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The 2012 Horizontal Directional Drilling Guide Is Back!

The 2012 Horizontal Directional Drilling Guide marks a first for us: It is the first time we’ve featured the same supplement topic in back-to-back years since we began publishing them on an annual base in 2006. We have covered some interesting supplement topics the last six years but the overwhelming reaction we received for the 2011 Horizontal Directional Drilling Guide made the decision easy when it came to deciding which topic we would spotlight this year. The response also makes us even more confident in the HDD market!

Horizontal directional drilling has certainly experienced its share of growing pains, market fluctuations and reemergence over the last 20-plus years. After a snag of a few years, the HDD market seems poised to regain its consistent footing, with some help from our friends in the natural gas industry and their pursuit of shale formation access. Pipeline and utility construction, longer crossings and wider diameters of pipe have pushed the HDD industry forward and its acceptance as a method of choice continues to grow.

In the 2012 Guide, we take a look at directional drilling’s past through the words and reflections of Martin Cherrington — a man indisputably referred to as “the father of HDD.” Cherrington takes us back to how HDD all began, giving us insight into just how much the industry has matured since those early days and what he thinks of its progression. His innovativeness some 40 years ago is why we are here today.

The industry’s future in shale formations is also presented. Natural gas production has booming potential because of the advancements in accessing the shale formations and one of those technologies to get at the shale is directional drilling. This has added a new and exciting dimension to the HDD industry, with drilling contractors big and small tapping into this market niche. The Marcellus and Utica shale plays in the Northeast, the various formations in the south-central part of the United States, with the Barnett, Eagle Ford, Fayetteville, Haynesville and Woodford regions, and the Bakken shale to the north are just a few of the reserves that could provide abundant, domestically produced energy for the next few decades. Directional drilling has become a critical component of the shale work, providing an economical access method, as well as reducing the environmental impact. We present a case study of the work H&H Enterprises is doing in Waynesburg, Pa., as just one example of this HDD market trend.

The Guide also highlights the diversity of products involved in the HDD field, as well as the popular Drilling Rig Specifications, brought to you with the help of the rig manufacturers.

I hope you enjoy this directional drilling supplement as a great deal of work went into developing articles we believe will be useful to you and the industry at large. Directional drilling continues to be a vital and critical asset to the trenchless marketplace, with its reach stretching and expanding with each year.

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A BRIEF HISTORY OF DIRECTIONAL DRILLING:

The Birth and Development of the HDD Market

By Andrew Farr

Martin Cherrington does not have a Wikipedia page explaining how he is an inventor of the original equipment and process that eventually revolutionized an entire facet of construction. But when trying to encompass the history of horizontal directional drilling, it’s only appropriate to start with the man who many veterans of the trade have come to recognize as the father of HDD.

The Beginning

Horizontal directional drilling is an idea Cherrington first conjured up in the early 1960s when he was working for a utility installation company in Los Angeles. While out on a job, he witnessed another company doing some work nearby, using a hand-held air drill for a gas line installation. From that, Cherrington became familiar with the concept of guided drilling and wanted to take it a step further. He ended up taking it several steps further.

“My father was a contractor and I had an extremely broad background in civil construction,” Cherrington said. “I had wonderful education in different disciplines,
so I was comfortable with welding, fabricating and mechanical-type things.”

By 1964 Cherrington had left the utility company and built his own drill rig to start his own gig with Titan Contractors Inc., where he began working under several contracts with the Sacramento Municipal Utility District (SMUD).

He described his drill rig as having a very basic, spindly, lightweight framework that supported the carriage that rotated the drill pipe. “It actually looked a lot like many of the HDD machines you see today, but slightly miniaturized, very light and skeleton-like,” he said.

Cherrington’s crew performed road boring for various utility companies in the Sacramento area and became known as a leading contractor for that type of work. Since the industry was nowhere near the development of electronic tracking, Cherrington’s crew used a technique he learned from the gas utility that used the hand-held air drill in Los Angeles. During the drilling, they would dig “potholes” at various intervals along the bore path, using depth to check the angle and direction of the drill head.

The River Crossing

As far as road boring for basic utility installations, that was the beginning, even for Cherrington. His next task would mark another milestone in the drilling industry. In 1971, Cherrington was in Watsonville, Calif., doing some drilling for gas lines for the Pacific Gas & Electric Co. (PG&E). While he was in town, PG&E was intrigued by Cherrington’s new methods and asked him if he would take a look at another small problem they were facing. PG&E needed to cross the Pajaro River, approximately 500 ft, to install a 4-in. gas line and was wondering if Cherrington would be capable of drilling underneath the river.

According to Cherrington, this was “no man’s land” at the time because nobody had ever attempted this work. Cherrington faced several problems and at one point, even enlisting the help of some oil drilling methods. After basically experimenting with different approaches, they finally broke through to the other side, having worked on the project for nearly a month.

“Everyone claims that was the first river crossing ever done,” he said. “As far as I was concerned, because we were doing different kinds of jobs all the time, I thought that was it. It was just an odd job and I thought we’d never do that sort of thing again.”

Sure enough, news of Cherrington’s successful river crossing caught wind and he was soon contracted to do an even bigger river crossing in Louisiana. By 1979, Titan Contractors had completed a river crossing in Houston to install a 40-in. diameter pipeline – a job that, at the time, was considered the largest diameter crossing ever attempted.

“It took about 10 years after that first river crossing for [HDD] to really become a household name,” he said. Cherrington would eventually make his way back to Sacramento on a permanent basis, where he founded Cherrington Corp. in 1984, focusing on HDD for fiber-optic installations. But ultimately, that’s how horizontal directional drilling began.

Technology and Modernization

While its beginnings can be traced to Cherrington’s early work, the growth and modernization of the industry over the years is equally important and can be attributed to several developments. Similar to just about every other industry, technology has changed things considerably. With regards to HDD, some of the most important advancements have been in the areas of tracking and steering.

According to John English, president of Horizontal Technology Inc., developments in directional drilling have been directly related to the steering capabilities of drill rigs.

English, who started his career in the oil and gas industry and eventually started Horizontal Technology Inc. in 1997, said techniques in HDD advanced most when early work was done in rural areas with little congestion. He said in order for these methods to be applied in urban areas where the majority of construction was taking place, the industry needed to develop methods of surface tracking. He credits the introduction of magnetic steering tools as a turning point in the modernization of HDD.

In the late 1980s, Tensor, a company working to develop magnetic steering tools, created a steering technology using an artificial magnetic field that allowed a steering tool position to be determined in relation to a source, such as the drill head. For the first time, a contractor could verify the location of a drill below the ground.

“One you could verify the location of a drill head, that changed everything,” English said. “You’re basically drilling with a compass below the ground. This opened up a big market for directional drilling. After that, it was a matter of the industry growing and wanting to get into that kind of work. The problem was that not a lot of people knew how to work in HDD because the process wasn’t well-known.”

English also addressed the environmental benefits HDD provided and said contrary to today, environmentalists were a big ally, mainly because they commended the use of HDD. He explained that environmentalists for example, preferred the method of drilling underneath a river rather than damaging it to trench across and so because of HDD, environmentally sensitive areas generally go undisturbed during a drilling project.

“There probably aren’t any tools in the world that have done more to save the environment than HDD,” he said. “The new generation of environmentalists tends to get HDD for certain applications mixed up with the oil and gas industry and don’t take into account the environmental benefits it actually has.”

The Bidding Process

On the business end, English talked about how the bidding process and the relationship between owners and contractors has shifted.
“Older bids would factor in everything that would need to be done in a given job and would also take into account everything that could go wrong,” he said. “Now everyone is just trying for the lowest bid.”

He also mentioned that because the owner of a pipeline, for instance, had such a close relationship with the drilling contractor, it allowed the owner to learn about HDD firsthand. English said that at the time, this was a great thing because it helped to educate people on directional drilling since it was still relatively unknown.

“At some point the industry grew so fast and you now have consultants communicating with the owner,” he said. “In some ways, the structure of the industry has taken a step backward. But in terms of overall improvements in HDD, methods are getting better, drills are larger and crews are trained better.”

Driving the Market

Since the initial HDD projects, many big companies have entered the market and taken directional drilling to a new level, both in terms of efficiency in the process and the size of projects. It wasn’t until several years after Cherrington’s first river crossing that other companies started to embrace the process.

Eric Skonberg, whose company Trenchless Engineering Corp. provides project management and consulting to HDD owners, engineers and contractors, discussed several of the major players who have driven the industry over the last 40 years and how the applications have shifted. Skonberg said early on, companies such as American Augers and InRock helped progress the industry in terms of providing a variety of services and equipment.

He also explained how many applications of HDD before the late 1980s were mostly in the oil and gas industry and that bore lengths and river crossings started with distances of at least 1,000 ft.

“The late 1980s and early 1990s was really when the small end of the HDD industry took off as Vermeer and Ditch Witch were coming into the market,” he said. “This was when fiber-optic cable installations began. It’s kind of interesting that the industry ended up growing down in installation size.

“The HDD market has also become more regional,” he said. “At the top end, companies like Laney, Michels, Southeast and Mears will pretty much go anywhere and take on any job.”

On the bidding side, Skonberg agreed with English that the majority of engineers and owners are much more knowledgeable about the process now than 20 or 30 years ago.

“I think it’s a much more competitive environment now,” he said. “Owners looked to the HDD contractor for all the engineering in the past, and didn’t have an appreciation for the difficulties that could occur. Now, they are fairly educated on the importance of ground conditions and other things related to engineering and planning for the work. As the technology has grown, so has the preparation of the projects before a contractor even gets involved.”

Cherrington’s Legacy

By the early 1990s, Cherrington held 13 patents on process and equipment he developed for the industry. While some of those have been sold and others have been acquired, Cherrington Corp. today still holds numerous patents on HDD design. Martin Cherrington reflected on how the trenchless industry has grown considering how most HDD practices evolved out of his original method.

“Along the way, as you’re out there working, you don’t really have a lot of time to dwell on things like that,” he said. “But I do reflect back now and look at the past and what has happened. I’ve seen a lot of changes and now, I see tremendous improvement in things like surveying and equipment.”

Cherrington also expressed his admiration of companies doing HDD today and the great strides that have been made with regards to the equipment. He said it has allowed for the completion of big jobs that are on a much different level than the early drilling jobs he was involved in.

“I think today, there are a lot of specialty companies out there making very efficient tools to help make this work possible,” he said. “That first job we did was to install 500 ft of 4- or 5-in. pipe. I just heard about a job that was to install 56-in. pipe that was 5,400 ft long.

“Look at the difference in size from what we did to now and look at how the equipment and tooling collectively, has allowed the industry to take a major jump like that. And what’s it going to be in the next 10 or 20 years?”

Andrew Farr is an assistant editor for Trenchless Technology.
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When our sister publication Directional Drilling would publish the rig specs in height of the drilling boom in the mid- to late-1990s for the compact, mid-size and maxi rigs, there were more than 15 North American manufacturers producing drill rigs. As the HDD market as changed and matured over the years, so have the rig makers. Through acquisitions, consolidations and company closings, today, there are eight rig manufacturers featured in our specifications guide.

Trenchless Technology contacted the industry’s rig manufacturers and asked them to provide the specifications for their fleet. No direct quality comparisons between equipment or manufacturers are implied. All information is provided by the manufacturers. To get additional information, contact the manufacturers directly.

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### Ditch Witch
1959 W. Fir St., Perry, OK 73077
800-654-6481 \ www.ditchwitch.com

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The installation wasn’t the most glamorous the company has completed in the Marcellus shale region, but it was indicative of the type of know-how these projects require: Challenging geology. Obstacles to avoid. Populated locations. Limited right of way. Experience required.

H&H Enterprises has spent the last few years building up its resume of Marcellus shale projects, according to Jason Hockran, vice president and owner of the contracting company based in Andover, Ohio. H&H first got involved in the Marcellus shale in 2008, with work intensifying in 2009. Since then, the company has installed 35,000 ft pipeline sections via horizontal directional drilling in the Marcellus shale region.

The challenges of working in the Marcellus shale, particularly in western Pennsylvania, are logistics and the geology, Hockran says. It can be difficult to...
maneuver equipment in and out of the tight areas found in the hills and mountains of the region, as well as working within a dense population area.

Waynesburg, Pa., located about 60 miles southwest of Pittsburgh, is the county seat of Greene County, which sits on the southwestern corner of Pennsylvania — “the cornerstone of the Keystone State,” as the county’s government website proclaims. Named for Revolutionary War hero General “Mad” Anthony Wayne, the small borough is home to a population of a little more than 4,170 people, according to 2010 U.S. Census data, and it was one of the first epicenters of the shale gas boom.

“Many energy companies have an office or satellite in Waynesburg,” Hockran says. “The region, including the city and a 100-mile radius outward, was one of the first major hot beds for Marcellus shale activity, along with another area near Towanda in Northeast Pennsylvania and 150 miles of the sur-
H&H Enterprises has come to Waynesburg to finish up a project to connect a natural gas well to an existing midstream pipeline segment owned by one of the prominent energy companies active in Pennsylvania’s shale play. Working as a subcontractor to D&M Contracting Inc., of New Alexandria, Pa., H&H completed a 900-ft installation of 12-in. high-pressure steel pipe, using horizontal directional drilling.

Nestled in the foothills of the Appalachian Mountains and located near a busy area just off the highway (I-79), the project presented a number of challenges within its relatively short span. H&H faced the task of drilling under a road, a river, a double set of railroad tracks and an existing gas line that this new pipeline would tie into when all was said and done. But the challenge started with the soil itself.

“In terms of geology, you have topsoil and soft clay on top, and then you can go into cobble and rock formations of sandstone and shale,” Hockran says. “The same geological formations that created the market [for shale gas] also creates the challenges of drilling here.”

The project required H&H to drill from near the well pad, which sits atop a high hill, across a valley — or rather under it — to the gas main on the neighboring hill to the south, where there were a state penitentiary and number of offices, including some energy companies. The right of way on the exit side presented a tight window for the H&H team target.

The five-person crew began drilling June 1 and finished the pilot hole June 4. H&H used pushreaming, rather than pull-reaming, to save on transportation costs and environmental impact.

“It keeps the mud retention system back at the rig, so we don’t have to pump or haul the drilling fluid back with a truck,” Hockran says. “It keeps it at the site where we have our recycling system, and that way we don’t have trucks going up and down the road.”

Because of the busy train tracks, trucks would have had to take a long, circuitous route from the entry pit to the exit side, which would have slowed the production time and caused unnecessary truck traffic on the local roads and highways.

Protecting the environment is just a part of what H&H does, says Bunky Jordan, who is involved with sales and marketing for the company.

“We were a green business before it was popular,” Jordan says. “We do things to
Waynesburg continues to be a significant hub for energy companies working in the Marcellus and Utica shale plays.

If you are interested in viewing a video of a shale pipeline installation project that H&H has completed, visit the company’s website at www.handhent.com for a project in Monongahela, Pa., 35 miles northeast of Waynesburg. The project was a 2,100-ft drill with 24-in. pipe.

These projects on H&H’s resume prove the company has the know-how to get the job done in the challenging shale plays.

Bradley Kramer is associate editor of North American Oil & Gas Pipelines (NAOGP), a sister publication of Trenchless Technology.
Horizontal Directional Drilling Guide

One Company’s Approach to Keeping Its Workers Jobsite-Safe

By Greg Warner and Jeff S. Mueller

As the demand for horizontal directional drilling (HDD) increases, so do requests for deeper and longer bores. With increasingly complex jobs, it is essential for the health and safety of the people involved in the process to remain at the forefront of project planning and execution.

Michels Directional Crossings, a division of Michels Corp., is an industry leader in land-based and marine HDD. Michels has completed pipe installations of up to 60 in. in diameter and has crossed spans of more than 15,000 ft.

While Michels prides itself in its inventive, record-setting solutions, ensuring the health and safety of its people and protecting the environment are integral components of our core values. The Brownsville, Wis.-based company goes to great lengths to implement and monitor comprehensive health and safety plans for its employees.

Safety starts with the crews that are performing HDD jobs. Their well-being is a paramount priority on all projects. Beginning with planning and following through to execution, steps are taken to limit monotony and complacency amongst our people. Michels achieves this by striving to minimize the number of hours worked in one day to the minimum required to meet our customers’ expectations and/or achieve the greatest chance for success on a given crossing depending on conditions encountered, and if at all possible, by not working on Sundays. By minimizing long work shifts, the people involved in the operations are less likely to get fatigued, which can contribute to unsafe practices.

When Michels is invited to look at and bid specific projects, not only are the locations, bore geometrics and terrain considered, but also the impact or potential hazards the work may pose on the public, traffic and the environment.

Once the project is awarded, many wheels begin to turn. A pre-construction meeting is held to plan the layout of the drill site and to execute a high-level hazard assessment. Discussions are focused on several topics, such as existing utilities, special weather and environmental conditions, accessibility for vehicles and the nearest hospitals and medical facilities. Weather conditions run the gamut from high winds to extreme heat to bitter cold to rain or snow, all of which have the potential to affect how people are able to safely move and work, let alone travel to and from the project site.

Comprehensive Site Specific Health & Safety Plans are developed to mitigate, eliminate and/or control any existing or potential hazards that may foreseeably arise during the course and scope of the project.

Meanwhile, back at Michels main office and yard in Brownsville, materials and equipment are continuously and thoroughly inspected as part of an extensive quality control — quality assurance program to ensure maximum possible integrity is achieved through our preventive maintenance initiatives. Prior to materials and equipment being mobilized to the jobsite, all loads are properly secured and double-checked. Once all the Ts have been crossed and the Is dotted, the necessary tools and equipment are ready for transit by Michels’ staff of professional trained and qualified drivers who are all part of a vast Department of Transportation program that is proactively managed by Michels Corp. for all of its divisions. The equipment is checked by the HDD maintenance supervisor and QA/QC manager to make sure it is ready for safe operations. The hydraulic systems are inspected for leaks, as well as any sign of damaged or frayed hoses. A test run is performed at system pressure to confirm all is in good, safe working condition. All engine guards and drill rig handrail systems are inspected and repaired or replaced as needed. All electrical systems are checked for proper grounding and to ensure that all connections are still weather tight. The teams also subject the high-pressure mud-pumping hoses to external visual inspections as well as internal video inspections to ensure reliability.
The hoses are then date-stamped and recorded as “fit-for-use” through use of an assigned serial numbering system. These are just a few examples of the extensive inspection and preventative maintenance systems that are in place within Michels.

While all the preparatory and mobilization operations are under way in Brownsville, the drill site itself is concurrently being prepared with the same care and attention to detail. Most sites Michels HDD works on are “matted” with timber mats, which leave voids or holes. These holes and voids can pose a hazard for slips, trips and falls, as well as cause damage to vehicles on site. In these situations, and in an effort to eliminate some of the risk posed to project personnel, it is best to place sand or small gravel (possibly even sandbags) in the voids, depending upon local and client environmental restrictions.

All site personnel and crewmembers, whether they will be on the jobsite for a few hours or several weeks, are required to participate in the company’s project-specific Health Safety and Environmental orientation training. They are then issued the necessary personal protective equipment — a hard hat, High-Vis vest or shirt, ANSI-approved safety glasses, safety gloves and hearing protection — all of which, if worn properly, should protect them in the event something goes awry.

Once all the support equipment and the drill rig are onsite, warning and project rules/requirement signage is erected at the site entrance to make people aware of the requirements needed to enter. Fire extinguishers are strategically placed around the site. Electrical cords, Kelly hoses with whip checks, water lines and mud hoses are laid out — and are often buried — as to eliminate any additional tripping hazards. “Goal Posts,” or overhead power line warning systems, are erected near all overhead utilities that project personnel may be required to cross beneath or work under, in an effort to prevent contact and raise the awareness of them to the people onsite. The height of the overhead utilities is measured and the “clearance” is displayed on the warning signage near the crossing.

After the site has been prepped and the materials and equipment have arrived, the onsite crew has a daily pre-job safety and Job Safety Analysis meeting to describe and review the tasks that will be taking place on that site for that day. That daily discussion includes any potential hazards (i.e. moving equipment, pinch points, terrain or environmental concerns) that may arise during the unloading, placement of the drill rig and staging of the support equipment.

By this time, the surveyor and other crewmembers have run the wire guidance lines and are getting ready to have the steering tool placed on the rig. The mud tech prepares the mixture of drilling fluid. Due to the noise levels from the diesel engines that run the pumps and electrical systems, and the dust that comes from opening and dispensing the bentonite bags into the hopper, the mud tech is required to wear both a particulate dust mask and adequate, approved hearing protection. Hearing protection is also required to be worn by anyone coming into the area where decibel readings are 85 db or higher.

Running the pilot hole, adding or taking off drill steel, reaming, swabbing and the pipe pull process involve potentially hazardous tasks, thus planning, communication and a high level of safety and situational awareness is of utmost importance. All personnel are made aware of what is taking place regarding the movement of equipment, swinging of the drill steel and rotation of the drill steel. Communication and eye contact between the operator handling the drill steel and ground personnel is critical. Radios are used to ensure communications between the driller, the operator and other personnel on the ground.

When drill steel is being added or taken apart on the exit side, stringent procedural and communication precautions are followed to protect the health and safety of all personnel that are either directly involved in the task, as well as those that may be affected by the task being performed. A safe work zone is established on the opposite side of the rotation when torque is placed on the drill steel. During the reaming and swabbing process, on the exit/pole side, personnel are prohibited from stepping over or coming near the rotating drill steel until an “all stop” command is issued and then verified with the driller on the other side. The verbal repetition of any and all instruction is paramount to ensuring there is no doubt of what has been said.

Once the swabbing process is complete and it is determined that the hole is clean, the product line is connected to the swivel section, and the pullback process can commence. The product pipe is pulled toward the entrance hole while it is suspended and supported by multiple side booms or pipe layers that are appropriately staged in a manner to enable the team to achieve the correct angle. When the pipe is raised, nobody is permitted to walk underneath or stand close to the suspended load. In some situations, water must be added to the product line for buoyancy control. This is accomplished by inserting high-density polyethylene pipe (HDPE) into the product pipe prior to the pull head being welded on. The HDPE is then filled with water through use of a pump until the level of buoyancy necessary is achieved. The water volume and pressure are controlled by a pump system, and pressure relief valves are placed in-line to prevent a possible HDPE pipe burst. Rollers are used on the tail section of the product line for support and carrying of the pipe. After the product line has been pulled through the crossing, the rigging-down process begins.

Completing complicated HDD projects safely, beyond customer expectations and under budget are among Michels’ primary goals, but the one that takes precedence is the safety of its crewmembers.

Greg Warner is the project HSE manager for Michels HDD and Jeff S. Mueller is the operations manager at Michels Directional Crossings.
n a world where congestion of underground utilities and environmental conscientiousness have progressively led to an increase in trenchless construction methods, horizontal directional drilling has seen an increase in both the quantity and the variety of projects on which it is used.

What was once an exotic construction technique for the most sensitive environmental crossings has become a common way to install ducts as small as water services or cable television lines without ruining carefully manicured landscapes. The increase in trenchless construction is growing because of consumer demand for the benefits of trenchless technologies, but utility owners, designers and contractors have to expand their technical expertise to take maximum advantage of these methods. While trenchless experts have historically been called in on maxi-HDD projects, mini-HDD appears to have trickled into the market without as much governance.

The purpose of this article is to introduce some of the resources and concepts from the maxi-HDD arena that can help midi- and even mini-HDD projects succeed more often.

Mini vs. Midi vs. Maxi

There is no hard and fast answer to what constitutes mini-HDD or maxi-HDD. In fact, many projects are now described as midi-HDD, combining characteristics of both schools.

In its 2009 report Guidelines for Use of Mini-Horizontal Directional Drilling for Placement of High Density Polyethylene Pipe – TR-46, the Plastics Pipe Institute (PPI) defines mini-HDD as “a class of HDD typically employed for boring segments less than 600 ft in length, at depths up to 15 ft, and placing pipes up to 12 in. in diameter. The equipment is characterized by a thrust or pullback capability of up to 20,000 lbs, with a torque less than 950 ft-lbs. Mini-HDD machines weigh less than 9 tons.”

PPI further define midi-HDD as “a category that is intermediate to mini-HDD and maxi-HDD, with regard to equipment capabilities and planning and engineering effort. Midi-HDD may be employed for boring paths up to 1,000 feet in length, at depths as much as 75 feet, and placing pipes up to 24 inches diameter.”

Maxi-HDD is logically anything that exceeds the definition of midi-HDD, but it is important to note that definitions of these classes vary greatly depending upon the source.

Although references may vary on the exact definitions of mini-, midi- and maxi-HDD, it is generally agreed upon that the equipment and techniques associated with each class are successively more sophisticated. Tracking systems, equipment, planning, and design requirements all become more sophisticated as a project climbs from mini- to midi- to maxi-HDD.
Maxi-Research for Mini-Projects

When you set out to plan a mini-HDD project, do not overlook information about maxi-HDD projects. The risk associated with a major crossing inherently lends itself to an in-depth analysis of the forces during construction. You may ask yourself what your 400-ft shot of 6-in. pipe has in common with a 3,000-ft shot of 30-in. pipe, but you can rest assured that the laws of physics apply equally to both of these bores.

When you set out to study HDD with the intent of understanding a project that is obviously mini-HDD, do not restrict yourself to case studies of mini-HDD exclusively. Even loosely understanding the careful research that has gone into maxi-HDD techniques will be greatly beneficial to the successful understanding and execution of a mini-HDD project.

The North American Society of Trenchless Technology (NASTT) is an excellent resource for all things trenchless, but peer-reviewed articles written for NASTT’s annual No-Dig Show, which is arguably the most significant trenchless conference in the country, are an excellent source of HDD case studies.

The Go-To Standards for HDD

ASTM F 1962, Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings, is perhaps the most widely cited method for calculating the forces on the pipe encountered during maxi-HDD. Numerous authorities in trenchless technology have written about this standard, some in an attempt to expand upon its capabilities and some in an attempt to explain its reasoning.

The Plastics Pipe Institute’s Guidelines for Use of Mini-Horizontal Directional Drilling for Placement of High Density Polyethylene Pipe – TR-46, referred to in short as TR-46, is a recent guide, at least partially derived from the formulas of ASTM F1962, that “is intended to provide useful information for the less sophisticated mini-HDD technologies and installations, as reflected in the corresponding planning and design practices.” As the report explicitly states, the use of less sophisticated practices in mini-HDD necessitates a conservative approach. In other words, the “rule-of-thumb” approach to mini-HDD that excludes detailed calculations and analysis must err on the side of caution.
It’s All About Mud

Experienced engineers and drillers know that the bits, reamers and other tooling sent down the hole are futile if not supported by drilling fluid flow to bring back the cuttings to the surface. Fluid flow must be sufficient to remove the volume of cuttings that are displaced, and the characteristics of the mud must be monitored to ensure that the mixture is correct for the soil conditions.

Although industry experts now advocate the use of advanced laboratory-quality viscometers to ensure the correct mud viscosity, the traditional tool is a Marsh Funnel. By measuring, the time it takes for a fixed volume of fluid to drain from the funnel, an approximation of viscosity is obtained.

Even for the smallest of bores, ensure that the drilling fluid mixture is correct for the anticipated soil conditions before commencement of drilling. A seasoned HDD engineer or contractor is a great asset here, but a drilling fluid supplier is an excellent resource, as well. Local suppliers tend to have great expertise regarding the local conditions and can describe the correct mixture for the project’s soils.

Although it requires little effort, measuring the viscosity of the drilling mud returns will go a long way to ensure that a clean hole is actually being bored and the mud mixture is appropriate for the HDD.

Of course, inadvertent return of drilling fluid to the surface (hydrofracture, for example) is a large concern for any HDD. A good mud mixture is at the front line of risk management of inadvertent return, but it is important not to overlook basic mud planning. As a rule-of-thumb, the highest flow of drilling fluid that must be collected is during pipe pullback, when the volume of the mud displaced by the pipe plus the amount pumped by the mud pump must be collected simultaneously. Maxi-HDD projects require very sophisticated mud management plans, but applying the basic math of mud management to smaller projects can save significant headaches due to mishandled drilling mud.

Guidance Systems

There are two primary guidance systems in current widespread use for HDD.

Wire-line guidance systems use a fixed electrical connection (hence the term wire-line) to a sonde located in the bottom-hole assembly (BHA) that measures forward motion, horizontal azimuth and vertical azimuth. A secondary coil on the surface is used to correct for the effects of interfering signals. The collected data is used to calculate the location of the BHA.

Although it may not be practical to watch over the driller’s shoulder through the entire locating process, risk of an off-track bore can be mitigated by ensuring that the contractor is qualified to operate a wire-line guidance system. Ensure that the contractor has been trained by the manufacturer of the proposed system. It is not uncommon, and perhaps preferable, for a driller to hire a highly specialized steering hand to interpret the steering data.

The much more common guidance system for mini- and midi-HDD is the walkover system. This system utilizes a sonde in the BHA that communicates with a handheld receiver to determine depth of the BHA. Walkover systems, for the right bore, are very accurate. However, like wire-line systems, require some expertise to use correctly.

A common complaint from utility owners with guidance systems is that there’s no way to verify the data from the contractor, and therefore the location of the pipe in-ground is uncertain. The primary way to mitigate this complaint is to understand the guidance system that is specified. Many HDD equipment suppliers provide complimentary training in walkover systems, and there are classes available for wire-line systems. If inability to inspect the steering process is a concern, training is the simplest way to overcome it, and often this training can be obtained at little or no cost.

If, despite a thorough understanding and comfort level with the guidance system, additional confirmation of the bore loca-
tion is desired, tracer wires can be pulled in with the bore. However, note that the fine gauge copper wire often used in open-cut construction is generally not sufficiently durable to withstand the abrasion of pullback.

**Contractor Qualification**

The idea of asking a contractor to prove qualifications on a highly technical maxi-HDD is not uncommon, but the reasoning applies equally to mini- and mid-HDD projects. Regardless of the size of the project, HDD is a specialized form of construction that requires a distinct technical knowledge. As the risks of HDD become better known, contractor qualifications are becoming common on much smaller projects.

For mini- and mid-HDD, specify that contractors show evidence of qualification by providing a number of reference projects. These references should include, at a minimum, a client contact, project location, pipe size and material, crossing length, site conditions and equipment used. Follow up on the contacts to ensure that each reference project went smoothly.

Also specify that the contractor provide resumes of key personnel onsite and in the office. Ideally, the project manager and superintendent to be used would be the same as those projects which were supplied as references.

**Work Plan and Contingency Plans**

Once required for only high-risk maxi-HDD projects, detailed work plans and contingency plans are now commonly employed on mini- and mid-HDD crossings. Just as shop drawings provide verification that the contractor’s means and methods of construction will meet the design intent, a work plan and contingency plan are essential components of any HDD project.

The work plan should identify the projected schedule, pilot hole and reaming sequence and a detailed list of equipment, including enough information to fully demonstrate that the contractor is prepared to complete the HDD. For mini-HDD, a work plan will surely be much simpler than the voluminous plans that accompany maxi-HDD crossings, but the effort involved in producing the work plan ensures that all stakeholders are on a level playing field before the work begins.

Contingency planning should be included as part of every work plan, and will be project specific, although certain issues are certain to show up in contingency plans for nearly every HDD. For example, the risk of inadvertent returns must be accounted for in most crossings. Proper contingency plans for inadvertent returns include vacuum equipment, containment vessels and strategies for proactively monitoring annular pressures and fluid flow.

Contingency planning should ask include specific methods for mitigating site-specific circumstances. For example, a contingency plan may need to address possible subsidence of a structure near the bore path.

James “Dan” Withers, P.E., is founder and principal engineer of Withers Engineering P.C., a firm specializing in utility engineering and trenchless construction methods.
The goals were straightforward. Replace a leaking potable water line. Protect the environment. Provide customers with reliable water for many generations. The path to success, however, for Miami-Dade Water and Sewer Department’s Infrastructure Assessment and Replacement Program (IAARP) wasn’t as straightforward as the goals.
The new water pipeline would need to be embedded some 60 ft under the bottom of the Biscayne Bay and consist of one, 4,000-ft long line. The environment was fragile. Plus, the new line had to be leak-free and have a 100-year projected life span — the old one was just 25 years old. These issues were resolved because the county elected to use high-density polyethylene (HDPE) pipe for this trenchless installation, which it has also been using in its 2-in. water line replacement program for several decades.

The Miami-Dade Water and Sewer Department operates and maintains the largest water and sewer utility in the southeastern United States, providing drinking water to more than 2 million customers.

The project used a 20-in. diameter HDPE pipeline that was installed using horizontal directional drilling (HDD) to replace a 12-in. deteriorated cast iron transmission line attached to the Rickenbacker Causeway Intracoastal Waterway Bridge between Hobie Island and Virginia Key. This main delivers water to the Port of Miami, Fisher Island, Virginia Key and Key Biscayne. The project was necessary to maintain the reliability of water availability and adequate pressure during peak flow demands. Typical pressure is 60 to 80 psi.

“This line was rupturing at least a couple of times a year and we estimated that every time this happened, we lose at least 2 million gallons of water,” stated Ralph Terrero, assistant director water, Miami-Dade Water and Sewer Department.

“Our study showed that by replacing the existing line, we’ll easily conserve 4 million gallons of water a year. Additional benefits include reductions in unnecessary pumping and operational and maintenance expenditures and eliminating potential health hazards associated with waterborne pathogens entering the distribution system. Based on our calculations that include the cost of water and energy savings, we estimate we will save our customers $156,416 annually by replacing the existing 12-in. pipeline with the new 20-in. HDPE line.”

“Miami-Dade has always been a leader in finding ways to improve the water service to its customers,” said Tony Radoszewski, executive director of the Plastics Pipe Institute Inc. (PPI). “The MDWASD has an ongoing program of replacing water lines by...
using HDD and HDPE pipe. They found that this method is efficient and pleases its customers mainly because there is very little digging. The Rickenbacker project is basically the same, but using pipe that is 10 times larger and is still as efficient and easy to install with very little disturbance to the environment.”

The new HDPE pipeline was completed in March 2010 and used one 4,000-ft long length of pipe made up of 50-ft sections that were heat-fused together using a McElroy T-900 self-contained fusion unit. The JM Eagle HDPE pipe used was PE 3608/PE 3408 HDPE, DR9 with a 2.7-in. wall thickness and a 20-in. inside diameter and supplied by ISCO Industries, Louisville, Ky.

For Chris Lamb, who has 20 years of HDD work to his credit and his crew at Utility Service Authority (USA), which did the drill, the project was “about average.”

“It was difficult but typical for the projects we undertake at USA,” Lamb said. “We were concerned about salt water intrusion and the varying subsurface conditions like limestone, coral and voids in the geological formation. I would say that the logistics of the project was our biggest concern. We had to lay out more than 4,000 ft of pipe, keep the traffic open during the prime season which is January until April, and we had a very small area for staging. The bore took two months — we had a crew of 16 split into shifts working around the clock. All of our concerns with the subsurface conditions were discounted, however, due to our pre-bore planning and we were able to just roll with the punches that Mother Nature gave us.”

The installation was done on a 10-degree entry angle starting from the entrance pit on Hobie Island. Lamb’s crew used an American Augers DD-440T drill rig with 440,000 lbs of pull back, which uses 30-in. drill pipe and a Tulsa MC-1000 recycler. The crew installed a wash-over pipe to complete the pilot hole due to the softer formation in the shallow waters and back reamer to the size required for the product pipe. This back reaming process was done by push reaming to the limited work space available.

Along with the pipe, ISCO provided technical and fusion assistance on the project. “It was a great installation and team approach between USA and ISCO,” according to Bryan Fletcher, ISCO sales manager for Florida. “The project went very smoothly. And what most impressed me was the percentage of pull back force that USA was able use compared to the safe pull strength of HDPE. With HDPE being a very conservative industry, our safe pull is approximately 40 percent of yield, and on 20-in. DR 9, PE 3608 pipe that equates to 165,000 lbs. USA's pull, because of its expertise and planning was less than 50,000 lbs for the entire 4,000-ft pullback. With PE 4710 material coming into the marketplace, the safe pull strength would have been 192,000 lbs. It just goes to show that using an experienced driller that understands his equipment, the job and all facets of the HDD installation, it doesn’t necessarily mean having to use the biggest equipment to make this kind of pull. Sure, there are some materials that have higher tensile yields, but at the end of the day the most important factor is using experienced, qualified HDD contractors.”

“HDD is the preferred method used in large scale crossings such as rivers or large bodies of water such as this project in Miami,” explained Radoszewski. “But the pipe must be able to withstand the force necessary to pull it through the bore and the resulting earth and groundwater forces applied after bore stabilization. As a result, it’s important to specify the appropriate strength pipe. To help design engineers and contractors in this critical step, we created an online tool called the
BoreAid Analysis Software Program specifically for HDD applications."

The BoreAid program can be used to make a preliminary evaluation of polyethylene pipe for use in a directional bore and can be found at the PPI website at www.plasticpipe.org.

“Miami-Dade continues to accomplish major water improvement goals that are cost-effective and will be long-lasting,” stated Radoszewski. “There are always many HDD projects underway here, keeping Luis Aguiar and his crews busy. This run of 4,000 ft is just one extremely long one that they consider ‘average.’ I want to know what they consider a challenge.”

Steve Cooper has been reporting on the water and pipe industries for several decades.

The USA crew used an American Augers DD-440T drill rig with 440,000 lbs of pull back, which uses 30-in. drill pipe and a Tulsa MC-1000 recycler.
HDD Creates New Opportunities for Utility Contractors
By Randy Happel

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For more than a century, the most widely used method for installing utilities beneath the earth’s surface was open cut — i.e., dig, place and cover. Over the past couple of decades, however, the utility installation landscape began changing with the advent of innovative underground technologies; most notably, horizontal directional drilling (HDD).

Despite the long-standing popularity of the open-cut method among municipalities for most utility installations, the HDD innovation locomotive is gaining momentum among the ranks of city officials. Adoption of HDD as a complement to open-cut is due in large part to an increasing awareness of the benefits of HDD, including less surface disruption, minimal inconvenience for residents and smaller footprints. Normal business operations can also remain largely uninterrupted during HDD installations, and more predictable, shorter construction schedules are often the norm.

Moving Forward
The increasing popularity of HDD among utility companies and project owners has prompted more contractors to consider expanding their installation service offerings to include trenchless methodology. Yet contractors are well-advised to be diligent in identifying and researching the pros and cons of offering HDD as an area of installation expertise within their company.

“Horizontal directional drilling is not something contractors just wake up one day and decide they want to offer as a service, and then go out and buy a drill,” says Tony, director of underground solutions for Vermeer. “HDD is a highly specialized installation method that requires operational knowledge, the right equipment and probably most important … experienced drill operators. Offering HDD as an option to complement open cut creates additional opportunities for utility installation contractors; yet it’s a decision that requires diligent planning.”

According to Briggs, getting the process started effectively often begins with visits from their local equipment dealer or manufacturer representative.

“Contractors often rely on equipment manufacturers and local dealers for objective assistance,” says Briggs. “[Manufacturers like] Vermeer have individuals with extensive HDD knowledge and experience, and can help contractors identify factors they should be considering. Their expertise can be a valuable resource in helping contractors make sound business decisions; from identifying objectives to selecting specific equipment models. A local dealer can also provide on-site consultation support when tackling a tough installation job.”

Expanding into HDD can be a great way for contractors to grow their business, increase revenue and further solidify relationships with current customers by providing an

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alternative to open-cut for utility installations. Given that an increasing number of municipalities are addressing aged, crumbling utility infrastructures and many are now specifying that projects — or at minimum, components of jobs — be installed using trenchless methods, the HDD market appears as if it will remain strong for many years to come. Yet, before expanding into HDD, contractors should carefully analyze a number of factors.

**Getting Started**

A good place to begin is for contractors to identify the types of utility installation jobs — fiber, water, sewer, electrical, etc. — their company is best suited for, or has the most experience completing. Once that’s been determined, contractors should then define their capabilities. Knowing this will help in targeting specific projects to bid as well as in selecting HDD equipment best suited for the job. This is an area where the experience and knowledge of established HDD equipment manufacturing representatives and dealers can be most beneficial.

Once the type and magnitude of utility projects has been determined, the next step is to identify equipment that is best suited for specific projects. The drill — albeit the focal point of an HDD equipment fleet — requires a strong supporting cast and crew to successfully complete installation projects. Additional components include (but may not be limited to) an excavator, loader, drilling fluid mixing system, locating equipment, vacuum system and track loader.

Selecting a drill model for the lead role can be somewhat daunting, especially for contractors unfamiliar with pairing an HDD project to drill requirements and capabilities. Size, power, torque, pullback, etc., range dramatically. And then, there’s the tooling … the actual drill bits, reamers and related instruments that are actually at the forefront of a successful bore. According to Briggs, selecting the proper drill and related equipment is an area where the experience and expertise of manufacturer and dealer representatives and specialists can be most beneficial.

“As a general rule, project scope will determine drill size and capabilities,” says Briggs. “Soil and ground conditions will
dictate the most effective tooling. And experience is often the best teacher. Again, contractors should rely on a local dealer and manufacturer representative that they trust to assist in making these decisions. There are very few installation scenarios and challenges we haven’t encountered. Contractors should not shy away from tapping into that experience and knowledge, and start putting it to work effectively within their own company."

Whether to buy new or used equipment will likely be determined by availability of capital resources, although there are obvious advantages to buying new pieces of equipment including warranties, servicing, parts and training — all important considerations for first-time HDD contractors. That’s not to say, however, that buying used equipment that has been well maintained is less desirable. Oftentimes, the cost differential of buying a previously-owned drill compared to a brand-new model will allow new entrants into the HDD service market to purchase required tooling and other equipment, while still being able to take advantage of warranties. If used equipment is purchased from a dealer representing an exclusive manufacturer — as is the case with Vermeer — an HDD contractor will still receive after-the-sale customer service support from an authorized Vermeer dealer regardless of whether a drill was purchased new or used. Estimating expenses for the various components of an HDD equipment fleet can be better established once the contractor identifies the types and scope of HDD utility installation projects they plan to focus on.

**Finding a Skilled Operator**

For contractors willing to make the commitment and allocate the necessary resources to become qualified, reputable HDD contractors but lack initial HDD experience, perhaps the single most important component of the equation will be the drill operator(s). And while the salary to bring on an experienced drill operator will likely pale compared to the dollars needed to establish a fleet of drills and supporting equipment, the importance of investing in a talented drill operator cannot be overemphasized.

“There is a lot of sophisticated, innovative and amazing HDD equipment technology available today,” says Briggs. “But even the most advanced drill is only as good as the operator. The equipment has been designed with operational features that make it efficient to train a good drill operator. But there’s those exceptional elite who just have a sixth sense — a ‘feel’ if you will — for getting the most out of the equipment. Suffice it to say that once a contractor finds an operator with the required skills it’s usually in their best interest to hang onto them.”

Randy Happel is a features writer for Two Rivers Marketing.
Record Crossing Symbolizes Advancements for Industry Standards
Laney Directional Drilling (Laney) completed a record 10,971-ft horizontally directional drilled (HDD) pipeline crossing for Kinder Morgan Pipeline in March, making the possibility of longer HDD crossings within reach for the industry.

“This was the first crossing of more than two miles. We’ve shown we can use the pilot hole intersect method to drill longer crossings,” says Grady Bell, vice president of business development at Laney.

“Instead of considering 7,000 to 8,000-ft drills, we can now realistically look at crossings of 14,000 to 15,000 ft long.”

It was time for Kinder Morgan to replace its existing pipeline that parallels the FM 1960 bridge crossing Lake Houston in northeast Harris County, Texas. The HDD crossing originally started as a design-build project and included a six-inch-diameter steel gas pipeline with a 0.432 wall thickness, fusion-bonded epoxy coating and an abrasion-resistant overlay.

Sunland Construction served as the pipe contractor, and Laney was the HDD sub-contractor called in to complete the project after the first HDD sub-contractor failed. Laney completed the record length drill in just over two weeks.

One key to the successful HDD design was avoiding the previously attempted pilot holes and lost tools left down hole by the first HDD sub-contractor. Bell explains, “Everyone assumed we would go deeper than the first crossing attempt that was at about 160 to 180 ft, but we decided there was a better formation of good, dense sand at about 120 ft depth.”

Laney picked the dense sand to reduce the potential for inadvertent returns and hydraulic fracture. It also wanted to be above the lost downhole tooling to reduce the interference and pilot hole surveying issues its drillers might have encountered from these undesirable obstacles.

The HDD design also included a side bend of 17.5 degrees, which normally is not a challenge on shorter crossings. John Odom, one of Laney’s field superintendents on the record-breaking project, says, “It takes a lot of torque to turn that much of the mud and PH of the water.”

Both Odom and Barton have been working as HDD drillers for nearly 20 years each, and this was the longest crossing either had participated in.

Besides the record-setting length, the Lake Houston HDD crossing had logistical challenges at both the entry and exit locations. The HDD design also included a side bend of 17.5 degrees, which normally is not a challenge on shorter crossings. John Odom, one of Laney’s field superintendents on the record-breaking project, says, “It takes a lot of torque to turn that much drill pipe. We just had to take the side bend gradually and make sure we had really good drilling fluid in the hole at all times.”

Kevin Barton, the other experienced Laney field superintendent on the project, agrees that managing the drilling fluid was another key to success. “We had a mud engineer onsite during construction to keep the fluid right. With this length, we needed to carefully consider things like the viscosity of the mud and PH of the water.”

Both Odom and Barton have been working as HDD drillers for nearly 20 years each, and this was the longest crossing either had participated in.

Besides the record-setting length, the Lake Houston HDD crossing had logistical challenges at both the entry and exit locations. The entry side also had to be modified to fit in between the two “hot” pipelines.

The dead man and LDD-750 rig on the exit side also had to be modified to fit in the space available, and Laney even had to move a section of old pipeline at the site to fit the drilling equipment. Other obstacles acting as work site constraints included railroad tracks, a gas station and apartment complexes to name a few. Odom says the alterations to the drilling equipment were made on the spot as they didn’t know the full extent of the space restrictions until they arrived onsite.

After Laney adjusted to site conditions, a crew from each side drilled toward the middle of Lake Houston.

A mile and a half of the crossing was under water. Barton and Odom worked from the exit side because that is where the 17.5-degree bend was designed. After the drill pipes intercepted, Barton explains that he and Odom took their drilling experience to the entry side to help push the drill pipe out all the way to the exit side of the crossing.

Having the second half of the crossing already drilled via the pilot hole intersect method made it possible to push the drill pipe successfully for such a long length. No reaming was required, so after the drill pipe was through to the exit side, Laney proceeded to pull the product pipe through the nearly 11,000-ft hole.

“As far as the pullback, everything went well,” says Odom. “We worked 24 hour days, in two shifts per day to keep the pipe moving, stopping only to make each of the tie-in welds.” Because of the space restrictions on the exit side of the crossing the pipe contractor, Sunland, had to make three tie-in welds in the rain as pipe pullback was completed.

Laney’s team effort helped make this a successful project for the contractor and for Kinder Morgan. With this crossing in the record books, Laney is ready for its next challenge, and considering the plausibility of even longer HDD lengths is now not out of its or the industry’s grasp.

Alan Snider, P.E., is vice president of engineering for Laney Directional Drilling. Snider has participated in the HDD industry for more than 22 years. He is a licensed professional engineer and holds a Bachelor of Science degree in Civil Engineering from the University of Arkansas.
Cross bores are defined as unintentional intersections of two or more utilities, according to the website crossboresafety.org.

The Problem

Cross bores are typically a result of three types of trenchless installation methods; those using percussion moles, horizontal directional drills or plows. They exist in large numbers, can cause significant damage, injury and death. Cross bores can be prevented and existing cross bores can be eliminated.

Cross bores of communications and pressurized utilities will often “announce” themselves. Water lines, communications cabling and electric lines disruptions are immediately recognized by the installation crews or the users — this is not the case with gas distribution lines installed through sanitary or storm sewers.

The effects of immediately recognized cross bores can be dangerous and expensive to repair. A damaged major fiber-optic cable can have tremendous impact.

Latent cross bores through sewers can collapse of the road surface, infiltration and inflows, higher sewerage treatment plant volumes, siltation of gravity sewers and high wear of pumps. In some cases larger cross bores of large diameter sewers will cause collapse, blockage and fines from regulators for sanitary sewer overflows.

The cross bores that are insidious and most feared are those of a gas line in a sewer. The most expensive single explosion was of single home with two young girls who were horribly burned. The cost to the installing contractor was $30 million. Typically, the explosion results when a drain cleaner is attempting to open a plugged sewer lateral drain with a mechanical root cutter tool. The gas line is cut, the pressure forces the gas into the structure and an ignition source initiates the explosion. It can take as little as 30 seconds from cut to explosion. The intersection of a gas line directly into a sewer would be described as a Class 1 cross bore.

A Class 2 cross bore is less frequent, but to me, less expected and less recognized as an obvious risk. An example would be drilling of a new utility that drills through a sewer but then continues on and later hits a gas line. The annular space around the tooling allows the pressurized gas to push back to the sewer and flow into a structure.

Explosions from cross bores have occurred across the United States and Canada. There are also few reports of water pressure jetting cleaning tools cutting the gas lines. One instance of a HDPE gas line failing after years of lying on jagged edge of sewer pipe is a bit unexpected.

So you may say: “I have never heard of this.” That is why it is important to read on.

Secondly, you may think what are the odds of a gas distribution line intersecting a sewer? Could it be significant? Do you need to worry about a HDD, mole or plow installation, whether as a company executive or an industry professional doing the work? Well, the odds are higher than you think.

One single investigation project done a decade ago found 2.15 cross bores per mile of the 200 miles of mainline sewer inspected, a total of 430. The highest reported project is three per mile. I suspect that an average is more in the range of 0.2 cross bores of gas distribution lines per mile of mainline sewers. Records are not required to be kept.

How could cross bores be so prevalent?

It starts with two primary issues. Knowing where the existing utilities are located, including depth and attributes of the installation technologies discussed. HDD, mole or plow users recognize these tools do not allow for visual inspection of the new utility. If using HDD, consider that the bore path achieved...
may miss other utilities initially, but the reamer may drift to a different alignment, i.e. hard soil interface may cause the reamer to ride upward if the hard soil is at the bottom of the bore. Allowance for the diameter upsize is also required.

Sewers are not typically accurate located by the sewer system operators, if at all. If located by the sewer operator, depth is not given. So sewer operators should provide as much information to the installers of new utilities as known. This is an essential ingredient for prevention of damage. Sure it may be said that “my lines were installed first.” The industry must take a modern progressive approach and work together, despite past traditions.

Keep in mind that the rate payer — whether water, sewer, gas or electric — is the same person. As rate payers, we should expect that the providers work together cooperatively to keep efficiencies higher.

In 1999, there was a good illustration of the simplicity of duties between gas and sewer utilities. A Goshen, Ky, sewer operator filed a complaint with the Kentucky Public Service Commission alleging the gas distribution utility was drilling through their sewers. The gas utilities defended by saying, it didn’t know where the sewers were. Heard that before? The ruling, as paraphrased, was: sewer company, tell the gas company where your sewers are; gas company do not drill through them. Simple... sort of. As you know, execution is not that simple, as you know.

Prevention

There is a justifiable strong damage prevention ethic now widely accepted in the utility industry. This has been a cooperative effort that has shown great success. Gas cross bore damage prevention may offer a slightly differing view of solutions to choose from.

Standard methods of damage prevention are loaded with pre construction methods that have either not been effective-ly implemented or do not fully eliminate the dramatic cross bore explosion from a gas line in a sewer.

So I challenge you to think a bit differently.

Prevention of explosions from gas cross bores should be the goal. Intermediate to that goal is prevention of creating intersections of utilities. So far so good. What has been shown is the present processes break down in effectiveness. If you are an installer, how do you know that you need to pot hole if you don’t know where or even if a line is in your bore path. What happens if a gutter drain is connected to the sanitary sewer or sanitary sewer connects to a storm system?

A gas line inadvertently bored through a gutter drain that is connected to a sanitary sewer provides a path of gas to enter a structure. Sewer laterals can have wyes to gutters, yard drains, and other structures. These types of interconnections require the inspections of lateral sewers to their full extent.

The added practice being used by progressive installers and gas utility operators is to include a post construction inspection of the sewers. This is the essential element in prevention of explosions from gas lines intersecting sewers. Pre-inspection locates are still the norm. The case seems clear that post construction inspections prove the construction has not erred. With the risk as high as $30 million for a single cross bore intersection, post-construction inspections may be the most significant element. Always include post-construction inspections as the essential element if both pre- and post-construction is not supported. Requiring both is the best choice.

Stop the bleeding. New lines should only be installed with additional high-confidence process that assure cross bores are not left behind.

Methods for Inspection

Essentially, the choices for installs is a choice of either open-cut methods or trenchless methods, with an additional inspection requirement. Potholing alone is unlikely to provide assurance that multiple laterals do not come from a single building, that gutter or yard drains are not improperly connected to sewers or that storm drain systems are not connected to sanitary systems. The reality is that when these explosions occur, the installing contractor is paying most of the claims, if enough equity or insurance is available. This is followed by the gas utility’s deeper pockets. Many installers can’t financially withstand such a major claim.

Additionally, inspection methods that are commonly used essentially always have a visual component. Using CCTV cameras is ubiquitous in cross bore pre-construction and post-construction locates. It is also the key element of legacy cross bore elimination projects. These are almost always coupled with sondes and walkover receivers to show at the surface the extent of the inspection. Frequently, the decision is made to inspect fully from the mainline sewer to the foundation of the structure. Potholing or exposing the crossing of the new line at existing utilities for visual inspection is logical after determination of all the possible intersections of sewers.

If accurate and verifiable positions of pipe lines are accurately known, those areas with gas lines widely distant from the sewers may not require inspection. The operative wording is “accurate and verifiable.”

More recently, GPS receivers capable of 1-ft or better accuracy are used to track the extent of the inspections. GPS points are mapped in a GIS system with overlays including aerial photos. This helps track and prove that the inspections were done to the limits required and provides confidence that inspections were not inadvertently missed or intentionally not done. Yes, unfortunately faked video inspections have happened in the past.

Follow-up of all inspections with QA/QC verifies the work is performed fully and accurately. Many experienced utilities have required 100 percent review of all videos. The information can all be tied together to run the project and maintain access to the data on a long-term basis using GIS systems. Analysis has shown cross bore inspection processes that provides for 95.4
percent confidence vs. 99.7 percent confidence are ultimately 80 percent less costly. Additionally, it is not hard to conceive that programs that have lower quality and lower confidence may be required to be completely re-inspected. I am concerned that much of the inspection work now may require re-inspection at a later date because of lack of focus on verification and quality. Certainly, low quality is not a bargain and should be avoided.

New technologies will be developed. GPR and multiple sensors can “see” underground utilities, “look ahead” HDD tools have been researched for many years and the next new technology awaits. Right now, these processes are either not ideal for cross bore identification or are still in need of further research. Currently, methods that include CCTV-based processes rule.

**Risk Evaluation**

Legacy installations need to be inspected. These “ticking time bombs” need to be removed. Cross bores have been recognized since 1976, after the investigation of an explosion and resulting two deaths in Wisconsin. NTSB identified the explosion as being caused by a gas line through a sewer. I believe it is logical that legacy inspection programs will need to last for 10 years or more to identify and remove over four decades of cross bores. Now is the time to start with legacy inspection programs.

Initially, a utility may question what areas are high risk. Well, where gas lines are installed with trenchless technology and sewers exist, look there first. Of those, go to high occupancy structures. First check schools, hospitals, nursing homes, etc. If you are a gas utility owner and don’t know where to start or how to start a comprehensive program. Don’t hesitate, call a cross bore-experienced, qualified CCTV inspection company now and have them start on these high risk locations tomorrow.

**The Solution**

You are the solution. Stop and think what the impact that a high occupancy structure explosion would have as compared to that of a single family home. Worst case, trenchless new installations could be placed under a moratorium by congressional or local action. We don’t need to go there. The industry can proactively handle this. It is our responsibility. You can be part of the solution.

We quantify many things on a dollar basis. What is not quantifiable is the personal impact that can result. First thoughts may be to the person burned or killed in an explosion. It does not stop there. Talking to the executives and the safety director of one company that was involved in a cross bore explosion, the statement was made: “Every morning I wake up thinking, I hope it is not going to another day like that.” I suggest taking heed. It is not only about the money, it can be a life-affecting event that you can act now to ensure that you will not wake up with that thought.

Mark Bruce is president of the Cross Bore Safety Association.
Derrick introduces the new Hyperpool 4-panel shale shaker designed for civil construction and oilfield drilling operations. Fluid Centering Technology maximizes fluid throughput by the machine’s concave screen bed design which produces positive and uniform screen-to-deck sealing. The Hyperpool offers up to 50% more capacity over conventional shakers. The Hyperpool’s single-side screen compression system reduces screen replacement time to less than 45 seconds per panel, permitting complete shaker screen changes in less than three minutes. The innovative screen compression system increases screen life, improves conveyance, and prevents solids from passing under the screen panels. The Hyperpool is powered by two Derrick Super G® vibratory motors, which applies over 8 G’s to the screen frame. Visit www.Derrick.com for more information!
FLYING THROUGH THE GROUND

How Improved Tracking Has Enhanced the HDD Process

By Andrew Farr

The most basic guidance tracking systems for HDD date back to the mid-late 1980s. Since that time, they have evolved significantly in several areas, helping drilling contractors perform the most precise work possible. Industry experts describe it as a matter of obtaining complex, technical information and allowing it to be interpreted in a simple way.

But directional drilling is never simple. Navigating a bore path often becomes challenging due to existing utilities and other underground infrastructure. With that, utility locating is an important part of preparing for an HDD project. When it comes times to do the actual drilling, another challenge is being able to make the most accurate pilot hole possible in terms of depth and direction to make pullback of the product as easy as possible. In order to accomplish this, being able to track the drill head and obtain critical information on what the drill is doing is essential. That’s where tracking comes in.
How It Works

Tracking systems consist of two primary components: a transmitter and a receiver. The transmitter is placed in the drill head, which records information about the drill and relays it back to the surface. The receiver is a device that is held by a crewmember on the surface, which collects and analyzes the data being transmitted.

Transmitters relay two types of information to the receiver. Some of this information is transmitter specific, meaning it is merely status information on the transmitter, completely independent of the receiver, which includes pitch (angle) and roll information of the drill head, battery status, temperature of the transmitter and more recently, drilling fluid pressure. For example, the receiver could be turned off and the transmitter would still be updating this information. The location of the receiver above ground also has no effect on this information. The other type of information that is relayed to the receiver is taken using a magnetic field given off by the transmitter. This information is used to determine depth, direction and target steering. Contrary, these readings are highly dependent on where the receiver is in relation to the transmitter. To pick up the signal of the transmitter, the receiver is set to the frequency of the transmitter and the readings are taken as a crew member walks along the bore path on the surface directly above where the drill head is underground.

John Bieberdorf, senior product line manager for Charles Machine Works Inc., said early tracking systems were slow and very basic. Some contractors adapted sewer line tracers by installing a sonde transmitter in the drill head and locating the position directly above with a sonde tracer or receiver, but these methods ended up being rather inaccurate with regard to distance.

“With the addition of drill head pitch, roll and heading, the bore profile could be controlled and monitored with more confidence when steering around or past other underground utilities,” Bieberdorf said. “Tracking electronics helped take out some of the guesswork and trial and error methods of the early drilling process, giving the operator more confidence in their ability to successfully complete or not complete a job.”

An Airplane Approach

John Mercer and Peter Hambling founded Digital Control Inc., a HDD locating and tracking system manufacturer in 1990. Both avid pilots, Mercer and Hambling wanted to develop sophisticated technology to assist in HDD tracking and had the idea of incorporating aviation concepts and terminology into the design of their products. Today, Digital Control and other manufacturers use aeronautical terms like pitch and roll to describe the orientation of the drill head being tracked during HDD projects. Applying these innovative concepts is just one way the market for tracking systems has evolved over the years.

Siggi Finnsson, a product manager at Digital Control Inc., explained that by looking at how some of the company’s products have modernized over the years is a testament to how trackers across the industry have advanced.

“The biggest difference between us and others is that most other tracking systems evolved out of the locating industry,” Finnsson said. “Most other trackers on the market today have their roots in utility locaters and the requirements of locating an energized utility are quite a bit different than what it takes to track a drill head efficiently. Our equipment was designed specifically to track transmitters.”

Although tracking systems ultimately improve the process and accuracy of drilling, effective tracking is not without its challenges. Allowing field crews to easily overcome these challenges is another way the systems have modernized. One example of is that trackers have advanced to be able to function in areas where drilling crews encounter interference.

Finnsson referred to two types of interference: active and passive. Active interference refers mainly to signal disruption caused by existing utilities and other underground units that emit a signal or generate a magnetic field. Some examples of active interference include power lines, traffic loops, fiber-optic trace lines and invisible dog fences. Passive interference typically refers to anything that blocks a magnetic field without generating a signal, one example being soil classifications. For instance, any soil that is conductive due to metal content – salt, iron ore, copper – can essentially invalidate depth readings.

Specifically, one way Digital Control has worked to overcome these problems is by designing transmitter with greater signal strength. Another improvement in this area has been in the use of multiple frequencies. Because tracking systems use specific frequencies to pick up the signal of the transmitter, another solution to avoiding interference is to simply switch to a different frequency. Therefore, Digital Control has addressed this problem by designing products with multiple frequencies, which is another major development that has been made in regards to overcoming interference.

Keeping It Simple

Finnsson said Digital Control has worked to address improvements to tracking systems in a technical way and when talking about how they have evolved, the biggest improvements have been in accuracy, speed and efficiency. Contrary to older tracking technology that used numerical LCD displays to present information received from the transmitter, new systems have been upgraded to a color display that shows simple diagrams. Finnsson described it almost like operating a video game in terms of its simplicity in reading information.

“Simply said, the ease of use and the way the information is presented is very important and from a contractor standpoint, this has a number of benefits,” he said. “As a contractor hired to drill and put pipe in the ground, I would want to be efficient and fast. Making the locating part of that as simple as possible is what we strive for.

“What we are talking about is relatively complex physics and math, and so it is easy to make it complicated, but very complicated to make it easy,” he said. “We work very hard in the background though design, mathematics and programming to take what is generally a pretty complex physics and mathematical problem and turn it into something that is very easy for the user.”

Andrew Farr is an assistant editor for Trenchless Technology.
Southern Diversified Technologies Inc. (SDT) is a nationally recognized telecommunications infrastructure services company engaged in a variety of large scale fiber-optic cable projects, with a history of fully built-out fiber networks for major telecom corporations.

SDT offers a widely diversified scope of cradle-to-grave telecommunications services, including but not limited to professional outside plant engineering, construction, maintenance and system management of wire line and wireless sectors, as well as real estate and right of way services capabilities.

SDT, in association with Contact Network, Inc., d/b/a InLine, based in Birmingham, Ala., is a technology solutions company offering a complete set of Internet, information technology, managed services and networking capabilities in the region. SDT and InLine are currently working together in Mississippi installing a high-speed, next generation fiber network. This network consists of hundreds of miles of fiber-optic cabling capable of carrying more than 50 billion bits per second of information. This is more than 30,000 times the capacity of the average business or residential Internet connection today. As technology advances, even more capacity will become possible over this same fiber-optic cable.

This network will initially connect more than 130 schools, hospitals, police stations and other public institutions at speeds of one gigabit (1 billion bits) per second. Connections of these speeds will allow schools to implement distance learning programs so that students can take AP and other courses that would otherwise be unavailable in their districts and take virtual field trips to the Smithsonian, NASA and beyond. It will also allow first responders to view video from schools and other sensitive sites in real time to improve public safety.

High-speed, next generation fiber networking will also allow hospitals to roll out telemedicine programs where specialists in Jackson or Memphis can assist in the treatment of patients at rural hospitals and clinics.

**Funding**

InLine was awarded multiple grants totaling more than $30 million under the Broadband Technology Opportunities Program of the American Recovery and Reinvestment Act (ARRA) of 2009. The American Recovery and Reinvestment Act of 2009 is aimed at closing the digital divide for unserved and underserved areas of the country.

InLine has matched the federal contributions required with its own funds. InLine, with the support of organizations and people across Mississippi, invested more than seven months of work in securing this competitive award. InLine president Martin Costa stated that the award was the result of a clear and compelling vision for moving rural Mississippi forward into the 21st century combined with the tireless work and dedication of the entire InLine team.

This project is scheduled for completion in June 2013. It is expected to create dozens of direct jobs and thousands of indirect jobs for the region by making it
more attractive for existing businesses to expand and new businesses to locate in the area.

SDT’s use of cutting-edge technology is not limited to design capabilities. Working with great suppliers like Southern Drill Supply and equipment like the Universal HDD drilling rigs gives SDT capability and confidence to meet difficult deadlines on projects such as the project currently underway for InLine. Universal built a specialized rig for SDT, a UNIVERSAL 36x50 drill rig, to enable SDT to make the longer shots (laser- and GPS-guided direct boring), up to 1,600 ft, faster (in less than four hours) and more accurately than ever before to meet critical schedules that this project requires.

SDT also uses five Universal HDD machines acquired over the past three years. According to SDT equipment manager Steve Smith, “The Universal HDD rigs and high-quality tools, bits, etc. from Southern Drill Supply has allowed SDT to increase our productivity and keep maintenance costs down.

Regional Progress

After dedicating much of their time and resources to disaster recovery, Mississippi is making progress by speeding into the future. That speed is driven in part by the installation of high-tech, fiber-optic networks that will initially connect more than 130 schools, hospitals, police stations and other public institutions at speeds of one gigabit (1 billion bits) per second, thanks to the Inline Project.

We requested a specific design in carriage speed, pump pressure and pullback capabilities to install product faster, further and within a small footprint,” said Smith. “Universal HDD and their local dealer, Southern Drill Supply Inc. offered us the ability to make the specific design changes. Universal HDD engineers like Michael Verbata took exceptional care in verifying our specific criteria could be met. And at delivery, the Uni 36x50 delivered just what we requested. This new machine is turning in production numbers much higher than expected.”

The HDD rig manufacturers like Universal HDD are continually evolving just as the telecommunications industry continues to produce higher speed networks and applications. These applications will be critical in helping Mississippi and the next generation of Gulf Coast Residents as they prepare and respond to future natural disasters.

Josh Varner is with Southern Drill Supply, based in Pensacola, Fla.
The rheological parameters of a drilling fluid define its ability to do work, and as such, it is very important to have a good understanding of what the rheological parameters refer to on a physical basis. Much of the presently available literature is specific to the conventional hydrocarbon drilling industry and is designed to help the reader learn the steps involved in performing a certain calculation. The formulas often used to contain numerous multiplies that act as short cuts to make the formulas easier to use in the field.

While this sort of literature is helpful to learn how to perform specific diagnostic tests, it is not very helpful if one wants to understand how the parameters reflect what is happening in the physical world. In this article, we will derive the fundamental units of the rheological properties by “reverse engineering” the Fann Model 35A rheometer, and through this process, reveal the physical meaning of shear stress, shear rate and viscosity.

**Shear Stress**

A rotating viscometer, such as the Fann Model 35A is used to measure the shear stress that develops in a fluid at various shear rates. This data is used to calculate the viscosity of the fluid. A sample of fluid is put into a cup and raised so that the viscometer’s rotor/bob assembly is immersed in the fluid. The rotor is rotated at a specific RPM via an electric motor. The fluid in between the rotor and the bob splits into layers. The layer that is in contact with the rotor moves at the same rotation velocity as the rotor. The layer of fluid that is in contact with the bob exerts a force on the bob that is equal to the sum of the frictional forces between each layer of fluid between the bob and the rotor. The bob is connected to a shaft that is connected to a spring. The frictional forces that arise between each layer of fluid are transmitted to the bob and cause a drag force on the surface of the bob. The drag on the bob, causes it to rotate but the rotation of the bob is resisted by the spring. The bob rotates until the drag on the bob is balanced by the resistance of the spring. A dial is also attached to the shaft. The shaft rotates the dial so that the dial shows the number of degrees that the bob rotated.

The amount of torque applied to the shaft, and therefore the spring, is equal to the drag force applied on the surface of the bob times the distance from the surface of the bob to the centre of the shaft. The standard spring (S1) that comes with the Model 35A has a torsional resistance or torsional spring constant of 386 dyne cm° deflection. If we applied a force of 386 dyne at a radial distance of 1 cm, the shaft would rotate 1 degree. If we applied a force of 386 dyne over a radial distance of 2 cm, the shaft would rotate 2 degrees. The standard bob (B1) that comes with Model 35A has a radius of 1.7245 cm. The drag on the bob that would rotate the shaft by 1 degree can be calculated using:

\[ T = Fd \]

\[ T = \frac{F}{d} = \frac{386 \text{ dyne} \cdot \text{cm}}{1.7245 \text{ cm}} = 223.833 \text{ dyne} \]

The drag on the bob is 223.83 dyne for every degree of deflection on the dial. This is the drag per degree of deflection that is exerted on the entire bob surface that is
in contact with the fluid, including the side and bottom of the bob. We are only concerned, however, about the shear stress that is created between the rotor and the bob, so the drag that is exerted on the bottom of the bob needs to be taken out of our consideration. The drag on the bottom of the bob is estimated to be about 6 percent of the total drag. If we decrease the total drag by 6 percent, we get a value of 210.399 dyne, representing the drag on the side of the bob per degree of deflection.

If we take the drag on the side of the bob and divide it by the cylindrical area of the bob, we get the drag that is being exerted on each square centimetre of the bob, which is the shear stress \( \tau \) that is being exerted on the bob. The shear stress \( \tau \) experienced by the bob per degree of deflection is thus determined by dividing the force per degree of deflection by the cylindrical area of the bob. The shear stress or drag per square centimetre on the vertical surface of the B1 bob per degree of deflection is:

\[
\tau = \frac{F}{A} = \frac{210.399 \text{ dyne}}{41.174 \text{ cm}^2} = 5.11 \text{ dyne/cm}^2
\]

During operation of the viscometer, we can calculate the stress that is developed in the fluid by multiplying the degrees of deflection by 5.11 dyne/cm².

**Shear Rate**

The Fann Model 35A rotates at six speeds which is given in rpm. The viscometer rotates at 3, 6, 100, 200, 300 and 600 rpm. To express shear rate in basic units of cm/s/cm, we have to convert the rotational velocity to an equivalent lineal velocity. The rotational velocity can be converted to a lineal velocity by first calculating the equivalent rotations per second. Using the 600 rpm rotational velocity as an example we would have, 600 rpm ÷ 60 seconds = 10 revolutions/second. We then calculate the angular velocity or angular displacement of the rotor per second by multiplying the revolutions per second by 2\( \pi \), which would give, \( \omega = f2\pi =10s^{-1} \times 2\pi =62.83 \text{ radians/second} \). Since 1 radian of a unit circle (a circle with a radius of 1 cm) is equal to a linear distance of 1 cm, we can calculate the equivalent lineal velocity of the inside face of the rotor by multiplying the angular displacement (in radians) by the internal radius of the rotor. The internal radius of the R1 rotor is 1.8415 cm. Therefore, the lineal velocity of the inside face of the R1 rotor is:

\[
\text{Lineal Velocity} = \omega \times \text{Radius} = 62.83 \text{ radians/second} \times 1.8415 \text{ cm} = 116.1 \text{ cm/second}
\]
cm. The lineal velocity equivalent to a rotational speed of 600 rpm is then 
\[ v = \omega \times r = 62.83 \text{ rad/s} \times 1.8415 \text{ cm} = 115.705 \text{ cm/s}. \]

The layer of fluid that is in contact with the rotor, is moving at the same speed as the rotor, while the layer of fluid that is in contact with the bob isn’t moving at all. So the fluid at the rotor has an equivalent lineal velocity of 115.705 cm/s, while the fluid at the bob has an equivalent lineal velocity of 0 cm/s. Since the radius of the B1 bob is 1.7245 cm and the radius of the R1 rotor is 1.8415 cm, the distance between these two layers is 0.117 cm. The velocity differential of 115.705 cm/s occurs across a distance of 0.117 cm. To determine what the velocity differential would be across a gap of 1 cm, we simply divide the velocity differential of 115.705 cm/s by the gap of 0.117 cm to yield of shear rate value of 988.906 cm/s/cm. Notice that the shear rate is now in basic units. The general formula to convert shear rate in rpm to cm/s/cm is:

\[
\text{Shear Rate} \left( \text{cm/s/cm} \right) = \frac{\text{rpm} \times \pi \times r}{30 \times 0.117} = \frac{\text{rpm} \times \pi \times r}{30 \times 3.51} = \text{rpm} \times 1.648
\]

For the Fann Model 35A, with an R1 rotor and B1 bob configuration, the shear rate in cm/s/cm corresponding to the 3, 6, 100, 200, 300 and 600 rpm rotation velocities is 9.944, 9.888, 164.8, 329.6, 494.4 and 988.8 cm/s/cm, respectively.

**Viscosity**

The shear stress developed in a 100 cP oil was measured using the Fann Model 35A. The results of the measurements are shown in Table 1 and Figure 1. Since the oil is a

<table>
<thead>
<tr>
<th>RPM</th>
<th>Lineal Velocity (degrees)</th>
<th>Shear Stress (dyne/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4.94</td>
<td>5.11</td>
</tr>
<tr>
<td>6</td>
<td>9.89</td>
<td>15.33</td>
</tr>
<tr>
<td>100</td>
<td>164.82</td>
<td>183.96</td>
</tr>
<tr>
<td>200</td>
<td>329.64</td>
<td>357.7</td>
</tr>
<tr>
<td>300</td>
<td>494.47</td>
<td>480.34</td>
</tr>
<tr>
<td>600</td>
<td>988.93</td>
<td>1052.66</td>
</tr>
</tbody>
</table>

Table 1: Shear Stress/Shear Rate Plot of 100 cP Oil
Newtonian fluid, the viscosity of the fluid can be calculated by simply dividing the Shear Stress by the Shear Rate.

\[
\mu = \frac{\tau}{\gamma} = \frac{183.96 \text{ dyne/cm}^2}{164.82 \text{ cm/s}} = \frac{1.11 \text{ dyne/cm}^2}{1 \text{ cm/s}} = 1.11 \text{ dyne/cm}^2 / \text{s}^{-1} = 1.11 \text{ Poise}
\]

The construction of the Fann Model 35A, with the B1, R1, S1 configuration results in a shear stress of 5.11 dyne/cm² (the drag or force on every square centimeter of the bob) for every degree of deflection that is shown on the dial reading. After converting the rpm to an equivalent linear velocity per radial centimeter (cm/s/cm) as shown above, we are able to express the viscosity of a fluid in a simple, clear and dimensionally consistent way. As a result, the physical meaning of viscosity also becomes quite simple.

Manley Osbak is vice president of engineering and estimating at The Crossing Co., Nisku, Alberta, Canada.
American Augers
American Augers was the first HDD manufacturer to eliminate chain and utilize a rack-and-pinion carriage design, which is now the industry standard. This rack-and-pinion drive provides smoother carriage movement, more precise operating control, longer system life and no complicated parts. The best-selling product from American Augers is Horizontal Directional Drill 10 (DD-10) featuring: a Quick Disconnect Anchor Plate – allowing for multiple drilling angles, available with 15- or 20-ft Pipe Loader, and 100,000 lbs of thrust/pullback. In addition, the DD-10 has a state-of-the-art operator’s cabin, Quiet Pak noise reduction system, an on-board mud pump and the most rotary torque in its class. American Augers machines are supported through a dedicated parts and technical service department.

Astec Underground
The Astec EarthPro Series DD-2024 horizontal directional drill offers 20,000 lbs of thrust/pullback force with up to 2,400 ft-lbs of rotary torque. Powered by an 83-horsepower B3.3C Cummins turbocharged diesel engine, it features field-proven quad rack-and-pinion drive with adjustable force limiter. The onboard mud pump flows 15 gpm at 1250 psi. The floating carriage has two speeds, including a 120 ft/min fast mode. The DD-2024 has independent rear stabilizers and a dual stake down system. It’s equipped with a tethered travel control unit to help operator visibility during tramming and transport, and the front-drive track system offers traction and balance. The patented Es/Lok system is integrated into the drill controls for added safety, and there is an additional strike alert system with a voltage sensor for added safety.

Atlas Copco
For more than 100 years, Atlas Copco has been manufacturing and developing innovating rock drills. As a result, Atlas Copco Secoroc has set the standard for horizontal directional drilling (HDD) under difficult rock conditions. Direct Shot bits combine hard rock-cutting structures, Atlas’s strongest shirttail wear protection and leading-edge bearing and seal package technology to create a pilot bit specifically designed for the HDD market. Atlas Copco bit’s third feature is a random cutting structure with proprietary carbide shapes and grades. A pressure compensated lubrication system and full armor protection package are included. Atlas Copco Secoroc Hole Openers are the first “bit third” type reamers designed specifically for the HDD industry. Rather than using evenly spaced rows of inserts, Atlas Copco uses a random pattern of inserts on the bit thirds, precisely positioned to assure equal load distribution and maximizing cutter count for hard rock applications.

CETCO Drilling Products
CETCO Drilling Products is pleased to announce the development of a new natural gum polymer. VARIFLO CG is a readily dispersible, lower cost alternative to guar. VARIFLO CG is equal to its predecessor in terms of high performance, as well as viscosity, fluid loss and gel strength. VARIFLO CG will build a protective wall cake and bonds to soil particles providing support. This biodegradable, easy-mixing cellulose polymer has now been added to CETCO’s extensive line of high-quality, reliable polymers. VARIFLO CG slurries can be controlled and broken for quick circulation from the bore using CETCO LEB-CD. CETCO’s diverse line of polymers and additives are able to handle any complex drilling conditions and consistently deliver the highest performance. Contact CETCO Drilling Products to find out how VARIFLO CG can assist you in improving the performance of your next drilling operation.

Condux International
Condux International offers the complete line of Triple D HDD and compaction boring tools and equipment. Products available through Condux include reamers, paddle bits and sonde housings for HDD applications and a wide range of compaction boring tools. Triple D is a leader in the manufacturing of high-quality underground construction equipment. Condux International has been manufacturing cable installation tools and
equipment for more than 30 years. Working directly with the electrical contracting, electrical utility, telecom and CATV industries, Condux offers the highest quality tools, engineered to reduce installation time and increase safety. The entire catalog of Triple D products available through Condux International can be found online at www.condux.com.

**DCD Design & Mfg.**

In 1996, DCD Design & Mfg. Ltd. developed the “Harsh Environment Swivel” for horizontal directional drilling (HDD) applications in North America to support this non-invasive, environmentally sound method of installing infrastructure for water, power and gas utilities. Mid-2011, the Maxi-Metric swivels were launched, specifically targeting OE machine builders in Europe. The proven Maxi-DUB Swivels were benchmarked to provide design criteria for the new 250 metric tonne swivel. The new swivel was entirely developed in 3D CAD utilizing finite element analysis. Components were machined from heat-treated alloy steel for strength and wear resistance. The swivels were fitted with precision bearings for long life under high tensile and impact loads and incorporated DCD’s proven three-stage sealing system. The first 250 MT Maxi-Metrics were completed and shipped in December 2011 from DCD Design in Richmond, B.C., Canada.

**Ditch Witch**

Ditch Witch All Terrain directional drills are proven to install utility conduit with exceptional efficiency in the widest range of ground formations, from mixed hard soil to cobbles to solid rock. Designed for use with the JT4020 All Terrain and JT100 All Terrain directional drills, the All Terrain Air Hammer expands the range of Ditch Witch All Terrain directional drills to include the hardest rock. Ditch Witch All Terrain directional drills are proven to install utility conduit with exceptional efficiency in the widest range of ground formations, from mixed hard soil to cobbles to solid rock. Designed for use with the JT4020 All Terrain and JT100 All Terrain directional drills, the All Terrain Air Hammer expands the range of Ditch Witch All Terrain directional drills to include the hardest rock.

**HDD Broker**

HDD Broker is the world’s most effective tool for buying and selling used utility installation equipment. With over a decade of experience buying and selling around the globe, HDD Broker offers the tools that ensure a fast, easy and safe transaction. Browse hundreds of pieces of equipment in dozens of categories at any time by visiting www.hddbroker.com.

**MetaFLO Technologies**

MetaFLO Technologies provides specialized mixing equipment and dry reagent chemistry to turn drill slurry waste into a soft solid that can be disposed of as a solid. The PDM mixing equipment can be mobilized to the site of the bore thereby eliminating the need for vacuum trucks to transport liquids to designated liquid waste facilities. The MetaFLO process reduces trucking expenses and complies with liquid waste management requirements. Benefits from the technology include: Cost-effective; Elimination of liability associated with liquid waste management; Reduction of waste as material reduces in volume as a solid; Use of dump trucks for disposal rather than vacuum trucks; Treatment of fluid onsite; Reduction of required vehicles, truck traffic and related disruption; Best environmental solution to meet regulatory compliance; and Lower GHG emissions consistent with HDD technology.

**INROCK**

INROCK’s new patent pending XTR-S Extreme Reamer features a revolutionary, proprietary, field interchangeable cutter design allowing drillers to easily change cutters, both tungsten carbide insert (TCI) and milled tooth (MT) on jobsite, in minutes, without any welding, XTR-S cutters (TCI and MT) manufactured by INROCK. XTR-S removes all costs associated with old, welded design split bit reamers, such as freight to a weld repair facility, weld repair time and cost or new body costs with each split bit reamer purchase and the need to actually have two reamers of the same type to avoid costly downtime.

**J.T. Miller Inc.**

J.T. Miller Inc. specializes in drill pipe, drill bits, mud motors and HDD accessories for the maxi-rig market. J.T. Miller offers new and Used/Premium Class drill pipe and maintains an inventory of high quality TCI and Mill Tooth drill bits, primarily sizes 8-1/2 in. through 12-1/4 in. J.T. Miller also offers Gearench tongs and spare parts, as well as various tong dies and many other accessories that the company keeps in stock-ready for immediate shipment. J.T. Miller also manufactures 16- to 60-in. split bit Mill Tooth and TCI hole openers designed for various soil or rock conditions.
Mincon

Mincon announces the HDD70 Hard Rock directional pilot hammer. The HDD70 drill bit drills a pilot hole of 7 ½ in. that is matched to the hammer so as to provide excellent protection against bit shanking and excessive stress caused by using a drill bit that is too large for the hammer. As with all Mincon Hard Rock Directional pilot hammers, the HDD70 provides excellent industry leading steering in rock cobbles and dirt, and unsurpassed performance in the hardest of rocks. The HDD70 pilot hammer can be used with existing Mincon Support Stations or obtained as a complete system.

M-I SWACO

M-I SWACO, a Schlumberger company, recently released the HDD Mining & Waterwell Essentials app for Apple and Android phones. The app, which can be downloaded from the Apple App Store and Android Market, enables rig operators to perform calculations for pump output, hole volume, annular volume and other functions. A reference section within the app contains charts and tables to reference pipe and casing details, hole and pump output volumes, unit conversions, product applications and flow charts. These reference materials help guide the rig crew in preparing basic drilling fluid formulations for various conditions. The Drilling Reference Guide within the app includes flowcharts for waterwell drilling, core drilling, and HDD applications. Also included is a Formulas section that allows users to input calculations without having to look to reference materials. Formulas for pump output (duplex and triplex), hole volume, annular volume, estimated solids content, annular velocity (with air or mud) and HDD drilling rate are also included.

Mud Technology International Inc.

Mud Technology International Inc. is a leading manufacturer of drill fluid mixing and cleaning systems. Its MPCT-1000 is an all-in-one Mixing, Cleaning and Pumping Unit. Equipped with a Triplex Mud Pump onboard, this unit pumps more than 600 gpm and cleans more than 1,000 gpm. In addition, the unit comes with four High G Force linear shakers, more than 110 sq ft. screen surface, four centrifugals and a 200-KW Generator.

NEPTCO

Introducing Trace-Safe, the only comprehensive Water Blocking Tracer Wire System available today. It’s a sophisticated system that’s very smart, yet simple to use. The system is comprised of a super-strong, water-blocked tracer wire, time-saving connectors which require no stripping of insulation, and a unique locate clip that eliminates water penetration or a path for water to enter. With this system, you can reduce labor costs and achieve superior locate results, while attaining the highest level of water blocking. Ideal for all trenching and directional boring applications in the natural gas, water, sewer, reclamation and telecom industries, Trace-Safe and the entire water blocking system is engineered and manufactured to deliver greater peace of mind, savings and accurate location.

Prime Horizontal

The Smart Pulling Head is a state-of-the-art pulling head for HDPE pipelines from 160 mm to 315 mm, capable of measuring and transmitting pull force and downhole mud pressure in real time. Pull forces up to 30 tons and mud pressure up to 400 bar are measured directly at the pipe head and displayed in real time to operators during the pulling process. A simple-touch-screen drillers’ display unit can be connected to a laptop to store digital data for later reference. The system requires no physical access or wire connections in the drill string, as all data is transmitted wirelessly to the driller display at the rig, avoiding downtime when pipe pulling. There is no limitation on the depth of boreholes or the length of boreholes making this a flexible solution for measuring pull force and pressure while pulling any suitable HDPE pipe installed with HDD technology.

Railhead Underground Products

The Incredipull puller quickly attaches to the Railhead Incredibit rock bit for the direct pullback applications required by the FTTP projects. No cut away slots in the bit. No bolts or mechanical fasteners to worry about. In fact, this puller will fit the Railhead Incredibit you already own. No need to buy a new bit. Simply remove the center tooth, install the puller, hook up and go.
**RIDGID**

The RIDGID CrossChek Inspection System is designed to find cross bores – the unintended intersection of utilities – during pneumatic boring and utility installation processes. The system allows installers to visually identify and locate unintended intersections with utilities.

The CrossChek system is constructed with a streamlined stainless steel camera and carrier device designed to be pulled back through freshly cut slots 1-3/4 to 3 in. in diameter. It is compatible with most air hoses, can be configured to meet a range of needs in a variety of environments, does not require a significant investment, and perhaps best of all, it offers sight to an otherwise blind process.

**Torquato Drilling Accessories**

HDD PDC Pilot Bits by Torquato Drilling Accessories of the United States provide improved pilot hole drilling performance for the HDD industry. Torquato HDD PDC Pilot Bits are designed for dependable high speed pilot hole drilling in consolidated rock formations including sandstone, limestone and shale. Unlike traditional roller cone bits, Torquato HDD PDC Pilot Bits have no moving parts and are therefore able to be operated at higher rotation speeds to improve drilling rates by a considerable margin. The design of the HDD PDC Pilot Bits also results in longer runs and extended overall bit service life. Product details can be viewed on the TORQUATO website at www.torquato.com.

**Trinity USA LLC**

Trinity USA LLC is pleased to announce the arrival of the X-Series HDD Bentonite Pumps. Traditionally, horizontal directional drilling professionals have relied upon pumping equipment built for other industries. It is now possible to buy bentonite pumps designed specifically for HDD, with: Flow rates ranging from 100 to 1,000 gpm and operating pressures up to 1,700 psi; Reduced pump size and weight compared to traditional pump designs; Advanced design and manufacturing; and Reduced operating costs and less down-time. The first diesel driven X pump (X-3000 with max. 1,000 gpm) was sold to MAXI drill rig operator SP VIS-MOS LTD, in Russia nearly three years ago. Today, X-pump units are operating around the world. The X-Series pumps were designed by Robert E. Oklejas, who together with his wife Laura Oklejas founded TRINITY Pumpenwerk GmbH in Germany in March 2006 where the X pumps are currently fabricated. After selling a minority portion of Trinity Pumpenwerk, Laura and Robert returned to the United States in 2011 to focus their energy on building HDD pumps, spare parts and drilling accessories at Trinity USA LLC, located in Monroe, Mich.

**Underground Tools Inc.**

Julius Caesar, Genghis Kahn, Attila the Hun – You ain’t seen nothin’ yet. Introducing the all new CONQUEROR Line of Pilot Bits from Underground Tools Inc. This new line of pilot bits will conquer more land than all three of these powerful rulers combined. With bodies built from Armor and Ballistic Steel Plate that boasts a hardness rating of R55 and tensile strength rating of nearly 300,000 psi, this new line of pilot bits will conquer any ground conditions they’re matched up against. Carbide segments brazed and welded to the bodies, along with carbide hardfacing complements the Armor Plate and creates the strongest, longest lasting bits on the market. With over a dozen styles available there is a Conqueror bit perfectly suited for your drilling conditions. In addition to being the toughest bits in the industry, they’re also priced to overthrow the market. Call your local UTI Dealer or UTI direct.

**Vermeer**

The D60x90 Navigator horizontal directional drill (HDD), provides impressive power in a small footprint. It’s the cost-effective choice for tackling difficult trenchless installations in challenging ground conditions. The D60x90 is powered by a 185-hp John Deere Tier4i (Stage III) diesel engine, which delivers 9,000 ft-lb of rotational torque and 60,000 lbs of thrust/pullback. Combined with a compact design and modest footprint, the power of the D60x90 rivals some physically larger drills. Contractors can customize the D60x90 with add-on optional features, such as a climate-controlled cab and a front-mounted stakedown system that can reduce the amount of time and materials needed to set up the drill. Customers can choose either 10-ft configurations of 2.875-in. diameter Firestick drill rods or 15-ft rod lengths at 2.875-in. diameter. A 3.5-in. rod option will be available soon.
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Prime Horizontal, providing drilling tools, mud motors and HDD guidance services for crossings beneath waterways and infrastructure, was the first company to steer HDD underground intersects. We have drilled over 50 HDD intersects around the globe now, 20 of which were over 2,000 m in length.

We look forward to partnering with your company for your next conventional crossing or intersect project.