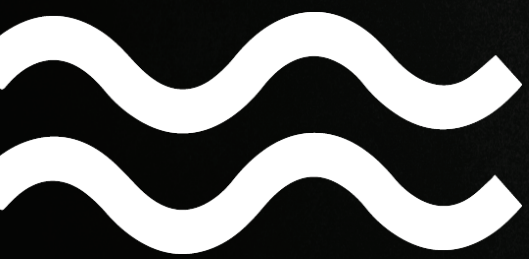
Just as there are differences in the size and spacing of the teeth on a metal saw vs a wood saw, there are going to be different sizes and spacing of the teeth on HDD tools depending on the nature of the soil you are cutting through. In addition to the cutting ability of the teeth, you need to consider what rotational speed of the drilling action will be best for achieving a successful bore. The general rule is to rotate the tool more slowly more slowly in hard or rocky ground conditions.

2. THE MIX

We mentioned above that drill fluid is specifically formulated to perform different functions during the bore such as, keeping the bore walls stable during the drilling and keeping the fluid from draining out of the hole. Other functions include cooling down the transmitter and transporting the soil cuttings out of the bore hole and into the vac and separator.

This specially formulated mud needs to interact and mix thoroughly with the soil cuttings during the bore, creating a viscous substance, called the "slurry," that flows into the receiving pit like hot peanut butter. The reamer you select needs to have a really good mixing action for this process to work properly, and different reamers work best with different kinds of fluids for the various soil conditions.

3. THE FLOW



During the pilot bore, you're not creating a very big hole, so the process doesn't generate a high volume of soil cuttings. During this initial cut the fluid pressure is high to help with the cutting action of the bit, but there is not as much flow of fluid out of the hole.

During backreaming, these principles are reversed. A higher volume of fluid, at lower pressure, is required to mix with the soil cuttings so they can flow back out of the bore hole. It helps if the backreamer is designed to help "pump" the slurry out of the hole as it spins.

CLAY & REACTIVE SOILS

Clay can be the trickiest soil type to drill into and pull back through. Clay and other soil types are considered reactive soils because the characteristics change when it is hit with water. These soils can swell up and become very sticky.

DRILLING IN CLAY

The fluid mix is hugely important for both the pilot bore, backreaming and pullback. There are additives you'll need to use that will keep the clay from sticking to the blade steer face and backreamer cutters. The additives also keep the clay from sticking to itself and reforming into large clumps that you can't float out of the hole.

While it may be possible to pull back the reamer quickly through these softer soils, make sure you're pulling slowly enough to allow the reamer to mix and make a really good slurry. Otherwise, you may evacuate all cuttings out the hole, which can then bind up around and block the product or pipe. This is called "outrunning your drill fluid." Consult your mud mix specialist and the drilling fluid specifications.

PILOT BORE

A standard-duty blade will work for this pilot bore with adequate fluid. Forego opting for the thread-on bit for this bore...you'll need to preserve steerability.

PULLBACK

Cutting won't be difficult but the a tool's cutters can peel off big chunks of clay, so ensure your reamer has good pumping & mixing action to carry those cuttings downhole. The reamer should also not have too many solid, flat surfaces for the clay to stick to. However, too many cutters on the reamer won't work either.

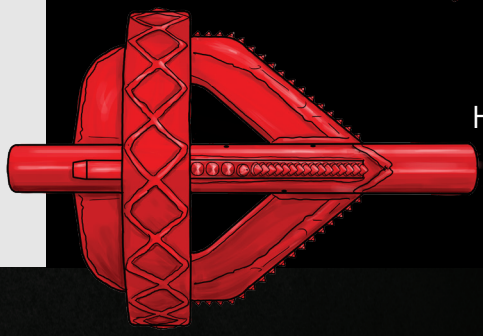
BORING TOOLS

Rock Saw

Clayslayer

REAMING TOOLS

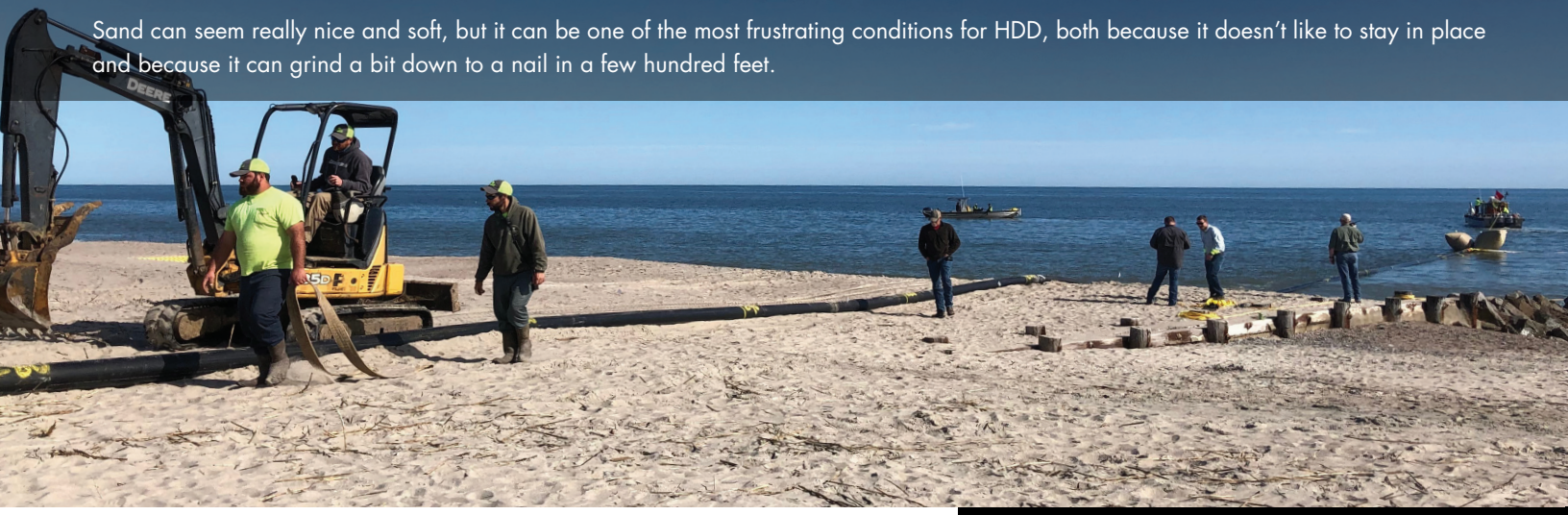
Tornado Reamer



Hedgehog Reamer

SAND & UNCONSOLIDATED SOILS

Sand can seem really nice and soft, but it can be one of the most frustrating conditions for HDD, both because it doesn't like to stay in place and because it can grind a bit down to a nail in a few hundred feet.



DRILLING IN SAND

Drilling fluid additives are your best friend...and you'll likely need a healthy amount of bentonite in your recipe. Bentonite is a finely powdered type of clay that serves, in this application, to coat and stabilize the borehole wall by minimizing the amount of fluid that seeps thorugh the filter cake. If the wall-pack gets too dry it is likely to collapse...along with your production for the day, ruining or delaying production.

PILOT BORE

Select a bit or blade with plenty of carbide cutters and hardfacing. The combination of carbide and hardfacing, applied to the right part of the bit can do a lot to prevent premature wear in abrasive soil conditions.

PULLBACK

You also need lots of wear protection on the reamer you select. Also key is to choose a reamer that keeps the cut sand mixed up with your drill fluid and keeps it agitated, and also has a pumping action to keep it flowing out of the hole. If the sand is idle it will settle very quickly at the bottom of the hole.

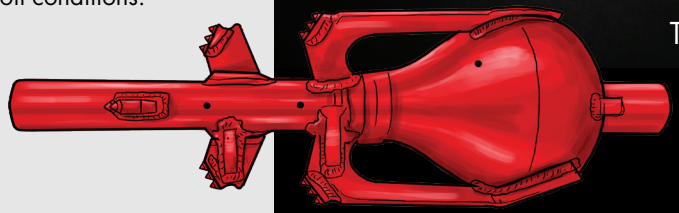
BORING TOOLS

The UltraBit

Bentonite

REAMING TOOLS

Turbo Reamer



Tornado Reamer

DIRT & SOFT SOILS

Soft soils refer to conditions like dirt or sandy loam. These soils are favorable to HDD drilling because they are fairly stable and they don't stick to your tools.

DRILLING IN SOFT SOILS

This type of soil is a driller's dream. Some call it "potato dirt" - a callout to the lush farmlands that potatoes grow in. Standard dirt is fairly loose and easy to work with. In some regions drillers have tried to "dry bore", or go without any drilling fluid, but that is always a risky bet since you never know what variations you'll meet downhole. We recommend adding at least some bentonite to your drill fluid to ensure the hole stays stable and doesn't collapse, but be sure to consult your mud mix specialist and adhere to manufacturer specifications.

PILOT BORE

If the soil is too soft, or boggy, you may have to go with a wider blade than normal to get some steering out of it. Expect the blade to react more slowly when making a steering push due to lack of soil resistance.

PULLBACK

With soft soil, like a loam, make sure the reamer has a good mixing action and then choose the reamer style based on other job conditions, such as rig torque rating and drilling speed. Fluted reamers are great all-around reamer, but an open-style reamer will also work without risk of "balling up".

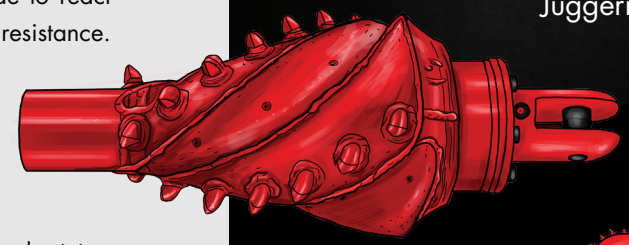
BORING TOOLS

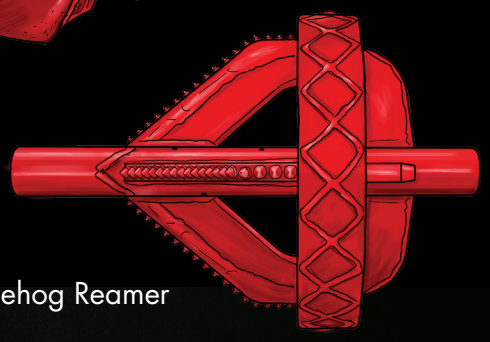
Red Diamond

The UltraBit

REAMING TOOLS

Juggernaut Reamer

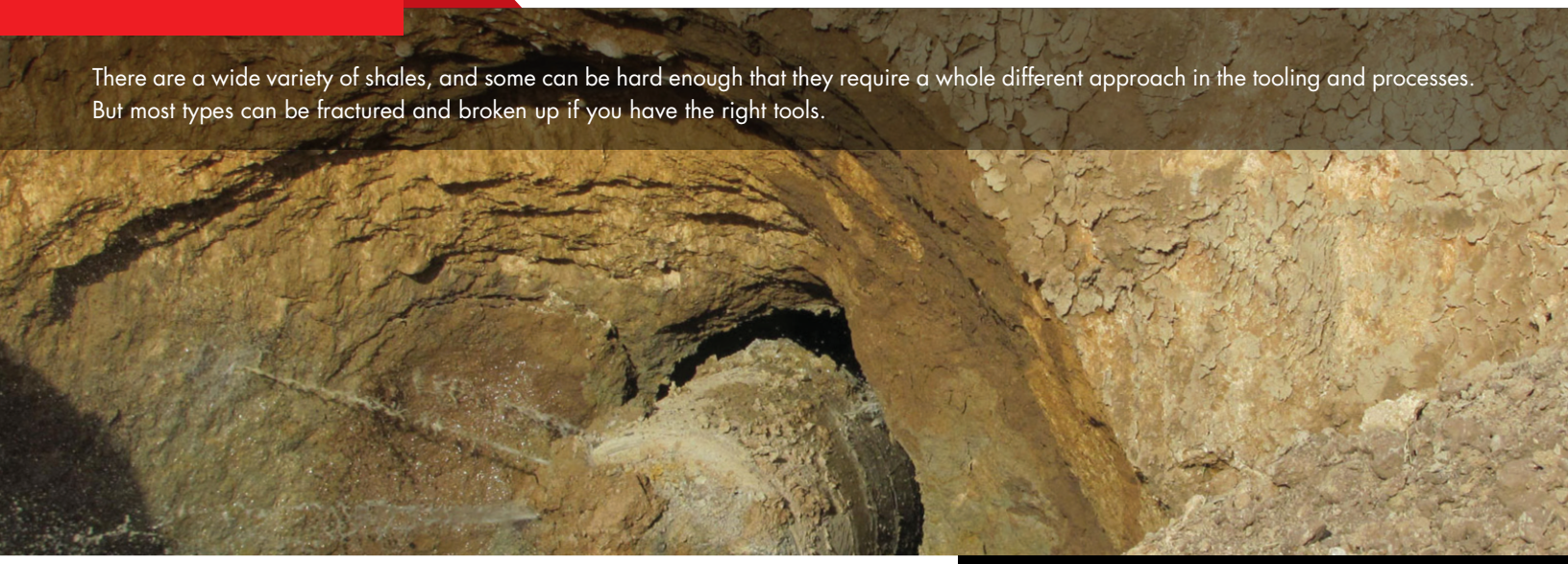




Hedgehog Reamer

SHALE

There are a wide variety of shales, and some can be hard enough that they require a whole different approach in the tooling and processes. But most types can be fractured and broken up if you have the right tools.



DRILLING IN SHALE

Steering in harder ground is slower without the rotary cutting speed that comes with softer grounds. You will want to use a "carving" technique. Basically, this means rotate about 15 degrees on either side of the desired directional change. For a 6 o'clock change (down), start pushing at "4", then slowly rotate with forward pressure until "8". Then pull just off the face of the hole, go back to 4 o'clock and start again. . When reaming, use a medium rotational speed. Unecessarily high RPMs in any hard ground will prematurely wear tooling. Instead, give the reamer time to fracture and carry the cuttings out the hole.

PILOT BORE

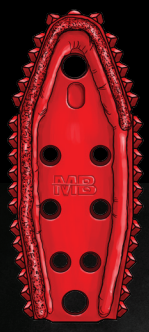
There are blades that can work for shale, but a better choice is a hard soil bit with independent carbide teeth that will gouge and fracture the shale. Shale is not only hard, but can also be abrasive, so make sure the body of the tool has a ton of carbide protection as well.

PULLBACK

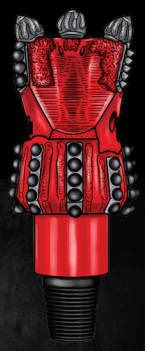
The cutting action of the reamer is very important here. Shale needs to be approached with shark-like, aggressive teeth that are able to fracture the shale. Solid stacked-plate reamers work well with all weight behind it and more teeth than a great white shark. The more teeth...the less each tooth will have to fracture, which will make the reamer life longer.

BORING TOOLS

Red Diamond

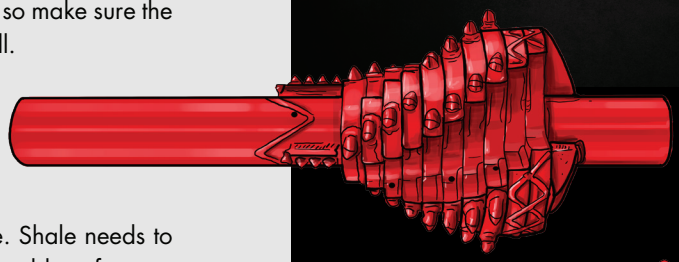


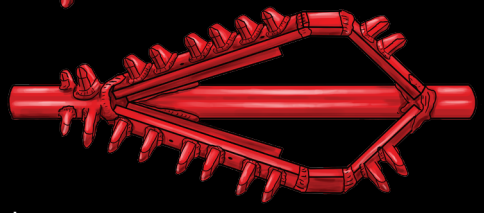
Eagle Claw SD



REAMING TOOLS

Ogre Reamer





Shredder Reamer

SANDSTONE & COMPACT FORMATIONS

These soils can be tough to drill and steer through but in the end you have created a very stable hole.

DRILLING IN SANDSTONE

It's important to anticipate how soil conditions can change when you cut them up from their normal, solid formation. For example, sandstone becomes less rock-like and more of a sand as it is pulverized. Though you likely won't have many problems with a collapsing borehole, you may still need to make sure you have a high rotational speed, with constant mixing and pumping action to keep the sand suspended in the mix so all the cutting can be properly pumped out of the hole.

PILOT BORE

There are blades that can work for shale, but a better choice is a hard soil bit with independent carbide teeth that will gouge and fracture the shale. Shale is not only hard, but can also be abrasive, so make sure the body of the tool has a ton of carbide protection as well.

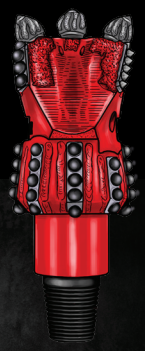
PULLBACK

Choose a reamer that has a lot of carbide cutters, closely spaced, with a gradual increase in cut diameter as the taper of the reamer profile widens. Picture this reamer like it's a hack saw vs a wood cutting saw. The key is to keep a fairly high rotational speed to give you a good cut and grinding action.

BORING TOOLS

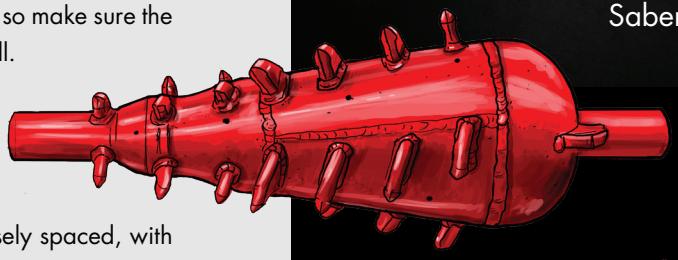
The UltraBit

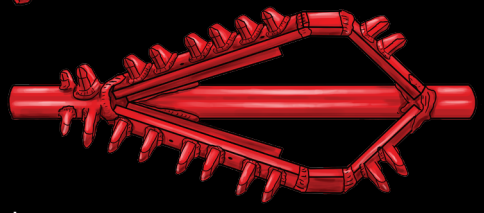
Eagle Claw SD



REAMING TOOLS

Sabertooth Reamer





Shredder Reamer

COBBLES

Let's face it…cobbles and gravel are difficult ground conditions to drill in. The key is to move them rather than cut, so you can pull the product or pipe back through a clean hole. Expect to move slower than other ground types.

DRILLING IN COBBLES

The drill fluid needs to be very thick, called "high viscosity," because some cobbles won't get pushed into the borehole wall and need to be suspended in the fluid and carried out of the hole.

In highly unstable cobble formations, you may even want a special reamer that has a smooth transition section going from the back of the reamer, over the swivel and just about to the puller and product pipe. This will minimize the chance of cobbles falling in the gap between the reamer and the pipe.

PILOT BORE

Though you may break up a few cobbles, mostly you are trying to push them out of the way and roll past them. You need a solidly built bit with lots of wear protection. The bit should roll the cobbles out of the way and compress them into the borehole wall. Use a "wobbling" or "rocking" strategy with a constant forward pressure.

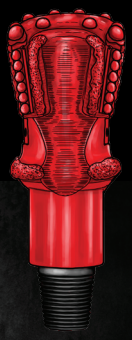
PULLBACK

A solid built reamer, with lots of short carbide cutters is essential to ream the hole without ruining the reamer. Ideally, choose a reamer with carbides that are conical or even dome shaped to minimize carbides breaking. Flutes in the reamers help allow some cobbles to pass by the reamer and out the hole.

BORING TOOLS

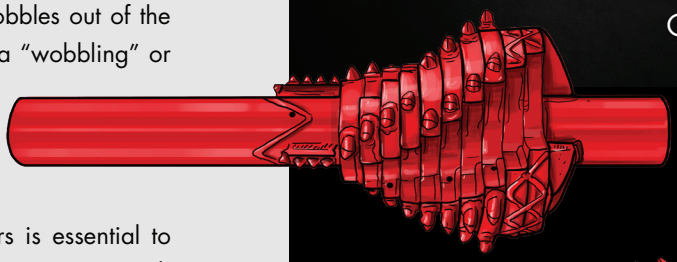
Steep Taper UltraBit

Iron Fist



REAMING TOOLS

Ogre Reamer



Juggernaut Reamer

In our 77 years of manufacturing HDD tooling we have seen all kinds of ground conditions and situations that have tested our expertise. We see contractors succeed when there is a firm grasp on the fundamentals of operations and tooling...everyone should have access to that.

- Peter Melsheimer

IN CLOSING...

By understanding the fundamentals of horizontal directional drilling, you can be confident in knowing how to choose the right tools and equipment, and improve your productivity and success at your job.

Melfred Borzall has been a founding member of the HDD industry and innovative manufacturer during its development since the beginning. We continue to provide support to drillers through education and the high quality standards in all of the tooling we offer.

Now that you understand the basic principles of HDD and the essential considerations when selecting tools for the job, we suggest you visit our website and have a look at some of our most popular HDD solutions. The perfect tool for your next HDD job may be over there just waiting for you to find it.

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