CableLink™ Solution for Wireline Systems

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Abstract
Most if not all of the longer horizontal directional drilling (HDD) crossings require a wireline guidance system to track the drill tool. These systems use a wire inside the drill string to deliver power to the transmitter and to transmit locating data back to the drill crew. Every time a new drill pipe is added or removed, a wire connection is necessary, which typically consists of a butt splice with heat shrink. The connection procedure introduces labor, time, and safety issues—not to mention the potential for a faulty connection. This paper describes a new product, the CableLink™ connection system. This system is permanently installed in the drill pipe prior to drilling, and the electrical connection is made when the pipe ends are threaded together. The paper discusses the development of this novel product and the results of laboratory and field tests, including a brief description of HDD projects undertaken using the system. The CableLink system not only provides a reliable electrical connection, it also delivers direct cost savings and increases in productivity.

Keywords
Wireline system, cable transmitter, drill pipe, wireline connection, transmitter, directional drilling.

INTRODUCTION
Although the majority of HDD projects are completed with traditional walk over locating systems employing battery powered transmitters, most of the larger and more exacting installations are beyond the capabilities of these systems. In those cases, the use of a wireline tracking system is the only feasible way of completing an HDD pilot bore.

The most accurate and sophisticated HDD tracking systems available on the market use a wire connection from the surface to the probe at the front of the drill string. This is accomplished by placing the wire inside the drill string and then splicing on a new section of wire every time a new drill pipe is added. The wire serves two functions: it transmits electrical power downhole to power the instrument, and it transmits data back up the wire from the instrument to the remote display at the drill rig. Generally, the drill pipe itself acts as the power ground and signal return path.

The most labor-intensive and potentially faulty aspect with wireline systems is the electrical connection made when each new drill pipe is added. There are a number of different ways of connecting the wire, but the most common includes the use of crimp fittings or butt splices, which provide the mechanical connection. Often a secondary heat shrink is used to provide a watertight seal for the connection. If the heat shrink does not secure a good watertight seal on the crimp or the wire, a cathodic reaction occurs, resulting in corrosion and a failed connection. This connection, by virtue of the way it is performed or the actual components used, is the weak link in the system.

As the pilot bore advances, the electrical connections are subjected to increasing loads by the drilling fluid being pumped down the drill string. Thus, these connections need to be made flawlessly for the system to work. Not only are the connections the “weak link” but they also add significant time and labor to each drill pipe change, often slowing down the process and reducing efficiency.

Digital Control Incorporated (DCI), the manufacturer of the DigiTrak® and Eclipse® locating systems, has manufactured and sold cable transmitters for many years. As a result, DCI has seen first hand the many ways that these wires and/or connections can fail. Many times, the only alternative has been to retract the drill string, rod by rod, and to start looking for either a break in the wire or a poor connection. This type of troubleshooting, often done under very difficult site conditions, is extremely time consuming and difficult. Experienced drillers have learned to plan for and budget time for unplanned trip outs in their bids. In essence, although the wire is necessary to track the bore, it is also often the source of much lost time and headaches.

This paper discusses a new system recently introduced by DCI called the CableLink™ connection system. This product provides a secure electrical connection for wireline systems without the need to make manual connections—the wireline is installed in the drill pipe, and the connection is automatically made when the drill pipes are threaded together. The system is described briefly below, followed by a discussion of the results of initial laboratory and field tests, including recent projects undertaken using the system. The benefits and potential cost savings possible with the system are also addressed along with a few productivity examples.

CableLink™ CONNECTION SYSTEM

The CableLink connection system is a product that is permanently installed in the drill pipe prior to initiation of an HDD project. A permanent connector is inserted at both the box and pin ends of each drill pipe. A male connector, which is a spring, is inserted in the box, and a female connector is inserted in the pin. When two drill pipes are threaded together, the spring in the box connects to the wire in the pin (see Figure 1), making a reliable electrical connection. At this point, the drill pipe is cable ready.

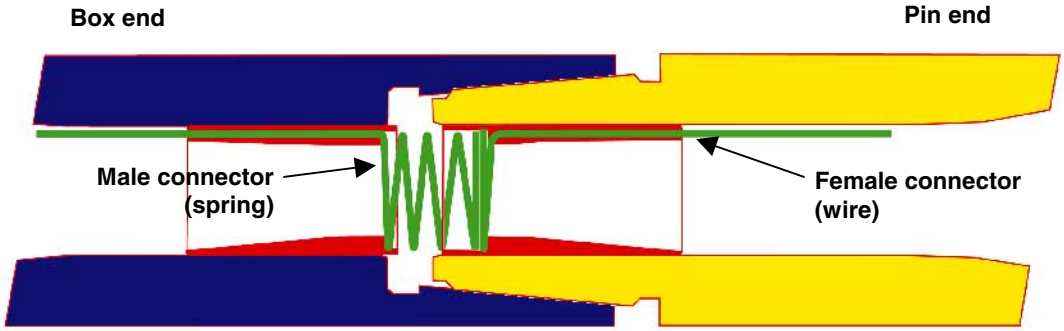


Figure 1. CableLink™ concept

During the development process, numerous criteria were established. The electrical connection resulting from the mechanical connection had to be very sound and able to withstand months upon months of drilling fluid erosion. The electrical characteristics had to be better than with the current butt-splice method and affected minimally by the drilling fluid flow. At the outset, some of these criteria seemed to be mutually exclusive.

Without describing the entire design process, the idea of using spring connections quickly became a front runner. The spring increases the installation tolerance and ensures a firm mechanical connection and a low-resistance electrical connection. In addition, the spring design proved best from a fluid flow standpoint. Since the drill pipe itself is the return path for the current, the spring design is stiff enough to reduce the likelihood of an accidental short between the spring and the drill pipe. The final design step dealt with the issue of drilling fluid conductivity—the spring needed to be electrically insulated to eliminate shorts, which was easily accommodated. After numerous iterations, the final concept emerged as shown in Figure 1.

PRODUCT TESTING

Initial Tests

For the CableLink connection system to be a viable product, two main considerations needed to be addressed and verified:

1. The pressure loss due to the narrowing of the pipe had to be minimized.

2. The power loss in the series of CableLink connectors had to be acceptable.

To test these two criteria, laboratory and field tests were conducted, as described below.

Flow Test

A flow test was set up at DCI using a single 8.9-cm-diameter, 4.6-m-long pipe (3.5-in., 15-ft-long) fitted with CableLink connectors at each end. The pipe was Vermeer Firestick I with an inside diameter (ID) of 2.1 cm (0.84 in.). Varying the volume and using a flow meter to verify the flow rate, the resulting pressure losses were recorded. The test results showed the effect of one set of connectors on the drilling fluid flow. To evaluate the overall effect, the pressure loss in one pipe needs to be multiplied by the number of connections (or drill pipes) in the drill string. The graph in Figure 2 shows the results of the flow test.

Based on the data given in Figure 2, with this pipe design the optimum flow rate is on the order of 303 to 341 lpm (80 to 90 gpm). It should be noted that the pipe tested, Vermeer Firestick I, has a smaller ID than some other similarly sized pipes. Therefore, the flow test was based on the most conservative assumptions.

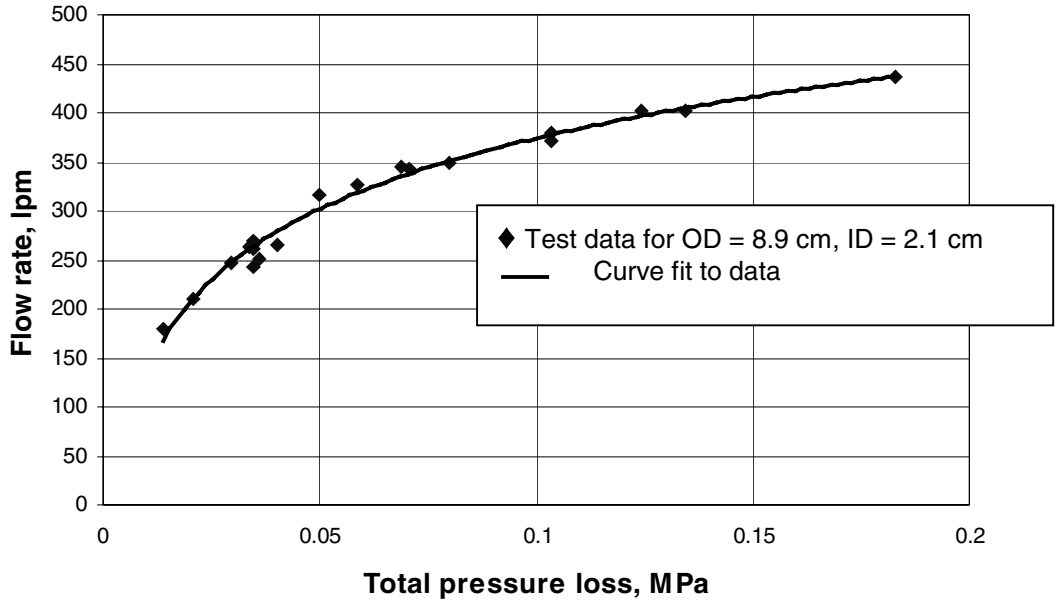


Figure 2. Pressure loss as a function of flow rate

Power Efficiency Test

A mathematical model was developed to predict the power loss based on the electrical properties of the CableLink connector. A field test was then conducted to verify the accuracy of the model. As a part of the field-testing, 396 m (1300 ft) of 8.9-cm Vermeer Firestick I drill pipe was fitted with the CableLink connectors. This pipe was used on a Vermeer D80x100 owned by Bob Hoffman and his company Daman Cable out of Blossvale, New York.

To gauge power efficiency during the field trials, every time a new drill pipe was added, a current measurement was taken. Because the cable transmitter being used is essentially a constant-power device, any increase in current draw would accurately describe the power efficiency. The graph in Figure 3 shows the results of this field test.

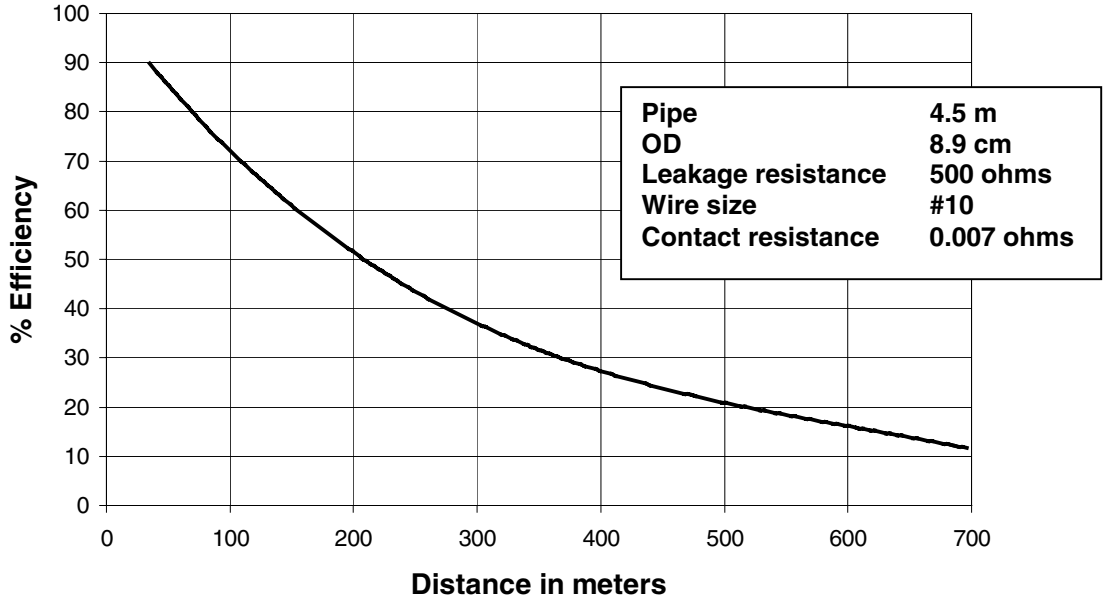


Figure 3. Power efficiency as a function of distance drilled

To quantify the information in the power efficiency graph (Figure 3), the transmitter being used drew about 1.5 amp, assuming a 12-V supply voltage at the outset of the bore. After 305 m (1000 ft) of drilling, the amp draw was between 2.5 and 3 amp.

Field Trials

The CableLink connection system has been undergoing field trials since August 2001. As mentioned above, it was installed in 396 m (1300 ft) of 8.9-cm Vermeer Firestick I drill pipe for use on a Vermeer D80x100 drill rig belonging to Daman Cable. The system has been tested on three separate projects, two of which included the use of a 9.5-cm (3-3/4-in.) mud motor with a 15-cm (5-7/8-in.) drill bit.

The first project was a crossing of the Susquehanna River in Binghamton, New York. This was a 300-m (980-ft) crossing using the mud motor, where the maximum depth was 5.2 m (17 ft) below the water surface. Due to difficult ground conditions, the crew had to trip out of the hole four times to check on and/or replace the drill bit. The second project was a 183-m (600-ft) crossing of Interstate 87 in New York State with a maximum depth of 6.7 m (22 ft), again using the mud motor. On these 300-m crossing the maximum pressure required to run the motor was about 6.9 MPa (1000 psi), which is about 85% of the rated capacity of the drill rig's pump.

The third project was a 283-m (930-ft) crossing in an industrial park in Syracuse, New York, with a shallow 1.8-m (6-ft) depth. The job was done using a conventional dirt head.

In all three of the field trials, there were only two instances where the spring failed in a CableLink connection. These problems were quickly identified and repaired/replaced in the field.

BENEFITS OF CableLink™ SYSTEM

Time and Cost Savings

According to Bob Hoffman of Daman Cable, using the CableLink system reduced his rod changing time from about 15 to 5 minutes. The 5-minute time includes the actual rod changing time and the recording of data as needed, as well as the time it takes to build pressure for the mud motor. On the Susquehanna crossing, based on the number of rods used, this came to a savings of 11 machine-hours. Considering the number of times they had to trip out of the hole, the actual time saved was many times that.

Direct cost savings include all the materials typically required for a wireline bore, such as the wire itself, splice connectors, and heat shrink. In addition, in many cases extra personnel is needed on the site for the connection work. This additional manpower is no longer required.

Additional Benefits

Hoffman stated that there are other less obvious benefits. As an example, the cost of tripping out as often as necessary to check tooling wear has to be weighed against the time saved by continuing with tooling that may be getting marginal. With the CableLink system, that decision is very easy because of the speed with which one can trip out. Changing or checking the tooling can be accomplished much faster than before.

According to Hoffman, the risk of a bad connection or even of a poorly manufactured connector is also eliminated. It is difficult to quantify in dollar terms, but anybody that has done any wireline drilling has experienced an unscheduled trip out. With the CableLink system, the expense of constantly purchasing batteries for the transmitters and, maybe more importantly, the risk of prematurely failing batteries is eliminated.

With the coming advances in the field of HDD locating, according to Hoffman, having a wire connection to the transmitter will be required to take full advantage of the capabilities of future systems. As such, he feels that the CableLink connection system is well worth the investment.

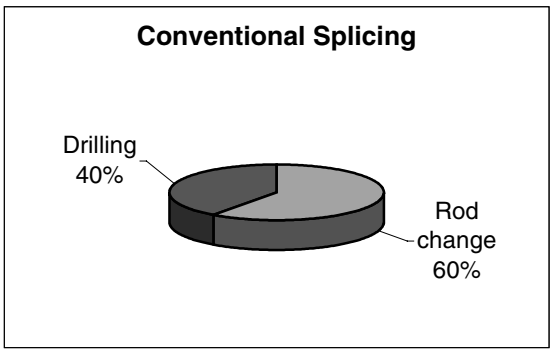
Productivity Study

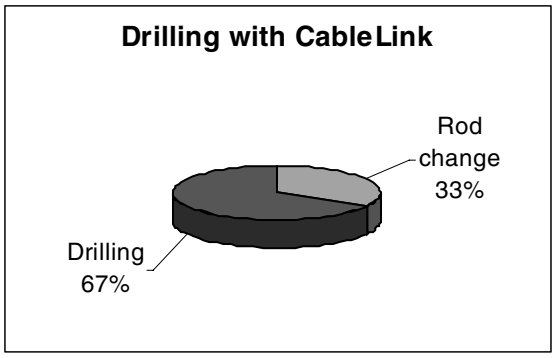
Using the field trials as a model, a number of productivity studies were conducted to determine the potential time savings. The primary assumption was that the time to change drill rod was reduced from 15 to 5 minutes with the use of the connection system. This assumes the use of a mud motor since without it the rod changing time would be quit a bit shorter.

We will look at two of the cases; first a pilot bore of a 400 m (1312 ft) length using 4.5 m (15 ft) drill rod with an average drilling time of 10 minutes per rod, second a 750 m (2,460 ft) drill, using 10 m (30 ft) rods with an average of 30 minutes drilling time.

These studies only look at how the time spent actually drilling and splicing the wire in comparison to using the CableLink connection system. In essence, with all other time factors being equal regardless of whether traditional splicing is used or not, the study looks at how much time can be saved with this new system.

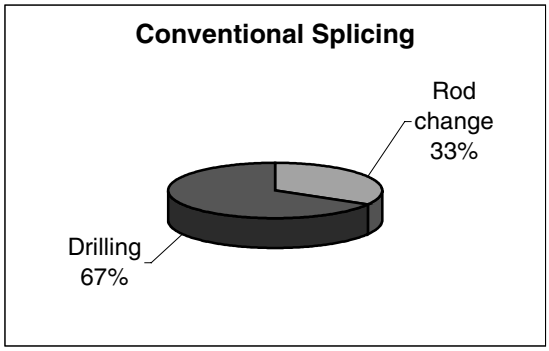
Case 1 - 400 m pilot bore, 4.5 m drill rods and 10-minute average drill time per rod.

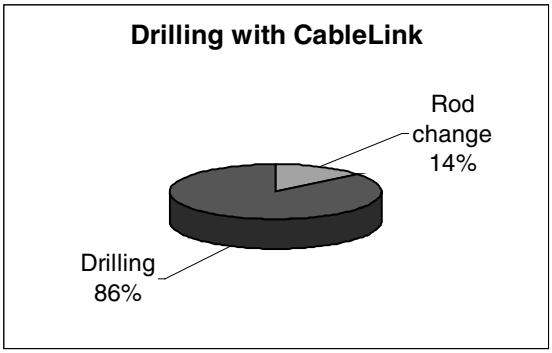




The overall time savings amounts to almost 15 hours, shortening the actual pilot bore time by 40 percent.

Case **2** - 750 m pilot bore, 10 m drill rods and 30-minute average drill time per rod.





In this case, because of the length of time it takes to drill each rod, the splicing function becomes a smaller portion, but still significant at 33% of the time. Here the time savings using the CableLink connection system is 12.5 hours or about 22% assuming conventional splicing.

CONCLUSIONS

The CableLink connection system has the advantage of delivering direct cost savings as well as significant increases in productivity for any contractor involved in wireline drilling. In addition, it eliminates the weakest link in conventional wireline projects and replaces it with an easy-to-use system integral to the drill pipe. A contractor can now have all the benefits of the higher capability wireline systems without most of the headaches and uncertainties associated with the traditional means of splicing the wire connections.

The CableLink system is in the final development stages. At this point in time, designs are being finalized for various pipe diameters, which should widen the range of machines capable of using this new product.