Dual tube drill rod that is 8⁵/₈ inches. Inner tube and outer tube connections are made up simultaneously.

The Expanding World of Reverse Circulation Drilling

The environmentally friendly process is ideal for large-diameter wells in a variety of formations.

By George Burnhart

Reverse circulation drilling is a drilling technique continuing to evolve and provide real benefits to the water resource industry and beyond.

A hybrid of dual tube reverse circulation drilling is dual tube flooded reverse, often called DTFR. It is an environmentally friendly, non-invasive drilling process that preserves sensitive ecology both above the ground and below the surface.

DTFR uses a combination of natural formation water, added clean water, and compressed air to mobilize drill bit cuttings to enable the advancement of large-diameter borings in formations ranging from unconsolidated geology to medium hard and fractured rock.

This is accomplished as a result of DTFR's unique ability to provide a stabilizing effect on the borehole via its fluid column by gently exerting hydraulic pressure on the wall of the boring.

DTFR employs a tricone bit equipped with an adapter sleeve designed to accept the cuttings that travel from the bit face through the interior of the tricone bit and are directed into the inner tube of the RC drill rod.

This hybrid technique has gained popularity in drilling communities across the country from contractors on the West

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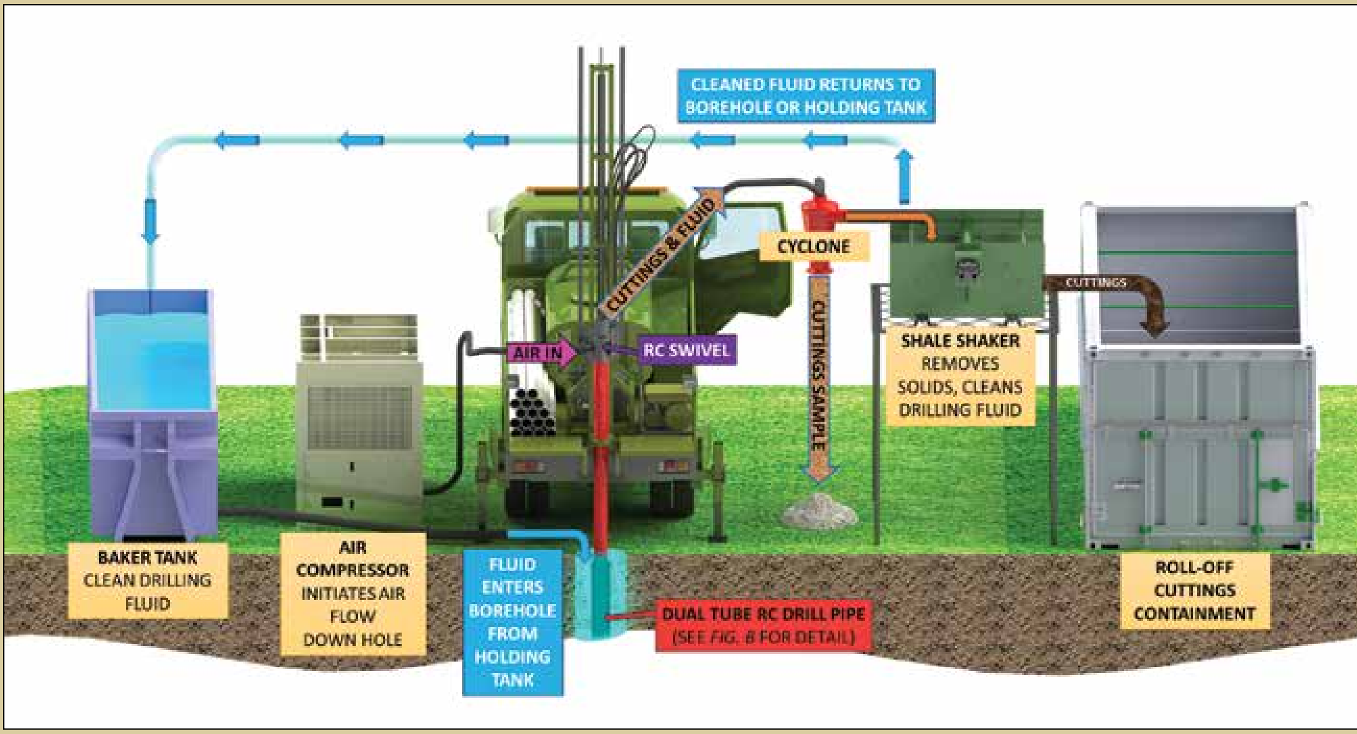


Diagram A. Surface view of a dual tube flooded reverse system setup.

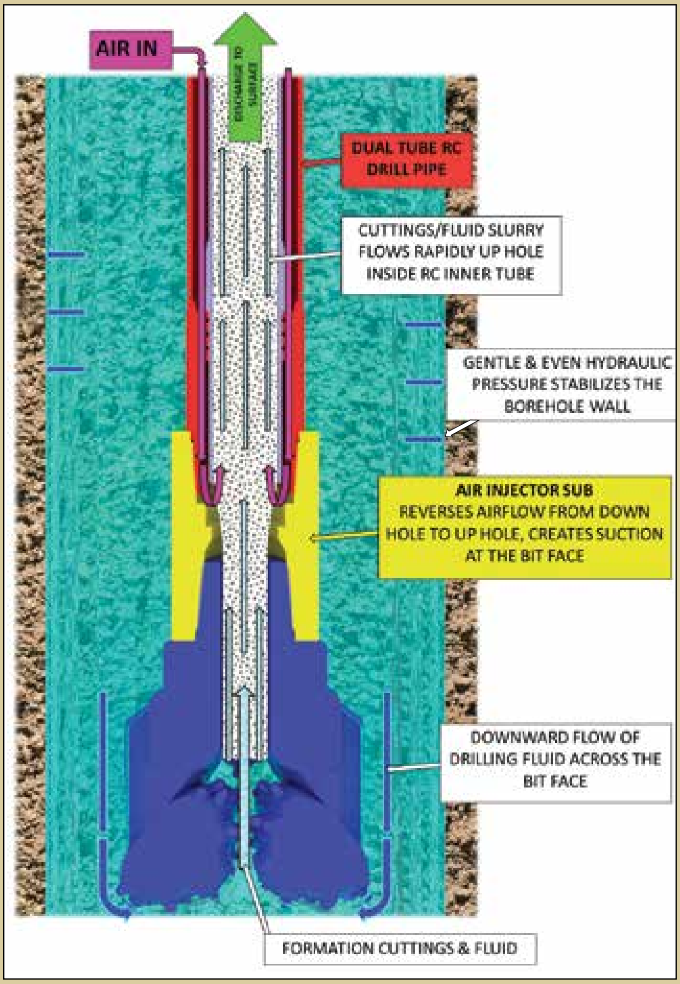
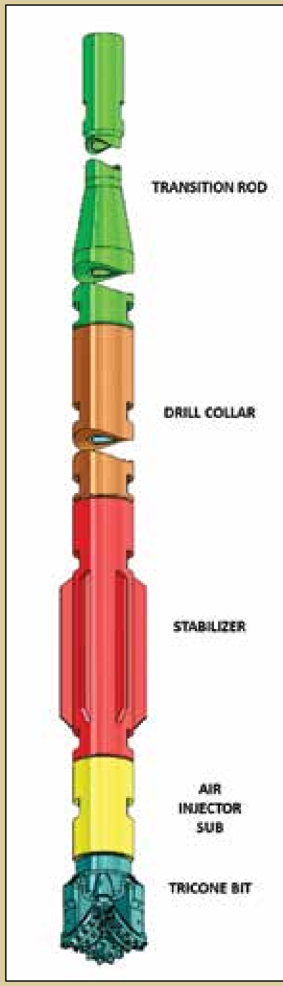


Diagram B. Movement of the air, cuttings, and fluid in dual tube flooded reverse drilling.



The bottom hole assembly (BHA) connects to the dual tube drill rod and performs a number of key functions: The stabilizer keeps the borehole plumb, drill collars deliver weight on the bit while keeping the drill string in tension, and the transition rod provides stress relief from potentially destructive torsional and lateral forces within the drill string itself.

The air injector sub reverses the airflow from a downhole direction to an uphole direction within the inner tube of the RC rod. The air injector sub is positioned directly above the tricone bit as shown in the diagram when using dual tube tools in the bottom hole assembly.

It is also common for drillers to use single tube drill collars, and a stabilizer and transition rod in the BHA. Utilizing a single tube BHA, the air injector sub is positioned on the top above the transition rod, making this the point at which the air is turned around to flow uphole.

Diagram C. Bottom hole assembly used in dual tube flooded reverse drilling. See hole opener image on following page.

Hole openers are commonly used as a component of the BHA to increase the diameter of the borehole. The hole opener can follow a previously drilled smaller-diameter pilot bore, a method used to ensure the boring is plumb before the final larger-diameter bore is completed. Alternatively given the right geology, the hole opener can be deployed close to the surface and achieve the desired bore-hole diameter in a single pass approach.

Dillon and Klint Gingerich of Gingerich Well and Pump Service LLC team up to complete a municipal well project using DTFR with a Schramm TX 130.

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Coast, in the deserts of the Southwest, the plains of the Midwest, the southern reaches of Florida, and on the islands of Hawaii. It has also gained traction internationally in Canada, Australia, and Latin America.

DTFR applications are typically characterized as projects entailing large-diameter water resource wells in sedimentary and/or metamorphic geology with depths commonly ranging from 500 feet to 3000 feet where environmental stewardship is of importance.

Applications

DTFR has also been utilized in applications found in the mining industry such as dewatering wells, construction of vent shafts, paste holes, and injection and disposal wells. In the civil construction industry, it has achieved notoriety for its ability to advance large-diameter foundation boring in environmentally sensitive urban areas.

It has been used many times on waterfront projects where controlling contamination is a primary concern. Large-diameter reverse circulation has also gained a foothold in its ability to set conductor casing for oil/gas and geothermal wells while protecting adjacent potable aquifers.

DTFR's recent emergence on large-diameter water resource projects is a result of industry pioneers and their success in applying this technology. Its unique benefits are gradually being disseminated and increasingly put to use within the drilling community and offered as options to their customers.

How It Works

See Diagrams A, B, and C. The borehole is continuously filled with drilling fluid and a fluid column is created and maintained between the borehole wall and the outside of the dual tube drill rod.

Compressed air is then introduced flowing downhole via the annulus of the RC dual tube drill rod (air flows downhole between the inside of the outer tube and the outside of the inner tube).

The airflow as it nears the bottom of the drill string is redirected uphole and inside the inner tube. The drill string component responsible for redirecting the airflow into the inner tube uphole is termed the "air injector sub." Its job is to release the compressed air into the inner tube where it expands and thereby creates a dynamic upward flow—following the path of least resistance—which then carries a slurry comprised of air, drilling fluid, and borehole cuttings uphole to the surface.

On occasion, suction pumps are also used to further assist the upward flow of the drilling fluid slurry.

Upon reaching the surface, the slurry enters the cyclone where the fluid and cuttings are separated using the cuttings' own weight combined with centrifugal force to effect separation. Once separated, the cuttings can be viewed and accessed. Next, the drilling fluid output from the cyclone travels to the shale shaker where it is cleaned by removing the remaining solids.

The shale shaker accomplishes removal of the solids and cleaning of the drilling fluid by utilizing a vibrating platform that employs a combination of screens, gravity, and vibratory energy. The cleaning of the drilling fluid is a vital step within the DTFR operation as too many solids carried in the drilling fluid can ultimately impede proper bit and hole cleaning and ultimately stick the drill string.

Once cleaned, the drilling fluid is then returned to the fluid holding tank and eventually back to the top of the borehole as needed. This recirculation and cleaning of the drilling fluid is an ongoing cycle that continues throughout the drilling process.

Benefits of DTFR

DTFR matches up positively with basic requirements needed to construct large-diameter municipal and commercial wells in many regions across the country. DTFR is also environmentally friendly, enabling control of both cuttings and drilling fluid discharge, thus minimizing runoff and site contamination.

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A shale shaker removing solids from the drilling fluid.

Samples are very accurate with dual tube flooded reverse drilling. Photo courtesy Traut Companies.

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Formations that can thwart the use of air or mud rotary drilling with loss circulation can be drilled effectively with DTFR. The borehole fluid associated with DTFR moves slowly—so it does not erode the borehole wall, rather it protects and preserves the borehole by exerting a gentle and even hydraulic pressure against its wall.

This provides stability and enables advancement of large-diameter wells in unconsolidated and/or sedimentary formations that would otherwise be problematic with conventional drilling techniques.

DTFR in most cases does not require the use of mud or additives and is a non-invasive drilling technique using both low psi air and low-flow drilling fluid.

The formation remains open, not sealed or packed with drilling fluid additives, which is significant as it enables both faster well development and many times results in enhanced quality of the well and its production.

DTFR samples can be considered more accurate than air or mud rotary samples as they are not exposed to the borehole wall which can contaminate the sample. The DTFR sample travels directly from the bit face uphole securely contained within the inner tube to the collection area.

The sample is also clean without a bentonite coating. The cuttings instantly reveal the current formation being drilled. The clean sample allows easy identification and characterization of the lithology, assisting in optimum placement of the well screen.

Only low-pressure air is required; therefore, howling air compressors and drill rigs at full throttle are not present. Rather the site is relatively quiet, thus minimizing disturbance in populated areas and to wildlife.

DTFR Limitations

Tooling up for DTFR requires a substantial investment to begin: a suitable rig, in-hole tools, shale shakers, and a compressor. And the economics associated with DTFR technique only begin to really pay off when borehole size is 20 inches in diameter or larger. Smaller-diameter shallow borings are more likely to be drilled by conventional air and mud rotary, cable tool, or auger techniques. Most DTFR projects are at least of medium hole depth and commonly range from 500 to 3000 feet.

The dual tube tools are relatively heavy; therefore, the rig must have adequate hook load capacity (hoisting and lowering capacity). There can be depth limitations, but if you have a large enough drill rig, DTFR has been used successfully in depths of more than 10,000 feet.

While the drill site can be relatively small, it's still a minimum of approximately 125 feet square, which is larger than some other drilling techniques require. DTFR also requires a good source for large volumes of clean water in proximity.

DTFR is less effective in homogeneous ultra-hard igneous formations; penetration rates are best in granular formations. Ultra-large cobbles can be a problem if they are so large they cannot pass through the RC inner tube. DTFR is also not a good match for extensive drilling of sticky clay, silts, and other ultra-fine grained formations.

Finally, it requires an experienced operator with expertise utilizing this drilling technique.

Voices from the Field

The following are comments from experienced DTFR drilling contractors from around the country.

Gingerich Well and Pump Service LLC in Kalona, Iowa

Klint Gingerich and his brother, Korwin, are co-owners of Gingerich Well and Pump Service, a family-owned and operated business founded in 1956. Gingerich's involvement with dual rotary drilling began in 2007 when Klint made the decision to employ the technique based on its ability to provide containment of drilling fluids and the efficient cleaning of large-diameter boreholes. Gingerich's primary applications for DTFR are on projects entailing the construction of municipal and commercial wells.

Gingerich Well and Pump utilizes DTFR in hard limestone and sedimentary formations in Iowa and surrounding states. Klint says that boring diameters of 20 inches and larger are a good match for DTFR. His crews use a custom RC drill string of 8⅝ inches OD × 5 inches ID. Klint chose this size of tools as the 5-inch ID of the inner tube is matched to the 5-inch through-hole in the tophead of the drill rig. Thus, with common dimensions he maximizes the fluid flow he can achieve with his equipment.

The fluid flow is a key factor in large-diameter drilling as it directly impacts cleaning of the borehole, drill bit, and the overall productivity in advancing the borehole. There is an extremely large volume of cuttings generated from drilling a 20-inch to 40-inch boring, and the greater the flow volume that can be achieved, the more efficient the removal of the cuttings from the borehole.

Klint mentions there are limitations to DTFR. He says the expense of gearing up for large-diameter drilling requires a substantial investment such as the appropriate drill rig, in-hole tools, and associated equipment.

Traut Companies in Waite Park, Minnesota

David Traut, MGWC, CVCLD, is vice president of Traut Companies and commented flooded reverse is a good technique for drilling large-diameter water wells in the fractured limestone formations common to central Minnesota.

He first used flooded reverse in 1999, and through experience has made it a method he relies on for municipal wells. The loss circulation zones that caused problems with other drilling methods are no longer a problem for him with DTFR.

Traut can operate DTFR within a relatively small footprint (125-foot square site dimensions), incorporating a drill rig and auxiliary equipment including a 5000-gallon drilling fluid tank, air compressor, and solids removal equipment.

Traut notes the air volume required for a DTFR borehole is relatively low versus air rotary. He says approximate air is 500 to 600 cfm at 150 to 350 psi with the psi more a function of hole depth.

Although not used as frequently as a tricone bit when harder rock is encountered, Traut uses a downhole hammer with a diverter/packer positioned above the interchange (crossover). The diverter/packer is a large rubber donut that surrounds the RC drill rod and partially seals against the borehole wall. It limits the inflow of water downhole to the hammer. A water column is still maintained above the diverter/packer to effect hole stabilization.

The use of a hammer for Traut is in dolomites and granites. The downhole hammer mode requires much larger volumes of air at higher pressures. Traut's crews commonly utilize approximately 3000 cfm at 325 psi and higher, again with the psi a function related to hole depth.

Traut adds the dual tube drill string is also used as a conventional drill string. At the beginning of the borehole drilling, the first 50 feet to 80 feet must be drilled conventionally as the DTFR process requires submergence when enough head differential pressure is created to initiate the dynamic suction required to sustain a robust upward flow. Many drillers set up their drills to be able to go back and forth from conventional drilling to DTFR. If for instance thick layers of sticky clay are encountered, the driller may choose to drill conventionally as it may be a faster method to advance through the clay before returning to DTFR.

Municipal Well and Pump in Waupun, Wisconsin

Mason Rens is a lead driller at Municipal Well and Pump, which operates two Foremost dual rotary drills. Rens says through years of experience in drilling large-diameter water wells his company has concluded DTFR is its preferred method of well construction based on a variety of factors.

First, DTFR enables complete control of on-site cuttings fluid discharge, thus minimizing contamination. DTFR is also a non-invasive method of drilling. From Rens' perspective, it does not erode the borehole like air rotary drilling and maintains borehole stability even in unconsolidated formations.

Bentonites and drilling fluid additives are not required for DTFR, so the formation is not subjected to unnatural packing or sealing. Thus well development can be faster and more complete while the well's quality and production can be many times better than wells where fluid additives are used.

Further, Rens states the sample accuracy with DTFR is superior as cuttings travel quickly and directly from the bit face up the inner tube to the surface without exposure to the borehole wall.

DTFR both contains and protects the cuttings sample within the inner tube and rapidly delivers it directly to the surface for scrutiny, enabling fast and accurate identification of formation changes—which Rens mentions is key to optimum screen placement.

Another aspect Rens mentions is reduced site noise. Both the drill rig and compressors work at reduced activity levels versus an air rotary rig, which in addition to a safety feature means less fuel consumption.

With DTFR, a single 350 psi compressor is adequate for even large-diameter borings. Backup compressors and boosters are not required.

Rens emphasizes the production utilizing DTFR is exceptionally good in sedimentary formations, common in Wisconsin and Illinois. He adds this is especially true for granular formations such as sandstones, sands, and gravels.

Summary

DTFR has primarily distinguished itself in unconsolidated, sedimentary, or metamorphic broken/fractured formations. It has created a solid reputation as a low-energy drilling technique, uniquely enabling large-diameter boreholes to be advanced in unconsolidated geology, while providing key environmental containment benefits.

As the drilling world becomes more acquainted with DTFR, we will likely see continued innovations in its application in the water resource industry and other fields. WWJ

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Diagrams courtesy Michael Center of Matrix Drilling Products.