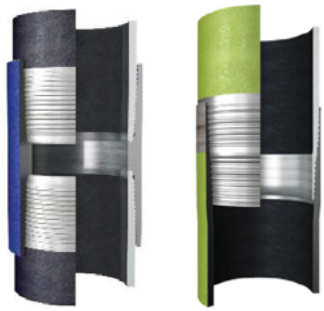
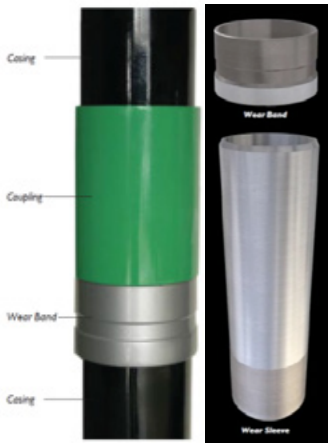


CwD connections.
Courtesy Tenaris.

CwD connections.
Courtesy U.S. Steel.



Wear bands/Sleeves. Courtesy TESCO.

Torque rings. Courtesy Premiere.

Figure CD-8: CwD accessories.

Plastering effect

In addition to increasing drilling performance, CwD technology has also shown strong potential for drilling in weak sections to mitigate lost circulation and wellbore instability problems and reduce NPT in drilling operations, specifically in narrow pore-fracture pressure sedimentary basins and deep offshore applications. It offers hydraulic improvements and the ability to plaster cuttings to the wellbore wall, which may restore the wellbore's hoop stress by wedging the created fractures and/or by increasing the fracture propagation pressure. Additionally, because of the larger pipe-to-annulus size ratio of CwD compared to conventional drilling, the casing rotation forms a better mud cake (**see Figure CD-9**). Although the increased wellbore containment is explained by the plastering of drill cuttings, the true mechanism is not yet well understood. Pipe size and annular clearance have been reported as the critical parameters for increasing wellbore strength. The other factors include the casing's contact with the wellbore wall, rotary speed, mud type, time, stress anisotropy, mud hydraulics, thermal effects and penetration rate.

Operations

Non-retrievable CwD systems are made up in the rotary table in similar fashion to how casing connection and accessories are installed into a standard shoe track. The main differences will be in the connection type and the amount of torque used to make-up all connections in the string (should be 20% higher than the maximum expected torque required to drill to TD). This may require power tongs. Floats are installed in the string that are rated for the expected circulating hours that are required to reach TD and cement the interval. The placement of the floats is as per the operators requirements on the amount of shoe track desired. Any centralization installed on the string is recommended to be done prior to the arrival of the casing to the rig.

The casing is tripped into the hole using the same methods as conventional. It is recommended to fill the string at regular intervals during the trip. After reaching bottom, drilling can proceed according to the parameters specific to the bit used and optimized to the specific application. When making connections, time in slips should be minimized as much as possible. If any positive indication of flow is detected, the well can be controlled using the casing rams sized to the casing string, in the same way well control is implemented when running casing. After reaching TD, the well should be circulated till shakers are clean prior to rigging up for cement. Cementing operations are similar to conventional operations.

Why drill with a non-retrievable CwD system?

Advantages include:

- Increased ROP in soft formations (eliminate need for control drilling due to improved hole cleaning);
- Minimize rig time and floor operations by eliminating dedicated casing run;
- Utilize the benefits of plastering effect to:
    - Reduce or eliminate the risk of lost circulation;
    - Reduce differential sticking while drilling depleted sands;
    - Extend casing point to eliminate casing/liner string;
- Reduced overall well costs by reduction of time on well.

One key advantage of CwD with a non-retrievable system involves the ability to take advantage of the high ROP experienced while drilling large outer diameter (OD) vertical top-hole sections. Drilling these top-hole sections has become an increasingly common practice for offshore wells in multiple locations.

a. Plastering effect to restore wellbore hoop stress and plug near wellbore fractures

b. Plastering effect to repair the imperfections of the mud cake and increase near wellbore integrity

Figure CD-9: A and B describe two plausible mechanisms of plastering effect to increase wellbore integrity. Courtesy Weatherford.

Typical non-retrievable CwD problems

- High torque: Because the casing is larger in diameter and heavier than drillpipe, the torque required to rotate the pipe to TD is often much greater;
- Hydraulics: As the casing is larger in diameter than drillpipe, the annulus between the casing and the drilled hole is much smaller; therefore, the hydraulics must be redesigned. Even with optimal mud rheology and reduced flow, it is very difficult to plan for CwD intervals deeper than 15,000 ft (5,000 m) due to higher ECDs that become increasingly hard to manage at greater depths;
- Tripping casing: The bit must make the minimum casing depth in a single run to be successful. If the bit is unable to drill the planned footage to an acceptable casing point, the only option is to trip the casing to replace the bit.

Retrievable casing while drilling

Retrievable CwD systems provide all the advantages of a non-retrievable system but add the flexibility to incorporate directional and measuring/logging while drilling (M/LWD) tools to both steer and log the well while drilling. Whereas a non-retrievable system must guarantee that the entire interval be drilled in a single run, retrievable systems allow multiple trips to replace the drill bit or any other failed logging or directional component of the BHA. A retrievable system also assures that the casing can be run to TD, and it captures many of the savings that have been proven when CwD vertical wells.

The same casing-running systems, centralizers and connections used with non-retrievable CwD are also used for the retrievable systems. Retrievable CwD systems use a special coupling with an internal profile installed above the last joint in the casing string.

The full retrievable CwD will consist of the individual components listed below and shown in **Figure CD-10**. Also required will be the casing accessories to provide centralization for cementing and stabilization for drilling.

Locking assembly

The locking assembly must facilitate several requirements in order for the remainder of the assembly to effectively drill with casing. The assembly must allow:

- Hydraulic isolation: All drilling fluid pumped from surface must be directed from the casing into the locking assembly, into the drillpipe BHA and ultimately through the bit below;
- Crossover from the casing to drillpipe connection: Engaging the locking assembly in the profile nipple provides a downward-facing drillpipe connection used to connect the drillpipe BHA to the casing used to drive the string from surface;
- Weight-on-bit transfer: The locking mechanism must allow weight on bit to be transferred from surface to the cutting structure;
- Torsional transfer: The locking mechanism must transfer the torque that allows the drillpipe BHA to rotate at the same RPM as the string is turning at surface;
- BHA retrieval: The locking assembly must be able to be used in tandem with drillpipe, wireline or hydraulic retrieval tools to convey the drillpipe BHA through the internal diameter (ID) of the casing string on multiple trips.

Internal duplex stabilizer

The internal duplex stabilizer is used to stabilize the drillpipe BHA inside the casing shoe joint below the locking assembly. This configuration provides lateral stabilization and ensures concentricity of the drillpipe BHA as it exits the casing shoe joint.

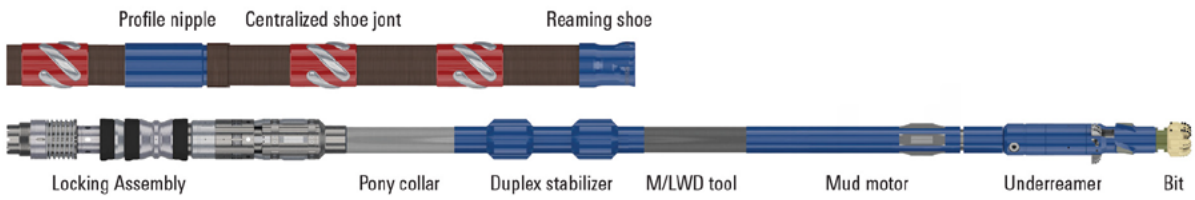


Figure CD-10: CwD BHA with conventional positive displacement motor. Courtesy Schlumberger.

Underreamer

As all components in the drillstring BHA must be smaller than the drift of the casing to allow conveyance in and out of the hole, an underreamer must be used to open hole larger than the casing's outer diameter. With respect to hydraulics, it is most common to underream the hole to the same size that would be used to drill the interval conventionally. For instance, when drilling an interval with 9 5/8-in casing, a 12 ¼-in underreamer would be used in tandem with an 8 ½-in pilot bit.

Successful directional CwD operations require more than simply having directional tools available that can be run below the casing. BHA response may be quite different when CwD as compared to drilling with conventional systems. Extensive pre-project planning must be completed, including hydraulics analysis, torque-and-drag modeling, casing connection analysis and selection, and BHA design. Wellsite implementation and successful execution of operational procedures at the wellsite are critical to success.

Retrievable CwD BHAs are primarily arranged into three categories:

- Directional with conventional positive displacement motor (PDM);
- Directional with rotary steerable systems;
- Short stick-out assemblies (tangents and loss zones).

CwD with a conventional PDM is similar to drilling with a conventional assembly. The motor orientations are extremely easy when drilling with the casing because there is very little twist between the surface and motor. For example, **Figure CD-11** shows the toolface for about five minutes during which time the motor stalled, the drillstring was picked up and the motor restarted. The tool face changed less than 10° when the string was picked up and returned to its original position when drilling resumed.

For larger sizes of casing, no loss of efficiency occurs while drilling with the steerable tools below the casing, allowing the operator to take full advantage of the faster tripping and trouble avoidance benefits provided by CwD. Improved hole cleaning while drilling through offshore top-hole intervals has eliminated the standard practice of control drilling and allowed wells to be drilled significantly faster with casing than with conventional drillstrings. Directional drilling with smaller casing may sacrifice some drilling efficiency due to the requirement to use smaller motors.

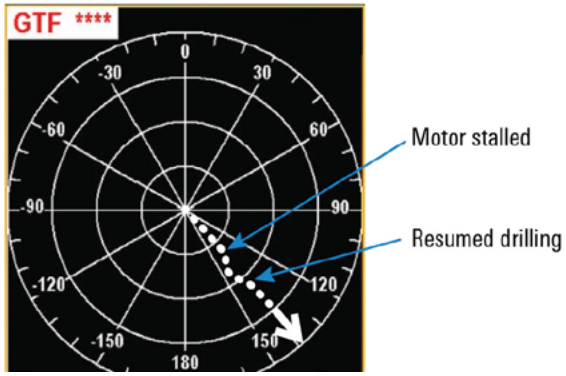


Figure CD-11: Tool face change when CwD

Rotary steerable-based retrievable CwD assemblies, as shown in **Figure CD-12**, provide a unique synergy by having both the drilling hazard mitigation benefits of the plastering effect and superior hole cleaning by allowing the assembly to be steered with continuous rotation. CwD assemblies with conventional PDMs must sacrifice these benefits over the footage where steering is required.

The drilling hazard mitigation aspects of CwD only occur after the formation drilled comes into contact with the casing component of the drillstring. For this reason, it is critical to manage the length of drillpipe that projects below the casing shoe or stick-out. In highly unstable formations or where large amounts of fluids are lost to the formation, it is critical to begin applying the plastering effect as soon as possible. In these circumstances, a short stick-out BHA, as shown in **Figure CD-13**, is a preferred design hold angle while drilling through difficult formations. It can also be used while drilling vertical intervals where more than one bit trip is required to reach TD.

