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-THEME-

Forage Par Tubage à L'avancement (Casing While Drilling)

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Dedication

This thesis marks a great part of our lives – yet, it is a beginning of a journey!

We thank ALLAH for helping us reaching this moment.

It is a great pleasure and we're feeling so high

because, in some ways, we deserve it.

Unlike Albert Einstein who once said:

"SUCCESS is 10% hard work and 90% keeping your mouth shut"

We want the whole world to hear us out.

They told us "we can't do it" and "YES WE already DID it"

You too, whenever they say "you can't"

just take the "t" off because YOU CAN.

To all those who believed in us

Our parents

Our brothers and sisters,

Friends and teachers

To 2016 graduates

To the next generations

To EVERYONE

….

Acknowledgement

We would like to express our deepest gratitude to All people who helped us with their useful comments, remarks and commitment through every step in the process of this master thesis.. Furthermore we would also like to acknowledge with much appreciation the crutial role of Ms **Abass hadj Abass** and Ms **Ziari Saber ,**Who gave us the permission to use all the required information and the necessary materials to complete our work.

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INTRODUCTION

Conventional drilling (drill pipe string) has monopolized the drilling of oil and gas wells for a century, after that, in the early 1900; the use of casing to drill oil and gas wells represents a fundamental change in the process of constructing a wellbore. Casing while drilling provides the same hole-making capacity as drill pipe operations, with better removal of drilled cuttings and improved hole-cleaning performance. The casing used for drilling can be a partial liner or a full string.

In 1920, the Russian oil industry reported the development of retrievable bits for drilling with casing, In the 1960,Brown Oil Tools, now Baker Oil Tools, patented a relatively advanced system for drilling with casing that included retrievable pilot bits , under-reamers to enlarge hole size, and downhole motors .However, low penetration rates compared with conventional rotary drilling restricted the commercial application of this system.

Research and development continued at a slow pace until the 1990s, when operators began using liners to drill from normally pressured formations into pressure-depleted intervals. This approach avoided problems, such as hole instability and enlargement, lost circulation and well control, which plagued conventional drilling operations.

In 2001, BP and Tesco reported success-using casing to drill surface and production casing intervals for 15 gas wells in the Wamsutter area of Wyoming, USA .These wells ranged in depth from 8200 to 9500 ft. (2499 to 2896 m). At about the same time, Shell Exploration and Production Company dramatically improved drilling performance in South Texas by drilling underbalanced with casing, realizing a cost reduction of about 30 per cent.

To date (2005), operators have drilled more than 2000 wellbore sections using casing. More than 1020 of these intervals have involved vertical drilling withe casing and non-retrievable bits, about 620 wells were drilled using partial liner, more than 400 used a retrievable BHA for vertical drilling, and about 12 used a retrievable BHA for directional drilling.

All of these early applications helped casing while drilling evolve from a new technology with unproven reliability to a practical solution that can reduce costs, increase drilling efficiency and minimize non-productive rig time (NPT).

years of drilling and exploiting petroleum reservoirs has left the drilling industry with a much more complex environment. Current drilling applications are frequently located in troublesome zones, depleted reservoirs, and wells with severe wellbore instability. Casing Drilling has been used in numerous difficult wells and to drill through troublesome well sections that would not have been possible with conventional drilling techniques. Nowadays, the oil industries are looking for new technologies in order to make more profit in shorter time and lessen costs.

In the other side, the decisions to increase the production and to drill in the challenging condition bring consequents on technology challenges. The casing while drilling technology (CwD) is one of the most effective technology employed successfully over the world and it appears good benefits, after millions of feet drilled, on- and off shore, straight, directional and horizontal wells.

This technology permit to save times (less tripping time), minimize drilling problems (lost circulation, stuck pipe and water influx, well control issue) , in addition to reduce well construction costs, improve operational efficiency and safety ,and reduce environmental impact. Fundamentally simple in principle, the well is drilled and cased at the same time, we use the large-diameter tubular that will permanently installed in a wellbore in place of conventional drill pipe.

There are three main purposes of our thesis; firstly we are talking about Advantages and features ,also we compare between CwD and conventional drilling (techniques, time, problems and cost) finaly we study a successful history and propose the CwD such a solution for drilling problems in Algeria.

CHAPTER I

CwD: Essential Items

I.1.THEORY

Drilling with Casing (DwC) is a process of using standard oil field casing replacing drill pipe in the drill string (CD), or replacing the lower sections of drill pipe in the case of (LD), so the well is drilled and cased at the same time.

The top drive system (TDS) rotates the casing, which transmits the mechanical energy to power the bit. Drilling fluid is circulated through the inside of the casing or inner string and up in the annulus between the casing and well-bore.

Both surface and downhole tools and components are necessary to make this process possible.

While many of the functions and activities are similar to the conventional drilling process, there are sufficiently different to warrant special drilling consideration. The drillpipe and drill collars are used and the logging, coring and perforating operations are the same with conventional. To meet the loading and bottom hole criteria, the modifications are done in surface lifting facility and bit.

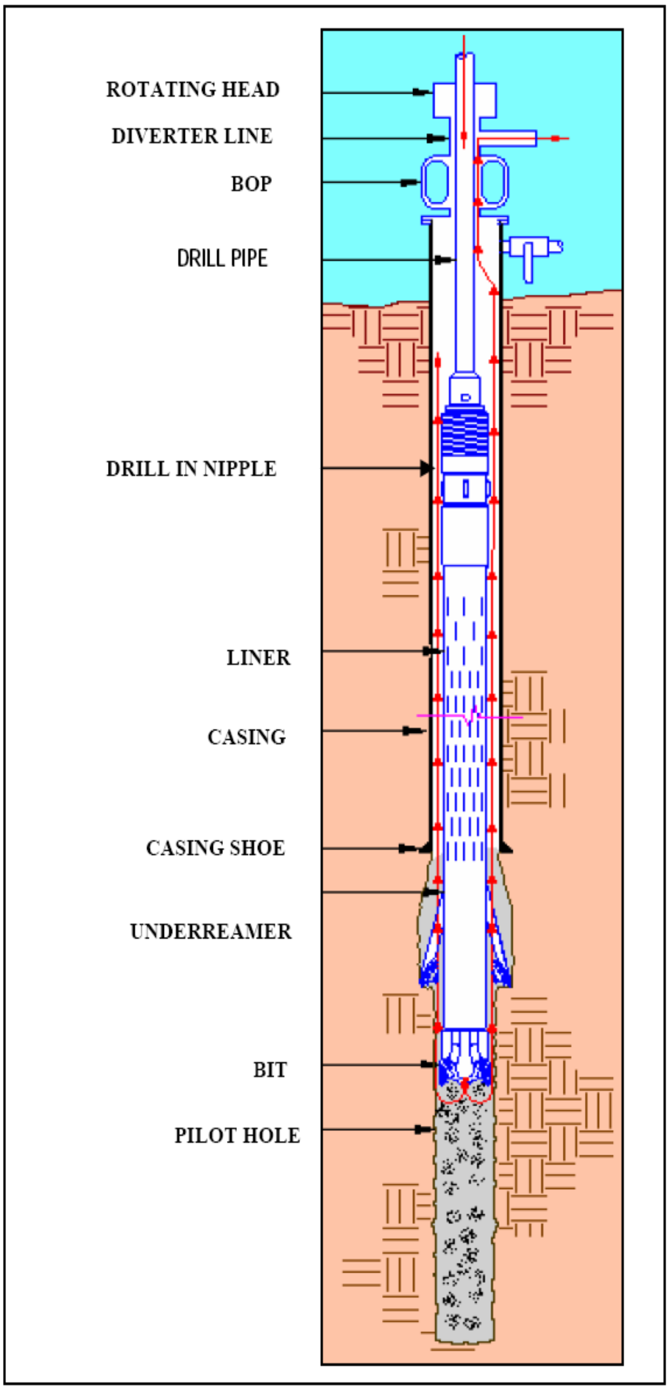


Fig. I.1 -Casing while drilling theory

Before 1950,the connections were not very robust and over time, drillpipe evolved as stronger and stronger connection was developed and the resulting casing was not been used for drilling. In 1950, the idea of drilling with casing re-emerged, while there were many potential advantages of this technique, it was not commercially accepted because of the limitations in material and cutting tools that available at that moment. But the initiatives to development facilitated the process sufficiently and now it becomes a successful commercial service.

The conventional drillstring must be tripped out of the hole each time the bit or bottom hole assembly needs to be changed, the casing point is reached or the bore hole needs to be "conditioned". Casing is then run into the well as a completely separate process to provide permanent access to the well bore. DwC systems integrate the drilling and casing process to provide a more efficient well construction system by eliminating these drillstring trips and allowing the well to be simultaneously drilled and cased.

I.2.Benefits and advantages of Drilling with Casing

I.2.1. Less drilling time

It is agreed that the more drilling time, the greater the probability of wellbore instability. Casing Drilling reduces the total amount of time that the well is being drilled by eliminating tripping, casing running, and mitigating NPT due to drilling problems (saving 20 – 40% of rig time).

I.2.2.Wellbore stability

Casing and liner drilling offer several unique aspects that may help to mitigate wellbore stability issues. Since the casing/liner is always at TD during drilling, the amount of time spent tripping is reduced, and every foot drilled is a foot gained in well length. It is generally accepted that most wellbore instability and stuck pipe issues arise during tripping. One of the most common issues while drilling is swab and surge pressure fluctuations which can lead to well control incidents or lost circulation. The inability to circulate the well from the bottom while tripping is an other challenge, and can result in cuttings settlement or stuck pipe while tripping. Elimination of tripping leaves no chance to instigate such issues.

Moreover, by definition, there would be no need for wash and ream procedures after reaching TD and before running casing.

Another beneficial aspect of CD/LD is that the openhole time is significantly reduced,And there is no mechanical load on weak formations after the casing/liner has been cemented in place. As the wellbore is cased off, reactive formations spend less time exposed to aqueous fluids, which is an other facet of the technology that aids in improving wellbore stability; less time exposed to reactive shales leads to less issues related to formation squeeze.

The inherent stiffness of the casing/liner string means that the string moves in a smooth, continuous motion while drilling compared to a string made up of conventional drill pipe. The result is a less tortuous wellbore, with a reduced risk of key-seating and stuck pipe incidents occurring as a result of mechanical friction.

The drill pipe and under-reamer configuration of retrievable systems add to this effect, generating a wellbore with a more circular profile.

I.2.3. No running casing problems

In other cases, it is difficult to run the casing after a conventional drillstring wich is tripped out because of poor borehole quality. Some of these difficulties are related to boreholes stability problems directly attributed to drillstring vibration, while others are related more to the particular well geometry and formation condition being drilled. The DwC system reduces these incidents by installing the casing immediately as the well is drilled.

I.2.4. Deeper wells

DwC offers the opportunity to drive the casing setting depth deeper than may be obtained with the conventional drilling. The need to drill with a sufficient mud weight to provide a trip margin before tripping out the drillstring to run casing is eliminated. Especially in deep wells the pore pressure and fracture pressure has a close margin, this because of the “Smear Effect”.

I.2.5. Smear Effect

The DwC process mechanically enhances the wellbore wall “filter cake” to reduce lost circulation.The smear effect, or plastering effect, is an observed phenomenon believed to affect boreholes being drilled with a narrow annular clearing.

It is believed that the wellbore wall is continuously troweled by the rotating casing or liner, and that cuttings are crushed and smeared into fractures and pore spaces in the borehole wall wich is illustrated in the Figures bellow.

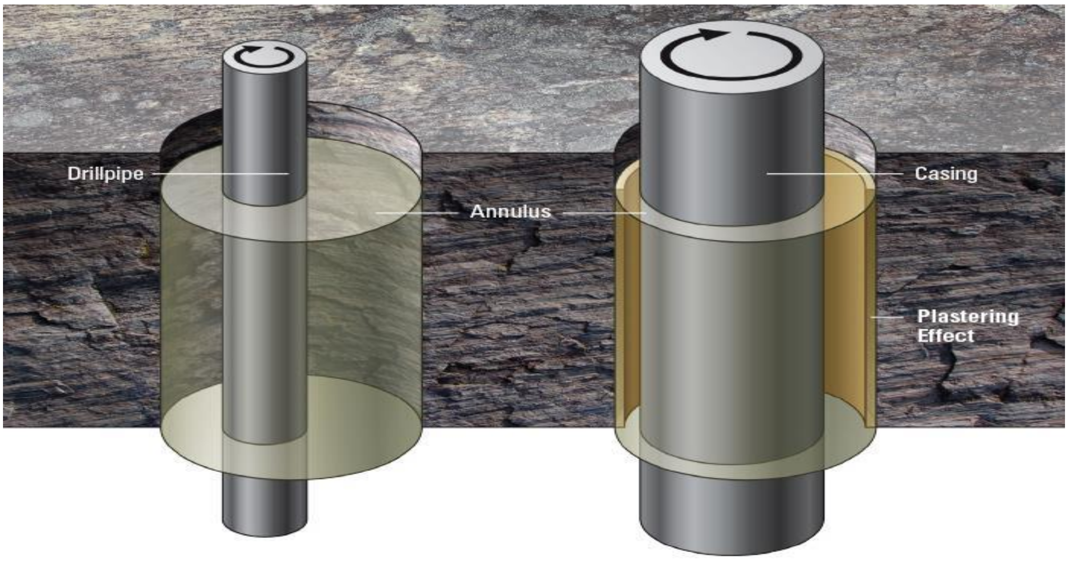


Figure I.2.The rotating casing string smears cuttings into the formation, "plastering" the wellbore.

This create a high quality impermeable filter cake, and serve to improve the stability of the wellbore by strengthening the formation ,the fracture gradient is augmented so there is a wider window of operation that allows for a better casing design by deepening casing setting depth or omitting one or more casing strings or liners. The proposed mechanism for Plastering Effect is shown in Figures bellow, it is also believed to cure lost circulation scenarios and reduce formation damage.

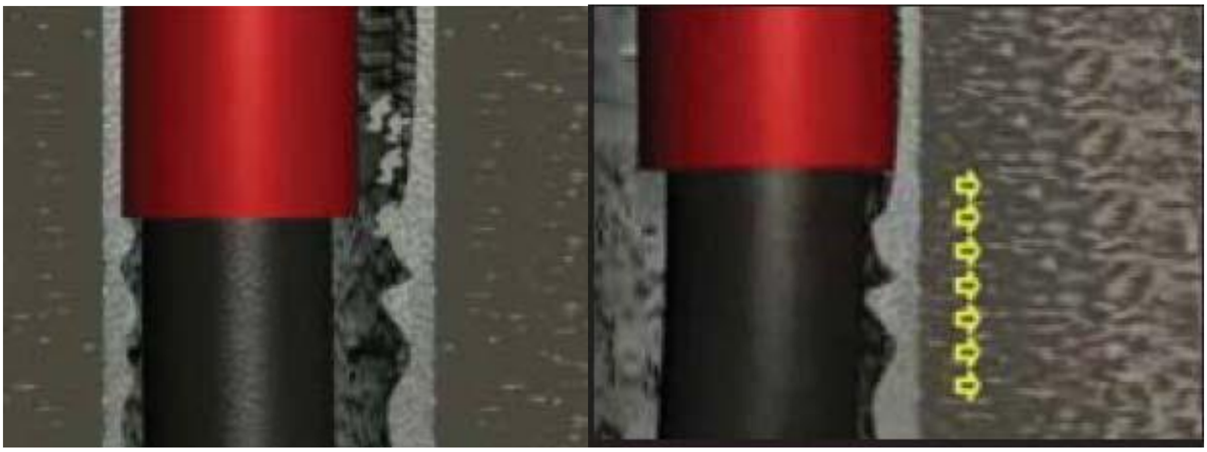


Figure I.3. The casing is forced against the bore wall and cuttings are smeared into the formation.

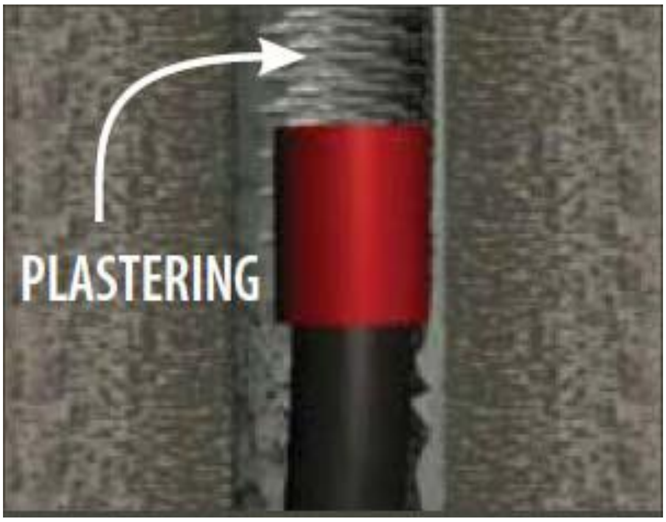


Fig I.4.Filter cake and cuttings are plastered and seals porous formations.

We note a reduction in cuttings returns when drilling with liner or casing, because solid particles are troweled into the formation, they help strengthening the porous formation around the wellbore and small fissures and fractures may be sealed. This has the potential to increase the fracture strength of the formation, increasing wellbore stability.

I.2.6.Wellbore Cleaning

Removing cuttings from a well is mainly a matter of maintaining sufficiently high flow rates to counteract the vertical slipping of cuttings in vertical sections, and to counter act settling of solids in horizontal sections.

In vertical sections, the flow rate and fluid parameters are the most important parameters affecting wellbore cleaning. Maintaining a high enough flow rate ensures that the axial fluid velocity is greater than the slip velocity of the solids. Slip velocity is a measure of the minimum velocity needed to lift these lid particles upwards; it is determined by the geometry of the solids and the fluid properties. In short, the goal is to ensure that a sufficient amount of energy is transferred from the flowing drilling fluid to the solid particles, to prevent a buildup of a cuttings bed.

Drilling with a large diameter casing or liner results a smaller annular flow area between the string and wellbore. As can be seen in the annular flow A (annulus), is directly correlated to the difference of the squares of the outer and inner diameter of the well bore:

$$A_{\text{annulaire}} = \frac{\pi\left(OD^2 - ID^2\right)}{4} \quad \ldots\ldots\ldots(1)$$

Furthermore, the flow velocity, V(annulus) , is determined by the relationship between the flow rate and annular flow area, as seen in:

$$V_{annulaire} = \frac{\emptyset}{\mathbf{Aannulair}} \quad \ldots\ldots\ldots\ (2)$$

Thus, the flow velocity will be significantly higher in sections drilled using large diameter casing or liner compared to regular drill string, provided that the flow rates are comparable. Pipe-to-Hole Area Ratio (PHAR) is a measure of the relative size of the pipe in relation to the wellbore. This parameter is often used in order to determine the appropriate pump rate and drill string RPM needed for achieving sufficient wellbore cleaning in medium (~35o- ~60o) and high inclination wells (>60o).
PHAR is calculated by :

$$\mathbf{PHAR} = \frac{Rh^2}{Rp^2} \quad \ldots\ldots\ldots.\ (3)$$

Rh refers to the radius of the wellbore, and *Rp* refers to the radius of the pipe.

The hypothesis states that there is a relationship between the PHAR, the pump rate, as well as drill string rotation required to maintain sufficient wellbore cleaning. Less drill string rotation is required in order to maintain a viscous coupling, and thus good hole cleaning, when drilling with a low PHAR, such as is the case when drilling with casing or liner.
The PHAR ratio of wells drilled using CD/LD systems will necessarily be lower than a comparable conventionally drilled well. The fluid velocities will also be high around the intervals of the strings exposed to the formation. Thus, it is reasonable to assume that wellbore cleaning in these intervals will be better than would be the case if the well is drilled conventionally. Cleaning will still be a concern in the well sections where the difference between the string diameter and well diameter is the greatest, which is in the upper sections.

I.2.7.The DwC is safer

Personal exposure to pipe handling during tripping and casing running operation is reduced. The DwC process also provides a circulation path to the bottom of the well at all times which reduces risk associated with well control operation.

I.3.Disadvantages of DwC

- DwC needs a special or modification rig and top drive system.
- DwC needs a special bit and bottom hole assembly system.

I.3.1.Torque, Drag and Friction

Torque and drag are very often limiting factors. Some of the parameters that have influence on the torque are :

- The length of the drill string.
- The weight of the string
- The radial and axial velocity.
- The well deviation.
- The friction factor.

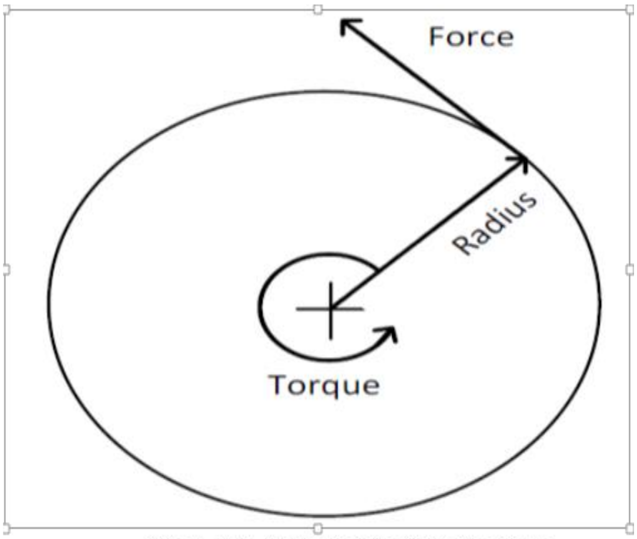


Fig 1.2.1- Torque Vector diagram

The increased diameter of liner and casing strings compared to conventional drill pipe means that more torque is required in order to rotate the string as well as increased drag forces acting on the string.

The Plastering Effect typically reduces the risk of getting stuck due to differential pressure, lost circulation scenarios and formation collapse when using CD/LD. But there is an additional risk of getting stuck while drilling with liner and casing due to Wall-to-wall friction and the inherent stiffness of the string; sensitivity to *Dogleg Severity* (DLS) is higher than with a conventional drill string.

I.3.2.Cementing

Cement typically has higher viscosity and gel strength than conventional drilling muds. The narrow annulus associated with CD/LD causes greater ECD while cementing, which may lead to formation fracturing, causing cement losses and a resulting insufficient cement job.

When running casing or liner conventionally a float valve is installed towards the end of the string, which is designed to only allow flow in one direction. The purpose is to prevent cement from flowing back into the string. Such devices may also be installed in the string when using non-retrievable BHA CD/LD systems. When using retrievable BHA systems, however, the valves have to be run downhole on a wireline, coiled tubing or drill pipe after the inner string has been pulled out of the hole. This has the potential to make cementing non-retrievable systems more time consuming.

I.3.3.String Elongation and Vibrations

Mud motors stalling cause an increase in fluid pressure on the inside of the drill string.Because the diameter of casing and liner piping is much greater than drill pipe, they tend to elongate more with increasing internal pressure. Drill string elongations increases the compressive forces acting on the bit since the string is fixed at the top.

The increase in compressive forces acting on the bit increases the torque required to rotate the bit, which increases the pressure drop across the motor, which further increases the *Weight on Bit* (WOB). This effect has a tendency to cause additional vibrations, and thus damage to downhole equipment.

I.3.4.Health, Safety & Environment

In the formation has already fractured, the smear effect may alleviate fluid losses by sealing up already existing fractures, but so far the phenomenon is too unpredictable for CD/LD to be used to “repair” fractured wells.

When performing casing drilling, the ability to shear the string and seal the BOP when encountering kicks may be a concern. Conventionally, BOPs are not suitable for shearing casing tubular. This is not a concern while using LD; at least not after the liner string has passed the shear rams. Potential hazards should be identified prior to running casing and liner strings.

Well control incidents takes place while tripping. Therefore, it is reasonable to assume That using casing/liner drilling (CD/LD) has the potential to alleviate certain HSE concerns, especially whenDrilling through formations in which fluid losses are expected, such as poorly consolidated sandstone formations.

I.4. Drilling with Casing equipments

This subject can be divided into two general areas:

1) Casing Drilling, where the casing is extended to the surface and is used to drill the hole much like drillpipe is currently used.

2) Liner drilling where only short sections of pipe are drilled into the ground and it is generally carried and rotated using drillpipe.

This technology has been mostly developed and deployed by the Tesco Company. Tesco has several rigs that are routinely drilling in casing in Southern Texas. Two operators have embraced the technology and are now using it to develop fields. ConocoPhillips is using the technology in their Lobo field of South Texas and Apache Oil Company in their Stratton Field. These two applicators of casing drilling are responsible for more than 90% of the wells that have been drilled.

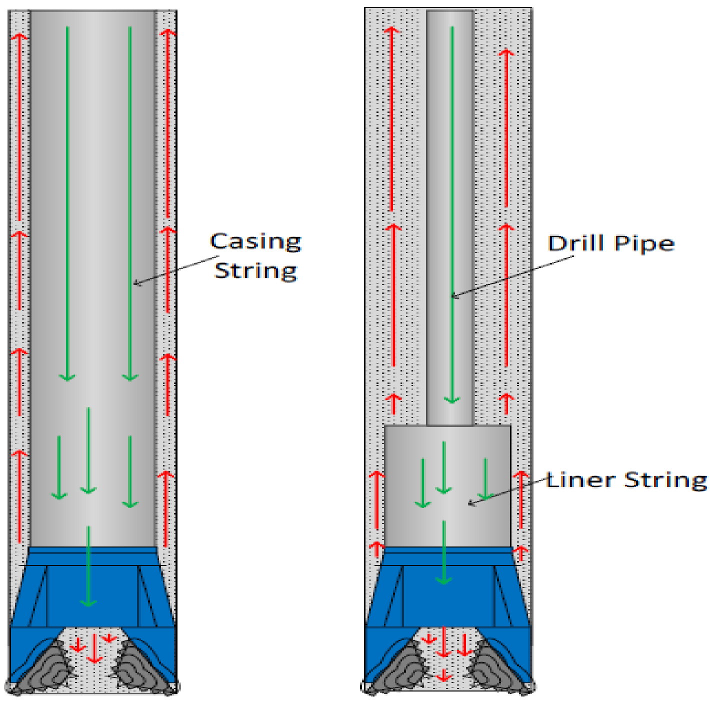


Fig.I.5- Casing/Liner Drilling concepts, Non-retrievable BHAs

The equipments required for a typical Casing Drilling operation are:

A.Surface lifting and circulating system

- Casing Drive System.
- Powered catwalk.
- Over-Drive System.

B. Sub-surface or downhole equipment

- A non-retrievable BHA (bit).
- A retrievable BHA (Bit and retrieval pin-box tool).

C. Casing Accessories.

Each of these pieces of equipment is required to conduct Casing drilling. Each will be described briefly.

I.4.1.Casing Surface Equipment:

I.4.1.1.Casing Drive System (CDS)

The Casing Drive assembly is used to grab and seal against the casing so torque can be transmitted to the casing and mud can be pumped through it. Tesco uses two different drive assemblies, depending on the size of casing being handled. An external gripping system is used for casing sized from 4 1/2” to 8 5/8” and in internal gripping system for 7” to 20” pipe.

Both assemblies use swab-like cups to seal on the inside of the casing so mud can be circulated down the pipe (figureI.6).

The gripper assemblies are hydraulically controlled. The external gripping mechanism has a 350 tons API 8C load rating while the internal system is rated at 500 tons. These assemblies both mate to a Top-Drive assembly that is required conducting the Casing Drilling operations. The Top-Drive supplies the torque through these Drive assemblies to make-up the casing connections and drill.

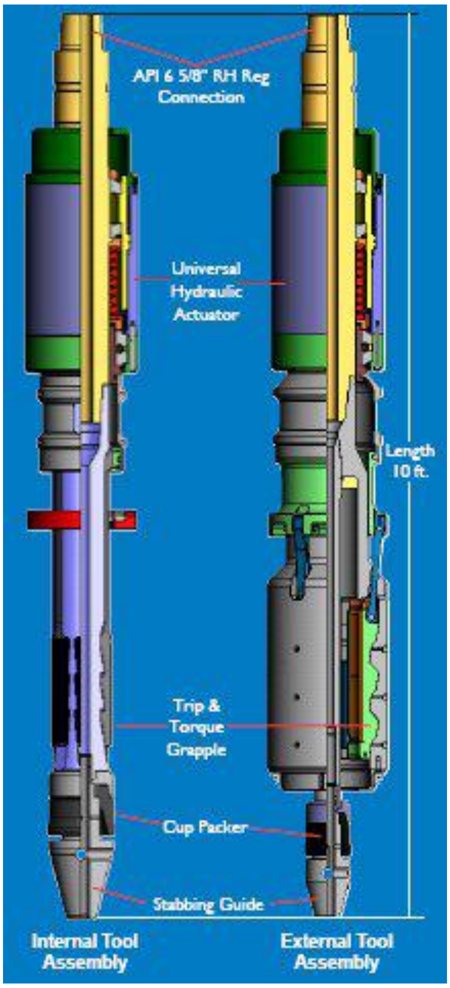


Fig I.6-Casing drive system

A modified elevator link-tilt mechanism is a part of the Casing Drive assembly, and used to pick the casing up and to hold the casing as it is screwed into the next piece hanging in the slips (figure **I.7.**).

The normal procedure is to lift the casing with the link-tilt mechanism and stab the pin of the casing joint into the box of the casing hanging in the slips. Once stabbed, the top drive is lowered, stabbing the drive assembly into the new joint of casing. The drive assembly is then activated to grip the casing and the top drive is used to spin the casing into the box. Final make-up is also accomplished with the top drive.

Figure I.7-Casing Drive system

I.4.1.2.Powered Catwalk

Tesco casing drilling rigs have several modifications that simplify pipe handling. One of these is their powered catwalk. The powered catwalk is a pipe handling system that is designed to automatically move pipe from the pipe rack to the drill floor without rig hand assistance. Pipe can be loaded or off-loaded from either side of the Catwalk. Hydraulic arms lift the pipe from the pipe rack to the catwalk trough.

Figure I.8.-Power catwalk for DwC

The catwalk trough then lifts and positions the pipe so the casing collar is located on the rig floor ready for the next drilling connection. This whole system is designed to automatically adjust for different lengths of pipe and can be completely controlled by the driller. Use of the powered catwalk and the link-tilt mechanism on the top drive and elevator link-tilt allows casing

connections to be made with very little roughneck intervention. Joints of casing can be picked up from the Catwalk tough and lifted until they are vertical (figure I.7).

I.4.1.3.Casing connections

The casing connections used in casing drilling differ from the connections used in conventional drilling. Casing drilling connections are subjected to severe well conditions. These connections are required to have satisfactory torsional strength, good flow clearance, adequate sealability and strong ability to resist fatigue. The providers of casing drilling connections are Hydril,Vam , Hunting Energy Services, GB Tubulars and Grant Prideco.

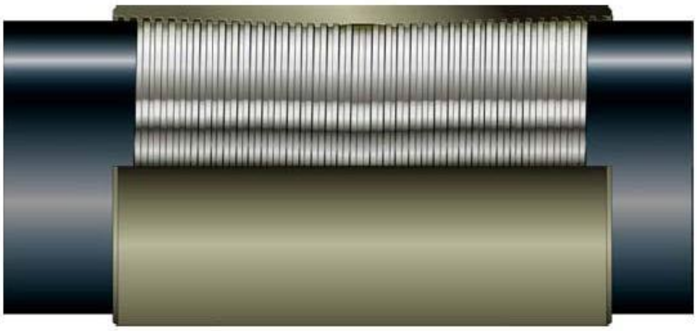


Fig I.9-Grant Prideco DwC connection.

I.4.1.4. Overdrive System

The overdrive system is Weatherford's casing and running system as compared to the retrievable casing drive system. This tool is attached to the rig's top-drive system and it can be used with any top-drive system.

The heart of the overdrive system is the Tork-Drive tool. With the aid of the rotational power provided by the top drive, the Tork-Drive tool makes up or breaks out the casing thereby performing the duties, which would have required equipment, scaffolding and personnel on the rig floor. The Tork-Drive tool is capable of circulating, reciprocating and rotating the casing, thereby decreasing any potential of differential sticking and other issues resulting to NPT.

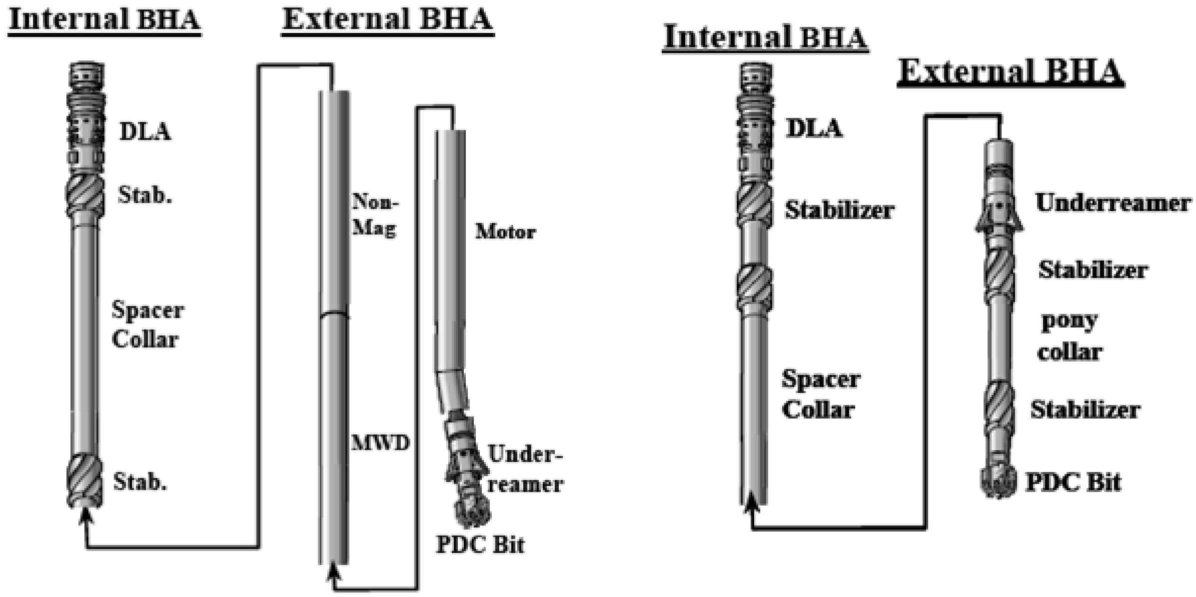
Fig.I.10. - Over-Drive system

I.4.2.Retrievable BHA

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. The retrievable system has a retrievable bit, a wireline retrievable BHA box and pin. The bit is made from hard steel and cutting material; therefore, it can be used to drill in the hard formation.

An under-reamer with a bigger diameter is mounted at the end of the casing/liner string to expand in the hole in order to run the liner. Some companies, such as Tesco, commonly use a wireline retrievable system to retrieve the pilot string.

Ex: 6 ¼’’ pilot bit is normally used with an 8½’’ under-reamer to drill with a 7’’ casing tool.



(a) **(b)**

Fig.I.11. Retrievable BHA for (a) directional drilling and (b) vertical drilling

I.4.2.1. Drill Lock Assembly (DLA)

The Drill Lock Assembly (DLA), shown in Fig.1.1 below, is located at the top of the BHA and it connects the whole drilling assembly to the bottom of the casing. The DLA functions primarily by unlocking the BHA axially and torsionally. The DLA also contains hydraulic seals, which enable the mud pass through the bit, and finally allows the downhole tools to be run in and out of the casing. Before retrieving the BHA, the locks are actuated by a ball-drop and released, after that, we run a wireline retrievable BHA (Pin) inside the casing to grapple the retrievable BHA (Box),to disconnect and retrieve the bit. Then the next smaller bit can be run in with the smaller casing inside the previous casing.

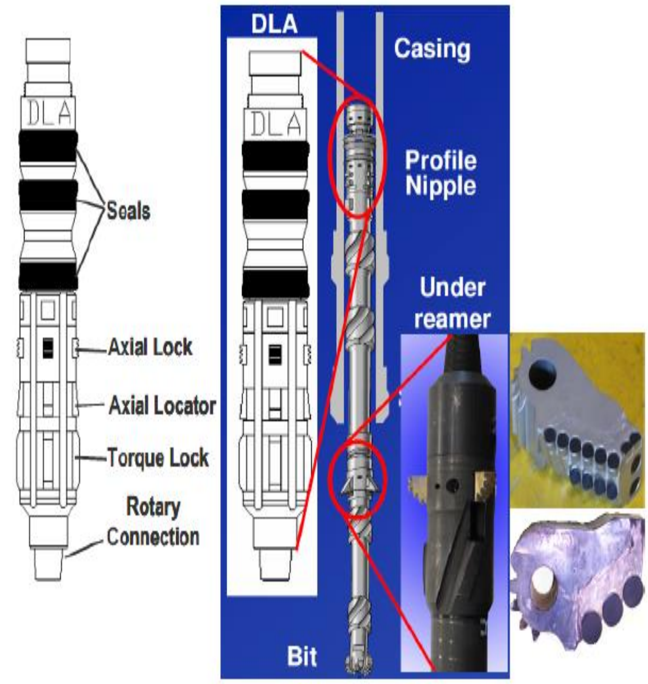


Fig.I.12- Drill Lock Assembly

Fig.I.13- Retrievable Pin assembly

I.4.3.Non-retrievable BHA

Most of the wells drilled using casing are drilled using a non-retrievable BHA (80%), because they are both cheap and efficient. These systems have bits fixed directly at the bottom of the drill string along with a float collar and the assembly is run down hole and cemented in place without a BHA. When the drilling reaches the target depth (TD), a ball is dropped and will fall into a ball catcher and totally closes the circulation inside the casing.

The pressure then is built up and forces the cylinder to push the bit to open. This piston force makes the bit expand from inside and leaves it with open cylinder. The drilling then can be continued with less small bit through the open cylinder.

Fig I.14.- Non-retrievable system

Weatherford is the main provider of the non retrievable casing drilling system.

The non-retrievable casing drilling system uses the same casing connections and top drive with the retrievable casing drilling system.

Fig.I.15- Drillable Bits (Drill Shoe)

I.4.4.Casing Accessories

I.4.4.1.Float Collar

The float collar is usually made up to a casing joint before transporting to the drilling location. After drilling to the total depth (TD), the cementing operation can commence at once since the float collar is already installed within the drill string throughout the drilling operation. This approach attains a single-trip procedure, which significantly reduces operational costs and time.

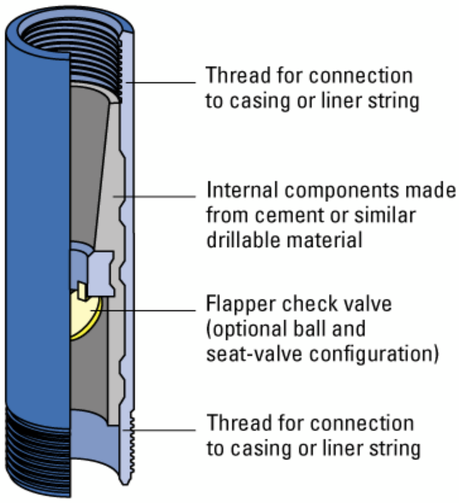


Fig I.16- Float collar

I.4.4.2.*Casing Protection Accessories*

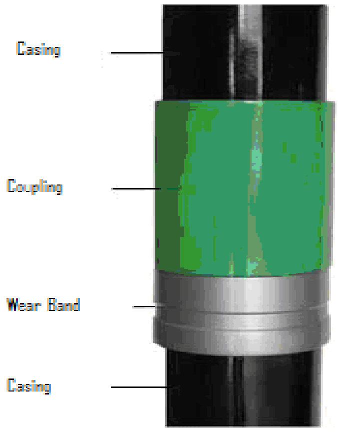
Wear protection accessories are provided to ensure that the casing is not damaged after the drilling process. This is important because after drilling, the casing is used in completing the well. The common casing wears protection accessories are discussed below:

I.4.4.2.a.*Wear Band*

It is placed below the coupling to maintain the strength of the connection.

I.4.4.2.b.*Wear Sleeve*

The wear sleeve is a cylinder made from steel with ample contact area, which is installed on any part of the joint as demanded. The sleeves are not coated with tungsten carbide hard facing.



Figs I.17-Wear band

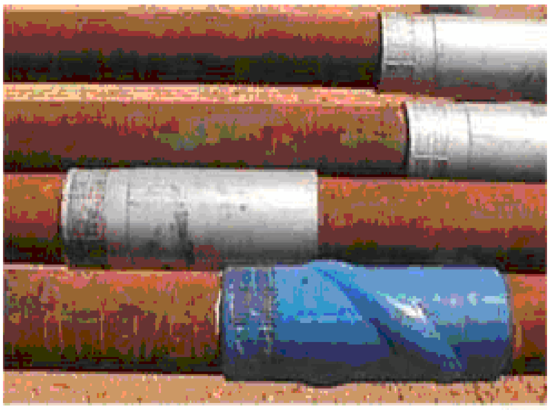


Fig I.18-Wear sleeves.

I.4.4.3. *Centralizers*

Centralizers are placed on the outside diameter of the casing to provide stabilization, directional performance, wear management, key-seat control and centralization for cementing. The centralizer has tough and strong-faced blades connected to the casing with a friction fit to enable rotation of the casing. Non-rotating centralizers made from zinc alloy have been used in directional casing drilling to reduce torque.

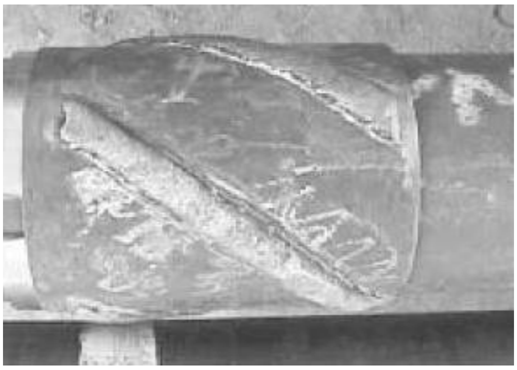


Fig.I.19- Centralizer

I.4.4.4. *Casing profile nipple*

- Installed near bottom of casing string.
- Functions with DLA to lock BHA axially and torsionally to casing.

Fig.I.20.- *Casing Nipple*

I.4.4.5. MLT multilobe torque

Multilobe torque MLT rings provide a positive makeup shoulder to increase torque capacity when installed in standard API buttress-threaded connections for casing tubulars. This increased torque capacity prevents pins and couplings used in API casing and tubing connections from being overstressed in drilling and workover application, reducing tubular connection maintenance and replacement costs.

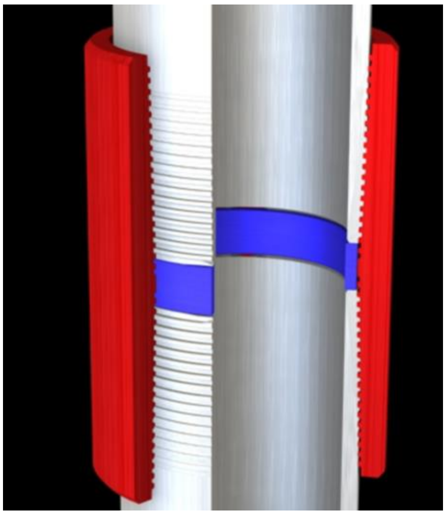


Fig I.21. MLT multilobe torque

The MLT ring inner diameter creates a flush geometry with casing, which enhances flow efficiency while protecting threads from debris. MLT rings are easily installed at the well site and are made from API-specified steel grade for rings is L-80; optional higher strength grades capable of enduring torque are available.

I.5. Liner Drilling

Liner drilling differs from casing drilling mainly in the length of the casing used in the system. In Casing Drilling, the casing extends to the surface and it is gripped and rotated much like drill pipe, in liner drilling the casing is suspended and rotated using drill pipe. Many of the same liner running tools are used in liner drilling. These tools must be capable of withstanding the torque that will be transmitted to the liner and the setting tools must be designed to allow the pressures that will be seen during the drilling operations. In additional information, for Casing and Liner Drilling have almost the same bits.

A conventional drillpipe conveys the bottomhole assembly (BHA) to target depth and carries the main drilling loads. A liner hanger or packer connects the drillstring with the liner. The BHA can be retrieved only when the hole is finished.

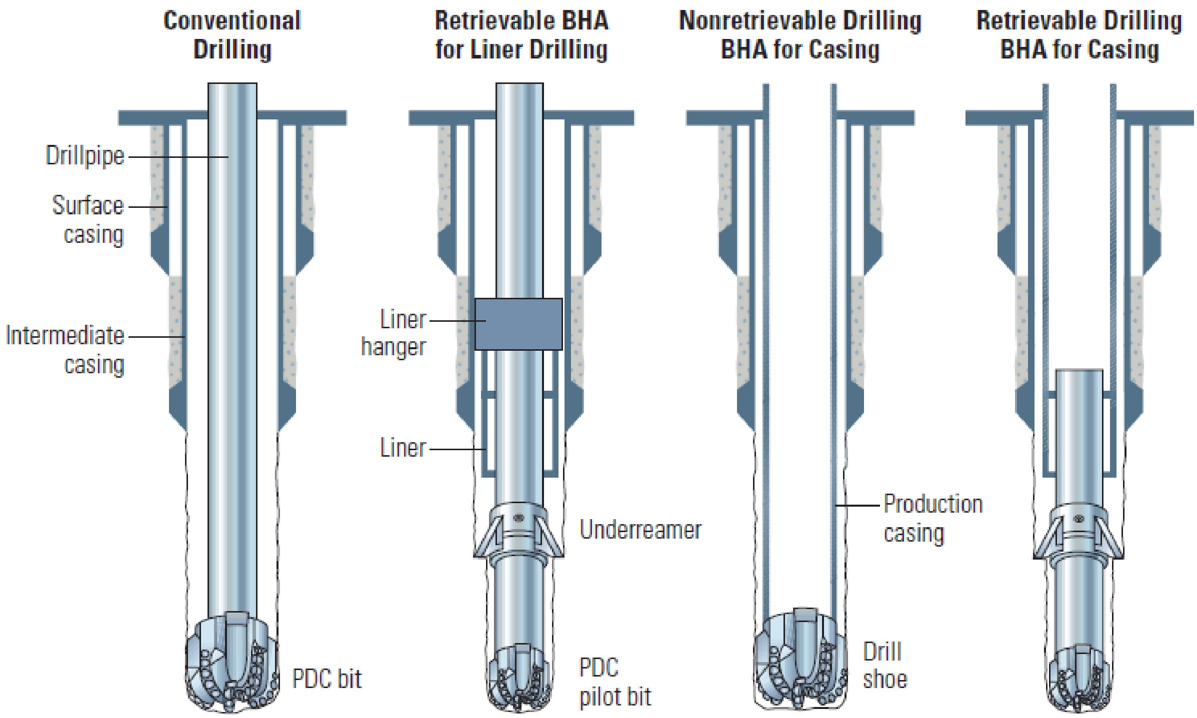


Fig I.22-Casing and Liner Drilling Mechanism

CHAPTER II

Discussion

II.1 Introduction

Drilling with casing system usually provided by Tesco Company, the casing is used as the drill string for transmitting the drilling forces. The casing could be provided by Tesco or Weatherford, depending on which method we are going to use.Tesco is a company that specializes in drilling with casing technology. Besides having drilled a test well with 29,000 ft., they have drilled 125 commercial wells.

Figure II.1 shows the Tesco drilling footage activities. In this figure, you can see there is a significant increase in the drilling depth using casing. Besides providing drilling with casing services, Tesco and Weatherford also provide drilling with casing rig and support equipment.

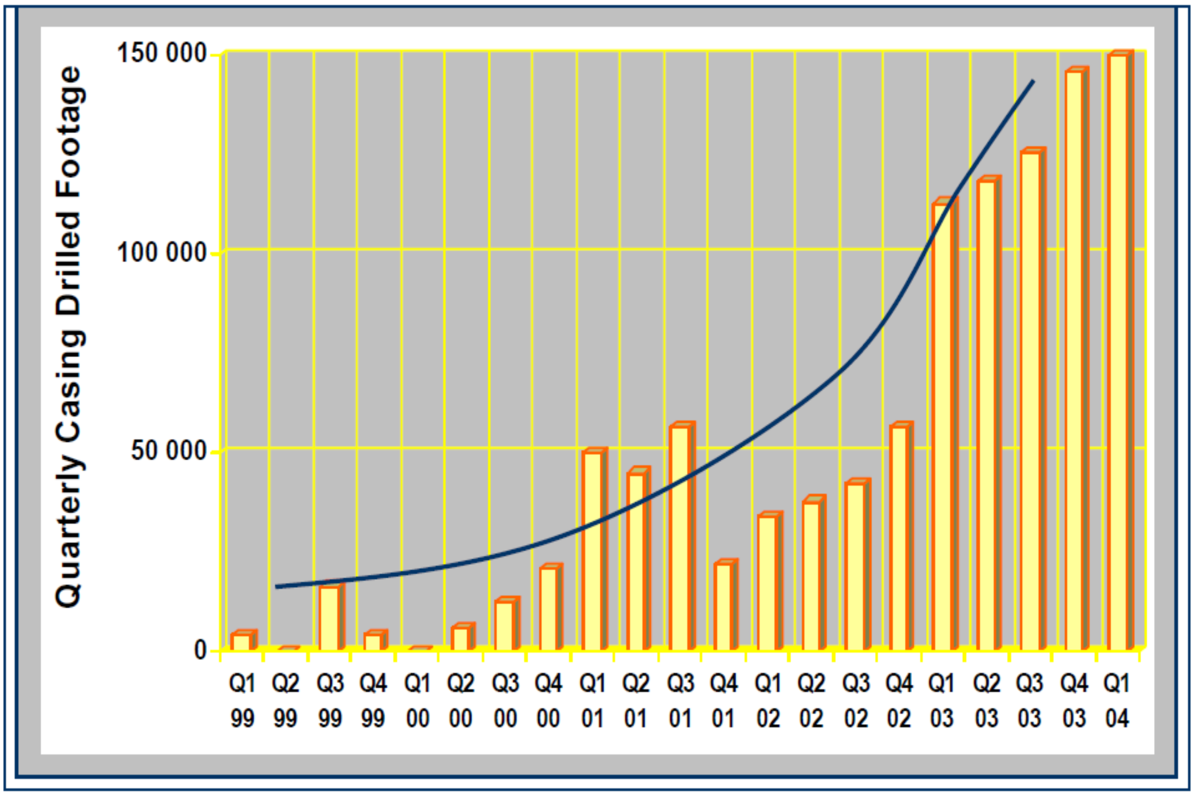


Figure II.1-Casing drilling footage

II.2. Smear (plastering) Effect

The well stability could be improved with casing drilling operations by “smear effect” during DwC operation, the operator raised the mud weight as needed on the first few wells and noted that they could drill a hole section with ½ to 1 ppg less mud weight without experiencing the losses they had worried about. Figures 1.3 and 1.4 show the smear effect.

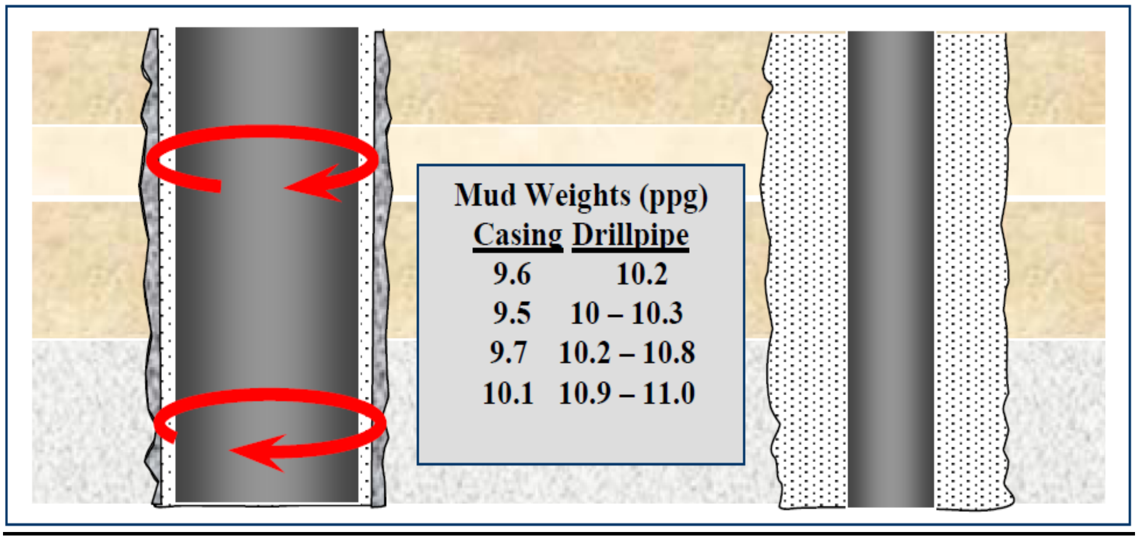


Figure II.2.-Smear effect Allows lower mud weight

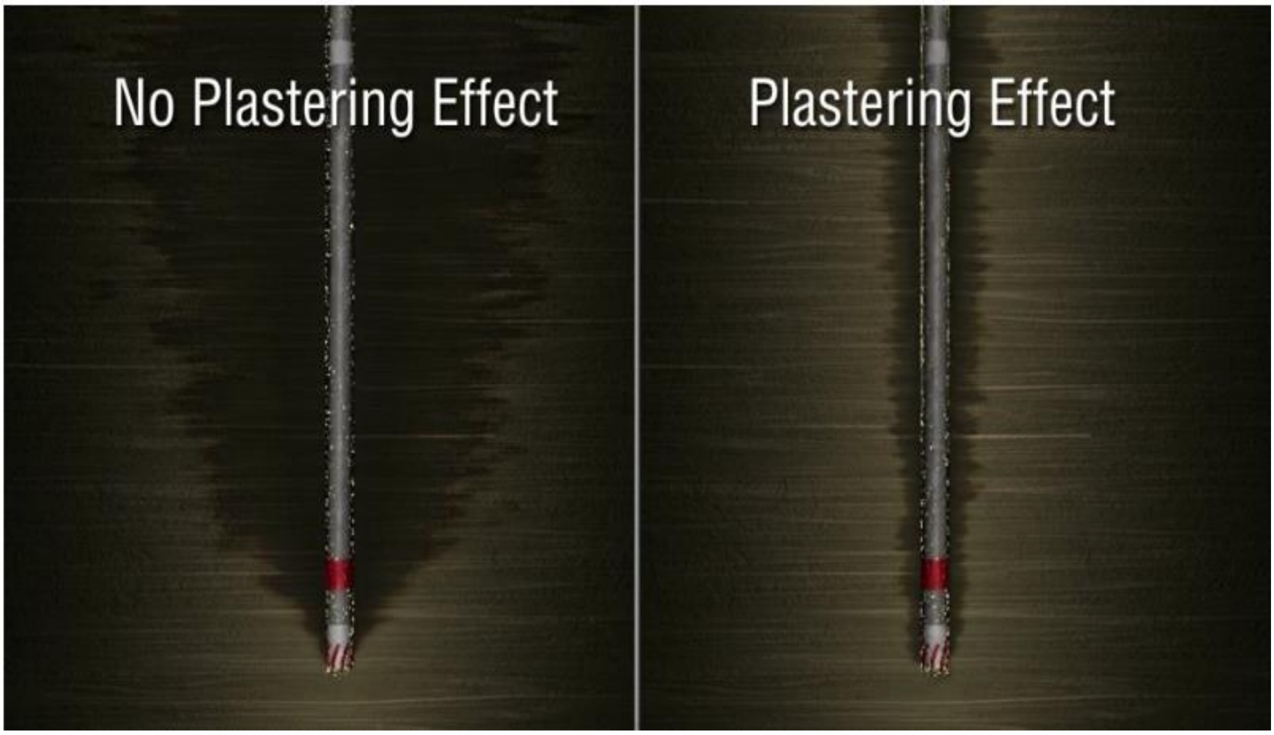


Fig II.3.-Plastering effect prevents losses

As it is shown in Fig II.2.2, the casing string plasters the cutting and filter cake on the borehole wall to seal off fractures and stop drilling-fluid losses.

II.3.Drilling window

The drilling mud window defines the operational area for mud weights. If the pressure gradient in the open-hole section drops below the formation pore pressure gradient, there is a

risk of inflow into the well. Conversely, if the pressure gradient in the open-hole section exceeds the formation strength, losses may occur. The casing contact strengthens and improves the perfection of the wellbore, the plastered filter cake reduces the permeability near the wellbore zone providing a high degree of sealing efficiency, witch improves the fracture gradient and allows for wider mud weight window, preventing any potential loss circulation and well control events, and by carefully managing the mud weight to stay in this window .
The driller can avoid lost circulation and potential kicks, which eliminates the need to run a contingency string to seal off trouble zones.

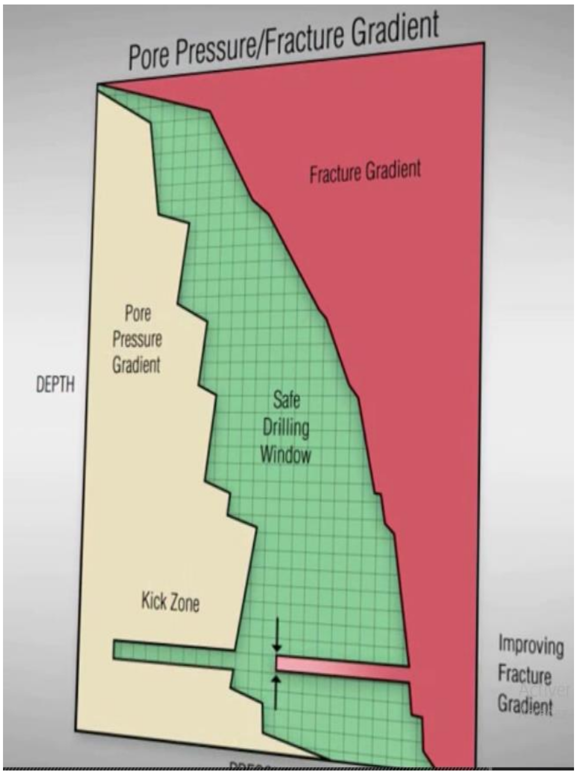


Fig II.4.- Mud Window in Conventional Drilling

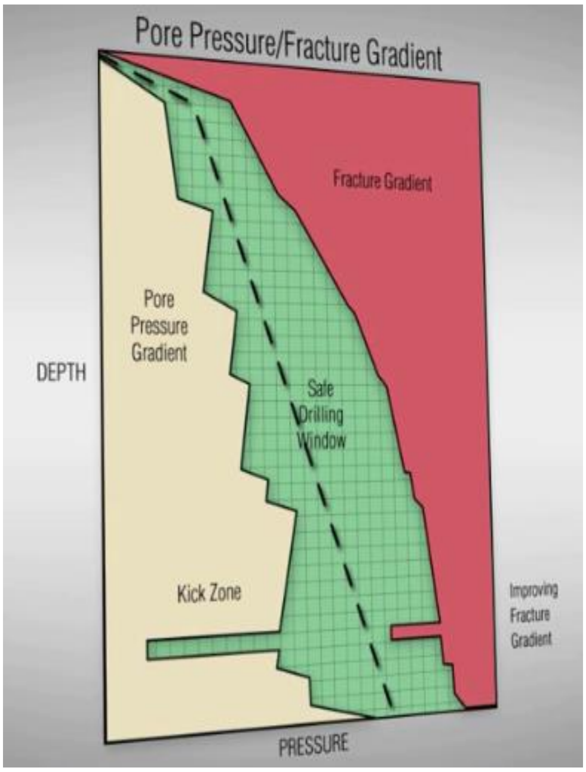


Fig II.5.-Mud Window in CWD

<u>II.4. Casing drilling Vs Conventional drilling</u>

II.4.1. Costs

For applying this technic in Algeria we have some estimation Costs. CWD is almost comparable with conventional drilling. However, since DwC faster on the rate of penetration (500 – 750 ft. /day) which saves a lot of money on rig expenses makes the cost more feasible.

Table below show cost estimation for drilling with casing included equipment and operation. (Source: Casing while drilling March 2004 conference, World oil)

Conversion Item	**Estimated Cost**
1.Drilling Wireline Winch	$ 500,000.00
2. Split Crown Blocks	$ 150,000.00
3. Split Traveling Blocks	$ 150,000.00
4. Wireline BOPs	$ 50,000.00
5. Solids Control Equipment	$ 85,000.00
6. Modify Mast for Top Drive	$ 20,000.00
7. Rig Day rate (Land rig)	$ 10,000.00
Total =	**$ 965,000.00**

Tab II.1.-Costs for conventional rig and equipments

Operation	**Per well cost**
Rig move days	$36.000.00
Top drive rig up	$ 24.000.00
Top drive rental	$ 25.000.00
Location constructuon	$ 10.000.00
Automated catwalk	$ 12.000.00
Casing drive assembly	$ 20.000.00
Total	**$ 127.000.00**

Table II.2.-Costs for Drilling with casing operations

In real cases, this technology gave very special results concerning saving costs, reducing rig time used.Here we have a real example of a well that had been conventionally drilled with severe losses. After three attempts to stop the losses with cement plugs, the well was abandoned. They moved one of the casing drilling rigs on to this wellhead and successfully drilled the well down with little trouble and much less costs.

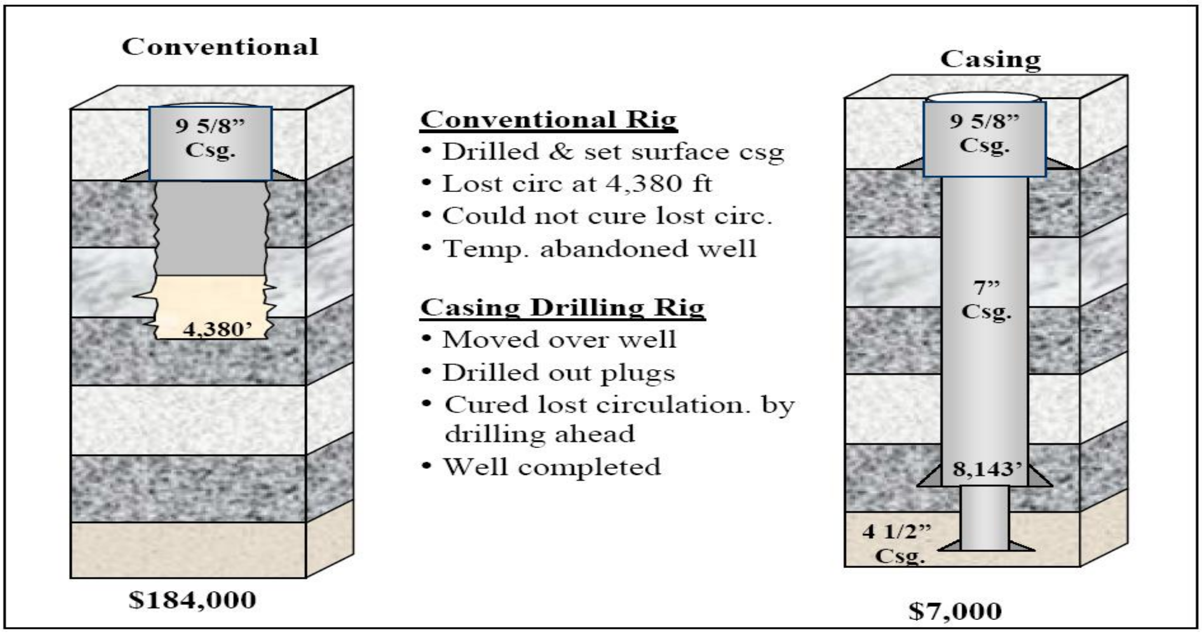


Figure II.6-Comparison between DwC and conventional drilling based on drill test

II.4.2. Cutting

We ought to note the difference in the cuttings that came from the well (figure II.4.4) compared with conventional drilling. In CWD case cutting are very thin and cut to very small particles comparing with conventional.

Figure II.7.-Cutting comparison between DwC and conventional drilling

Because an important part of them were smeared and plastered on the wellbore wall with creating a super touch filter, super impermeable filter cake.

II.4.3.Drilling efficiency

Using CWD method, a candidate well was drilled in an area near three wellbores, which had all suffered from severe lost returns problems. Two of the wells required not only cement plugs to stop the losses but eventually a liner as well. The third well was stuck and side-tracked due to open hole problems including losses. The casing drilling well was drilled in the middle of these three wells and did not experience any losses or stuck pipe trouble.

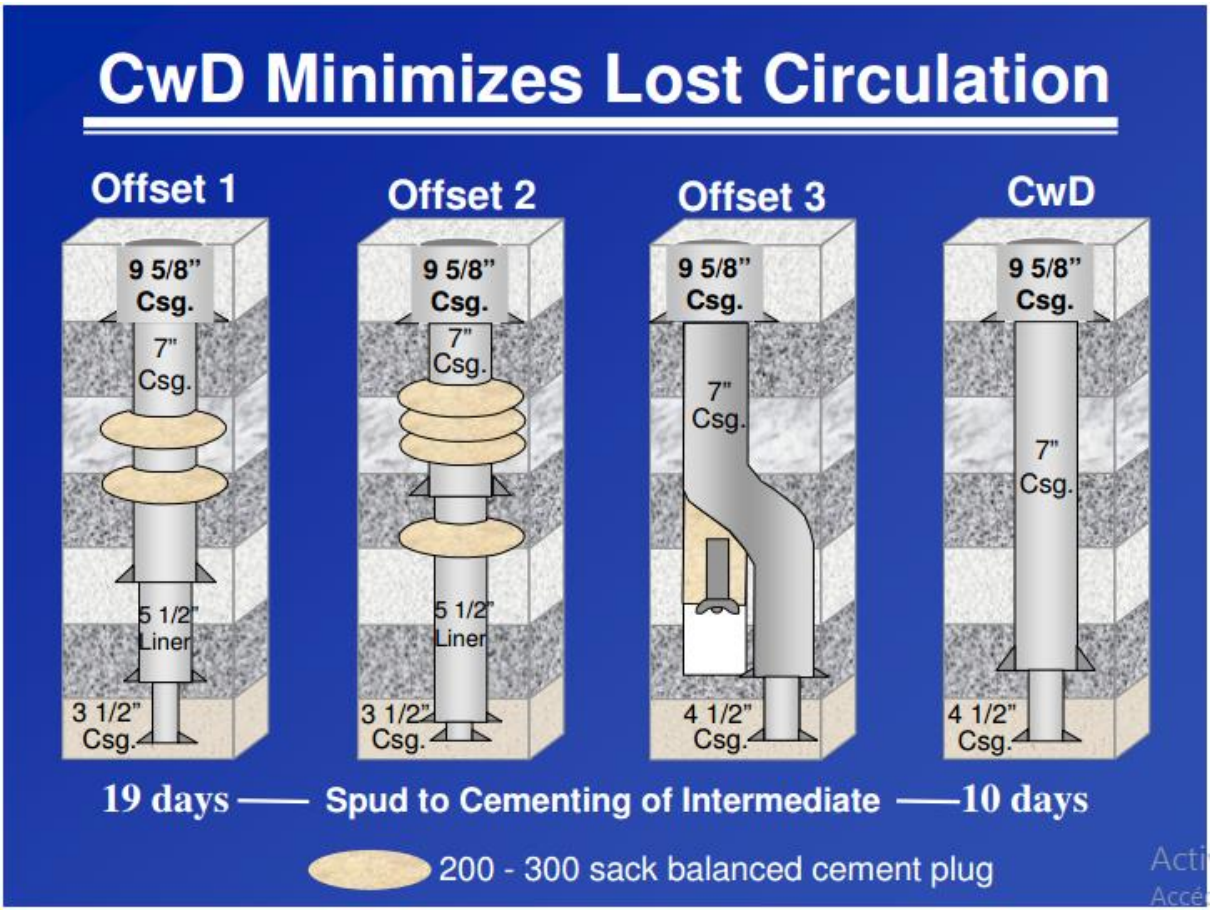


Figure II.8.-CwD effect experiment on testing wells

II.5. Casing Connections

When talking about connections between the casing pipes, we have two main types the Hydril connection and Enventure connections .For comparison we will list a connection with the same specification that shows stronger properties. Hydril provides this connection for conventional drilling. From the table below, obviously we can see that the Hydril connection is stronger than the Enventure connections. There is a large reduction in the casing connection strength after being used in drilling. Therefore, in anticipation of failure, the stronger connection is always preferred.

9 ⅝ XPC #36, N-80 flush joint (Enventure)		9 ⅝ 511 #36, N-80, flush joint (Hydril)		comparison
• Connection joint strength	533,900 lbf	• Connection joint strength	684,000 lbf	1.28 x stronger
• Compressive load rating	427,100 lbf	• Compressive load rating	686,000 lbf	1.60 x stronger
• Min parting load	634,000 lbf	• Min parting load	684,100 lbf	1.08 x stronger
• Max pure bend rating	$19,8^{0}$/100 ft	• Max pure bend rating	26^{0}/100 ft	1.32 x stronger
• Torque		• Torque		
Mimimum final torque	2500 ft.lbf	Mimimum final torque	9200 ft.lbf	3.68 x stronger
Optimum final torque	2800 ft.lbf	Optimum final torque	11,000 ft.lbf	3.93 x stronger
Maximum final torque	3100 ft.lbf	Maximum final torque	- N/A -	- N/A -
Maximum Yield torque	6200 ft.lbf	Maximum Yield torque	88,000 ft lbf	14.2 x stronger

Table II.3.–Comparison Enventure and Hydril connection

The criteria for connection properties to assure the successful operation are:

• Make up torque of connection must be bigger than torsion in drilling operation

• Connection joint strength must be higher than tension or hook load in drilling operation. .

• Maximum bending rating must be bigger than the dogleg in well profile.

The connector provides discontinuities that may be the weakest point for fatigue. The main fatigue in connection is because the casing connector geometry may create stress riser where local stresses are higher than expected. Alternating stress is higher in the connection than the body, which means the connection is weaker.

This coupled connection utilizes a thread seal and resilient seal ring to enhance the pressure containability (see figure II.9). The design employs an API buttress thread with abutting pin noses as the torque shoulder to improve the torque capacity and fatigue performance.

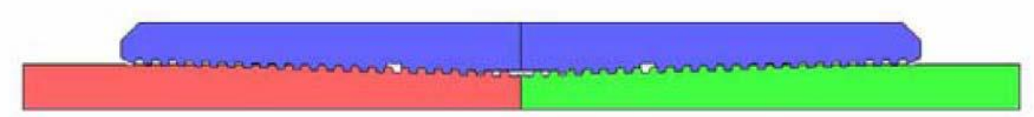


Figure II.9. - DwC/C-SR connection

CHAPTER III

Case study

III.CASE STUDY:

CwD IN FIQA FORMATION IN THE SULTANATE OF OMAN — A SUCCESS STORY

III.1.Summary

Highly reactive Fiqa shale used to compel well engineers in the Sultanate of Oman to plan drilling phase of surface and intermediate sections primarily based on time exposure to aqueous drilling fluid water-based mud (WBM). The new approach of drilling the time-dependent Fiqa formation using casing-while-drilling (CwD) allows well engineers to plan prospective top/intermediate wellbore sections differently by enhancing the overall drilling performance. This reduces the risk of setting casing strings at unplanned depths, getting pipe stuck, or reaming continuously when drilling with conventional drill-string. The technical feasibility study, risk assessment, planning, execution, and the lessons learned during the process of drilling two top-section pilot projects are described in this document.

The CwD team compares the drilling performance of several offset wells and suggests actions to improve the CwD technology in Oman. Two 17(1/2) and 22 in surface sections were drilled successfully with large-diameter casing strings and reached 754and 894 m measured depths, respectively. The implementation of the CwD concept reduced the overall drill/case phase time up to 40%, in comparison with the average using conventional drilling in those fields.

Exposure time of Fiqa to aqueous environment was reduced by eliminating conditioning trips and nonproductive-time (NPT) associated with wellbore instability.

Drilling both sections with non-retrievable 17(1/2) _13(3/8) in. and 22_18 (5/8)-in. CwD systems did not require modification of well design or rig. The optimization of this technology will support its implementation as the conventional drilling approach in some fields in Oman.

III.2.Introduction

Fields A and B in Northern Oman present a host of drilling challenges in upper-wellbore sections. Wellbore-instability and reactive- shale problems are common when drilling the highly reactive, troublesome Fiqa shale formation,as solutions they do an excessive reaming during drilling and before running casing, and use of oil-based drilling fluid oil-based mud

(OBM) or especially formulated water-based drilling fluid (WBM) to mitigate borehole instability across Fiqa. This case shows how applying CwD technology as an enabling tool will result in improved drilling performance indicators in both fields. Two candidate wells in fields A and B were identified, where top-hole sections were drilled from surface to bottom of the Fiqa shale formation. Monitoring real-time data, analyzing the tendency of mechanical energy consumption, and implementing optimum drilling parameters produced an efficient time-on-bottom top section in field B.

Such outcomes were accomplished with no rig modification and by deploying standard American Petroleum Institute (API) casing grade/weight pipe and connection, fit-for-purpose Casing Drive Mechanism (CDM), and polycrystalline-diamond-compact (PDC)-type drillable bits.

III.3.Fiqa Formation

III.3.1. Geologic Formation of Fiqa

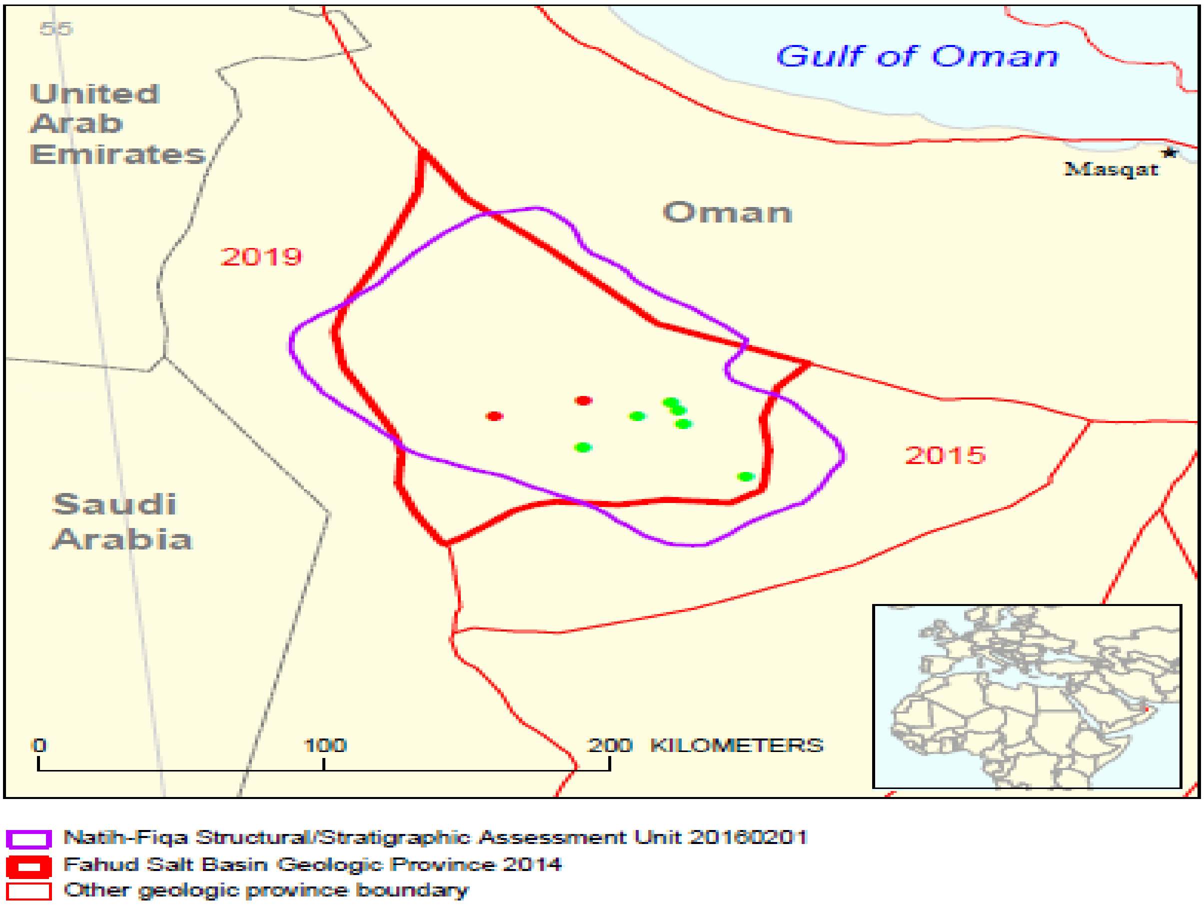


Figure .III.1 Natih-Fiqa Basin Geologic Province 2014

In the Sultanate of Oman, the Fiqa formation ranges from 50 to 1400 m in thickness and is formed by two independent layers: Upper Fiqa, known as Arada, and Lower Fiqa, known as Shargi, the thicker layer that causes a majority of drilling problems. Fiqais a clay-rich member of the Upper Cretaceous Aruma group, which provides an effective seal for Wasia group reservoirs such as Natih field, which was deposited in the Middle to Late Cretaceous
(Harris and Frost 1984). The hydrocarbon migration commenced after the Fiqa was deposited. The Fiqa formation is an efficient, impermeable, thick seal (Borowski2005) with low hydrocarbon source-rock potential (Alsharhan1995). It is a sequence of moderately shallow to deep marine shale, consisting of limestone and marl.

The amount of clay varies, and Shargi has the maximum concentration. The clay portion is primarily dominated by kaolinite, while the non-clay part is dominated by calcite, quartz, and feldspar with traces of dolomite, pyrite, siderite, glauconite, and phosphate (Alsharhan 1995; Harris et al. 1984). Drilling Fiqa reveals complications similar to those encountered when drilling very reactive clay/shale formations.

The typical lithology in northern Oman is shown in Table 1. Fiqa is rich with limestone formations that, in many fields, is considered a potential loss zone. For years, well construction included very-large casing sizes to case off the well sand subsequently drill Fiqa with either expensive polymer WBM or OBM. That was the common combined-mitigation system used for decades to avoid drilling problems across Fiqa.

Formation/Layer	Depth-Average	Description (Composition)
Surface Sediment	Surface	Undifferentiated sequence of dolomites, limestone, shale, gypsum/anhydrates
UeR—Upper	219 m	Succession of variably
UeR—Middle	289 m	chalky limestone
UeR—Shammar	359 m	Shale
Fiqa Arada	369 m	Limestone
Fiqa Shargi	689 m	Shale
Natih	958 m	Limestone

TABLE III.1—Typical lithology in Northern Oman; thickness of each Formation varies

III.4.Operational Challenge

Drilling across reactive shale commonly causes borehole instability (Tan et al. 1999), and physicochemical interactions with WBM are responsible for such swelling phenomena. This validated fact has been discussed widely in the literature, along with all associated drilling problems (Santarelli and Carminati 1995; Civan 1999). To minimize the negative effect that shale swelling produces on drilling performance, two major chemical solutions were defined in the past: OBM (Santarelli 1992 et al.), or redefined-chemistry WBM (Santos et al. 1998). The occurrence of mineralogical transformations while drilling Fiqa shale with WBM in northern Oman is prevented by use of chemical additives (inhibitors and polymers, for instance) in the drilling-fluid system.

In addition to these specialized systems, the mud weight is designed to contribute to the stabilization of Fiqa by preventing it from collapsing. Even though the refined WBM system assists in preventing wellbore instability, drilling operations are highly affected by NPT associated with stuck pipe or reaming continuously to ensure a stable borehole before running casing. The time to drill, case, and cement the casing before Fiqa swells and collapses is crucial; these stages must be achieved quickly.

Excessive reaming and numerous conditioning trips—potential NPT—became part of the planned drilling time in both fields. In the last decade, the top hole sections in Fields A and B were drilled successfully either with roller-cone or PDC bits. Formation drillability is not a concern when drilling this section up to the top of Natih.

III.5.Proposed solutions

Unplanned events in the past became planned or highly possible events in the last decade when drilling across Fiqa.

Simple operations such as short trips, circulation, and back reaming were included in drilling programs, along with special drilling fluids, to remediate Fiqa swelling problems and to run casing strings successfully. Well-engineering groups, however, were open to solutions that allow them to enhance the overall drilling performance, to overcome wellbore instability and enhance drilling efficiency, CwD was proposed as an enabling technology.

The proposed concept of drilling with casing and then cementing just after reaching STD allowed drilling teams to reduce both the drill/ case phase and the exposure time of Fiqa to WBM. It was planned to drill a 17” (1/2) top hole with 13(3/8) casing in Field A and a 22” top hole with 18” (5/8) casing in Field B, using drillable PDC bits in both cases. The drilling rig was chosen on the basis of availability of a top-drive system (TDS) and expertise drilling in the local area with a conventional drill-stem. The TDS made the casing string rotate by transmitting the required energy through a CDM connected in between. The long-term scope of the CwD technology to enhance overall drilling performance in Petroleum Development Oman (PDO) relied on the success of first trials.

During the planning phase, and to ensure a successful CwD operation, the team selected suitable CwD tools with conventional casing accessories, evaluated the mechanical properties of the drill-in string, and simulated drilling parameters by modeling torque/drag, hydraulics and hole cleaning, bottom-hole-assembly (BHA) performance, and cementing operations. Along with all technical preparedness, several risk assessment workshops were held to evaluate the risk associated with every unplanned event and identify the actions to be taken in case of occurrence.

III.6.Well Planning

Surface-hole sections in northern Oman, (i.e. deep gas wells) are regularly drilled with large-diameter bits (171=2 – 23 in.; either roller cone or PDC) using WBM and a standard rotary BHA. The top holes are cased with 133=8-in. 72# L80 BTC or 185=8-in. 87.5# K55 BTC casing strings, with no well-control system in place. The following sections in both fields are commonly drilled with 121=4- or 171=2-in.PDC bits and cased with 95=8- or 133=8-in. casing, respectively. Intermediate sections are not included in this study, but they were relevant in the selection of CwD bits.

The feasibility study revealed that CwD should be planned for candidate top sections without modifying existing drilling-rig and casing design. The major components of drill-in strings and the CwD system are:

(a) drillable PDC bit, (b) fit-for-purpose stabilizer in Field A to mitigate the risk of buckling (no stabilization required in Field B),(c) high-torque ring to increase the torque capability of BTC connection, (d) 133=8-in. 72# L80 BTC casing in Field A and 185=8-in. 87.5# K55 BTC casing in Field B, (e) Casing drive mechanism CDM made up to rig's TDS, and (f) two conventional flow collars for Field A (high-flow-rate float systems not available) and one sting-in float for Field B. The selected BHA for the drill-in string is shown in Fig. 1.

Different tools were used to simulate drillstring mechanics and determine optimum-drilling parameters such as maximum weight on bit allowed, rotary torque, critical rotary speed, and hydraulics.

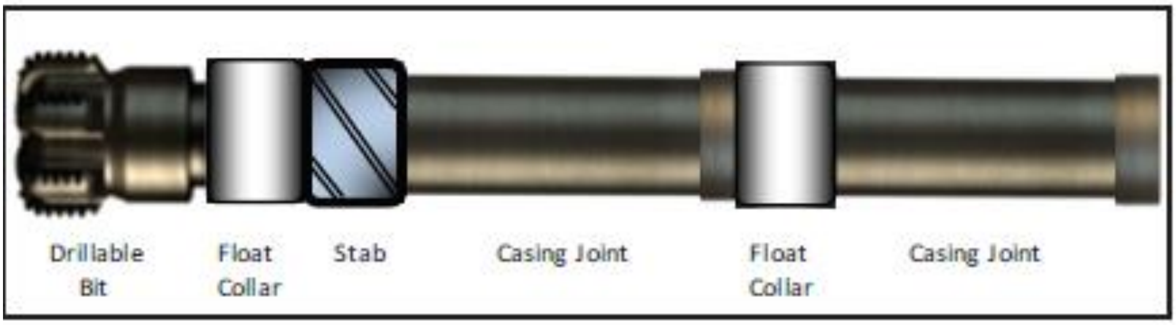


Figure.III.2—BHA designed for CwD job in Fields A and B (no stab needed and only 1 float collar).

III.7. Drillable Bit, CDM, and CasingMaterial/Connection

A comprehensive analysis was made concerning local availability of the CwD components and casing accessories to strengthen reliability of CwD system in both fields. From surface to 40-m depth—rathole—conventional drillstem was used to preserve integrity of drill-in BHA and ensure total verticality across unconsolidated formations.

The objectives for selecting (a) suitable drillable bits and (b) CDM for the first two trials in deep-gas-well areas are summarized as follows:

- Be able to drill though Fiqa with only one drillable PDC bit.
- Cement the casing into place before borehole collapses.
- Avoid conditioning trips as well as bit balling.

III.7.1.Field A

The 17” (1/2) top sections of the previous 19 wells were drilled with roller-cone bits, and in Well #20, a five-blade PDC bit was used. The recovered PDC bit was grade 2-5-WT-A X-I-BT-TD. This successful run led the CwD team to choose a PDC bit with similar cutter structure for Well #21, but with six blades instead.

The 171=2-in. drillable PDC bit drilled from 40 to 754 m in 50 hours, with an average rate of penetration of 14.3 mph. Fig. 2 shows the bits used in Field A.

Fig. III.3 —(a) Roller-cone bit used in 19 wells. (b) Conventional PDC bit used in Well #20. (c) Drillable PDC bit used in CwD of Well #21.

III.7.2. Field B

As a result of the experience in Field A, along with the complexity of drilling a larger-diameter wellbore, the team improved the bit selection. Before use of CwD, six consecutive surface sections were drilled in Field B using standard 23” to 26” roller-cone bits; PDC bits were never used, as Table 2 describes. Fig. 3 shows the bits used in Field B.

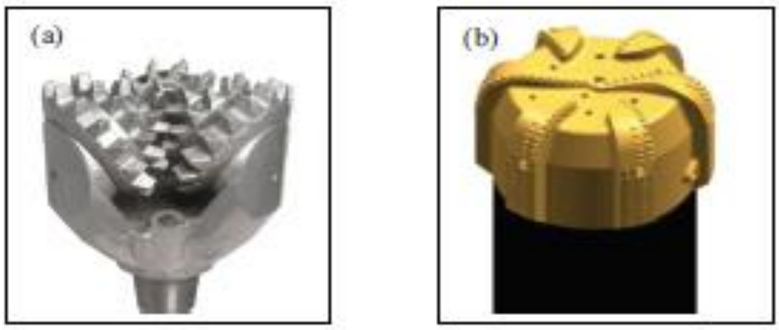


Fig. III .4— (a) Roller-cone bit used in previous wells.
(b) Drillable bit used in CwD of Well #10.

- Log-based rock-strength analysis was performed at top hole in only one well.

Fig-I.7.2 shows the unconfined-strength (UCS) analysis completed from surface to base of Natih A/B. It is evident that UeR Middle, UeR Shammar, Fiqa Arada, and part of Fiqa Shargi contain a few isolated, hard stringers with UCS values ranging from 20,000 to 38,000 psi. These hard stringers correspond to different formation elements.

Fig III.5—Lithology (0–1000 m) and rock-strength analysis in Field B-West.

- The tri-cone bits well campaign are designed as 115-IADC. used in the previous nine- The drillable PDC bit used in the CwD well, which is recommended to drill harder and more abrasive formations ,was chosen to ensure success while drilling with casing.
- Internal grappling CDM system was connected to the TDS to transmit rotation and axial movement to casing string. It included a set of link tilt arms with single-joint elevators.
- Collapse and burst rating of large-diameter casing is many times lower than that of drill-pipe (DP). The external- and internal pressure rating of drill-in string is irrelevant while drilling because large-internal-diameter casing reduces maximum standpipe pressure.
- Body-yield strength, yield torque, J-polar moment, and toughness of 133=8-in. 72# L80 and 185=8-in. 87.5# K55 casing strings are several times larger than in API DP, allowing them to resist greater axial and torsional loads than traditional 5-in. 19# S135 joints. In other words, chances of twist-off during these CwD operations are negligible

Casing	Mechanical Properties					Connection Dimension/Properties			
	Collapse	Burst psi	Body Yield Strength klbf	Impact Test	Yield Torque	OD (in.)	ID (in.)	Length (in.)	Torque Yield w/HTR (ft./lb)
18 5=8-in. 87.5# K55 BTC	630 (4,398)	2,250 (15,708)	1,367 (617)	Unknown	500	19.625	17.755	12	Above 60K
133=8-in. 72.0# L80	2,670 (18,640)	5,380 (37,550)	1,661 (755)	100–130	400	14.375	12.347	12	Above 70K

BTC									

Table III.2—Standard mechanical properties of casing pipe and connection used in fields A and B

III.8.Hydraulics

In comparison with conventional drilling, CwD with large-diameter casing increased the total internal fluid-flow area by more than 8 times and reduced the annular flow area by 2.2 times.

Drillability features of drillable PDC bits in Fields A and B were unquestionable. Consequently, the hydraulic energy was the major power-component used to optimize drilling efficiency of the system as an alternative to mechanical energy. Therefore, the team was focused on providing enough hydraulic energy to (a) clean the bit and prevent bit balling with high jet velocity, (b) remove cuttings rapidly to avoid accumulation inside tight-clearance annulus and flowline, and (c) reduce overall energy consumption.

Several simulations were completed to assess hydraulic parameters when drilling 171=2- and 22-in.

III.9.Cementing Drill-In String

III.9.1.Field A

Conventional cementing operations were performed after the drill-in string reached the planned STD (754 m) and the wellhead was successfully installed. Although some difficulties were expected when executing the cementing job, because of possible premature damage to float collars, no problems were reported. Cement slurries were displaced through bit nozzles as per the plan. The total cement returned to the surface recorded 92% of pumped excess in comparison with the 20% average in the field.

After drilling the next 12(1/4) in. section, open-hole logging tools were run including a cement-bond log (CBL), which showed good cement bonding.

III.9.2.Field B

The CwD team suggested a conventional cementing job, to hold pressure after cement slurries were displaced, and wait on cement. The total volume of the cement recovered at the surface reached up to 98% of the pumped excess, in comparison with 25% average in the field, which indicated the high quality of the wellbore. Such characteristics could be associated with the concept of smear effect, the ratio of casing OD to borehole inner diameter was higher than 0.8 witch help wellbore strengthening.

The CwD with 185=8-in. string was successfully implemented until an incorrect procedure was detected 20 m before the bit reached the planned STD. Making up the connection with inappropriate hand slips caused the casing to collapse, leading to an unplanned casing-setting point of 894 m. This resulted in NPT of 0.83 days in the surface section, and no NPT in the intermediate section.

III.10. Results and Lessons Learned

III.10.1. Field A

The total time for drilling the surface hole and cementing the 133=8-in. casing at planned STD was 3.8 days, with an average rate of penetration of 8.27 m/h, in comparison with the average reported in the field of 5.15 m/h. no additional trips were required to improve the borehole conditions as in the previous 20 wells drilled with conventional methods.

Figures bellow illustrate that the drill/case efficiency within the field using a conventional drill-stem averaged 123.5 m/d, while in Well A21 it was 197.9 m/d

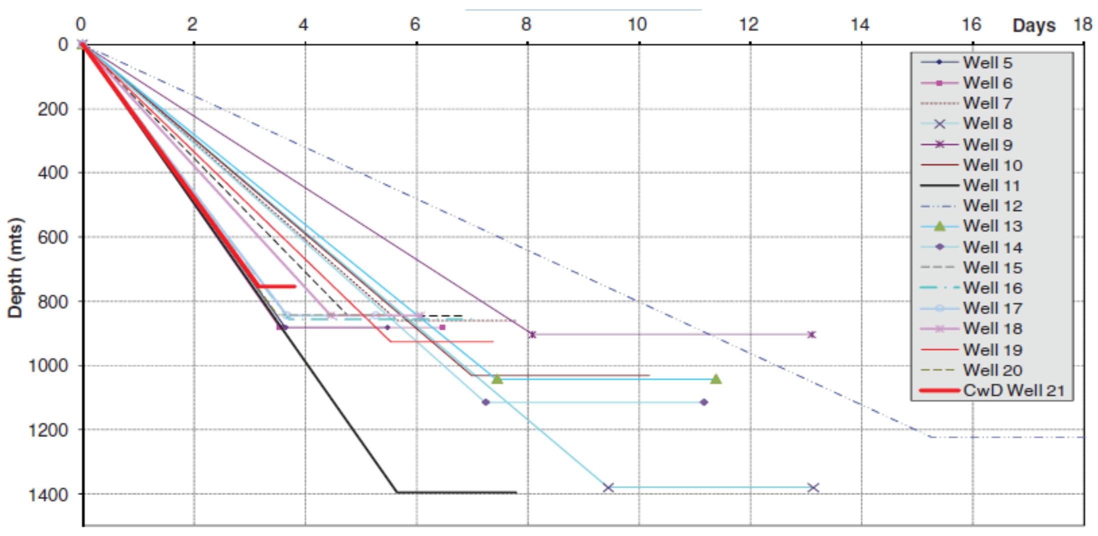


Fig. III.6—Historical Depth-Time-Drill/Case Surface Hole in field A.

Such statistics include the time drilling the rat-hole, and exclude the time required to drill out the drillable bit before resuming drilling operations. This CwD job was the first in Oman northern areas and allowed the drilling group to improve the overall drill/case efficiency of 171=2-in. sections in Field A by 60.5%. Well A21 represents the evidence to consider CwD as an effective mitigation system against wellbore instability across the Fiqa formation. Additional time was required to drill out the drillable bit.

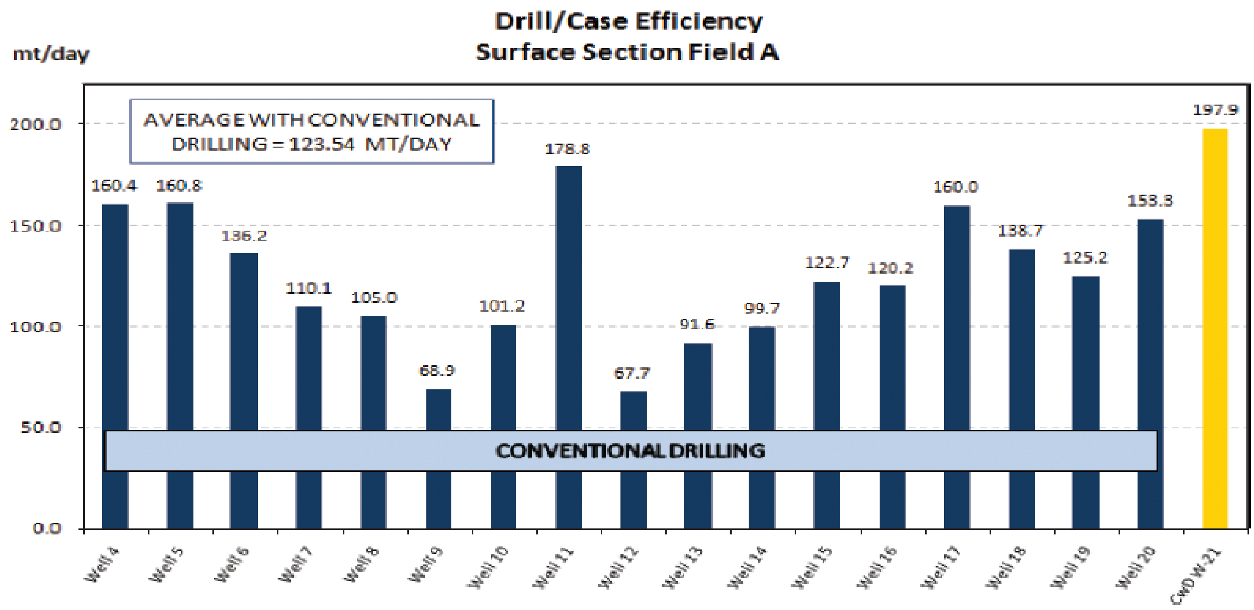


Fig. III.7—Field A, historical data and drill/case efficiency 171=2_13 3=8-in.surface section.

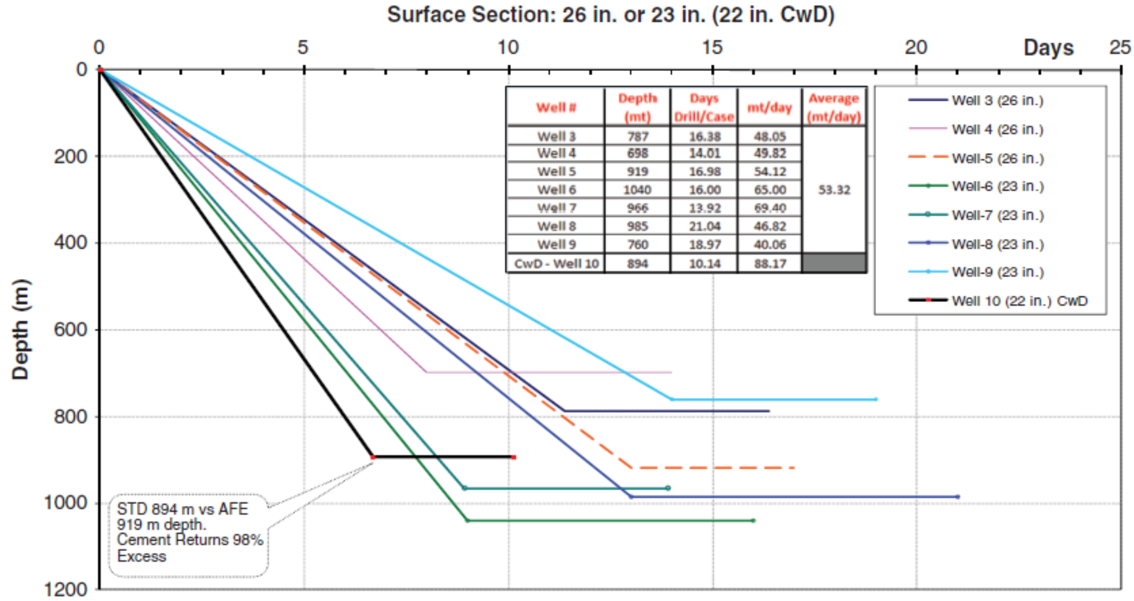
The determined planning and execution of this first CwD job in PDO established a fit-for-purpose solution to the historical wellbore-instability problems in northern Oman, with limited changes to conventional drilling setups. The main objective of this pilot project was to prove the concept of CwD as a mitigation system against the risk of wellbore instability and related NPT, resulting in certain innovations in deep-gas development and exploration wells. It also opened new horizons toward enhanced well integrity, and minimum HSE-related NPT and concerns in terms of OBM usage.

III.10.2. Field B

The 22-in. surface section was drilled to a STD of 894 m in 6.68 days with an average rate of penetration of 5.58 m/h, when the average reported in the field was 3.55 m/h.

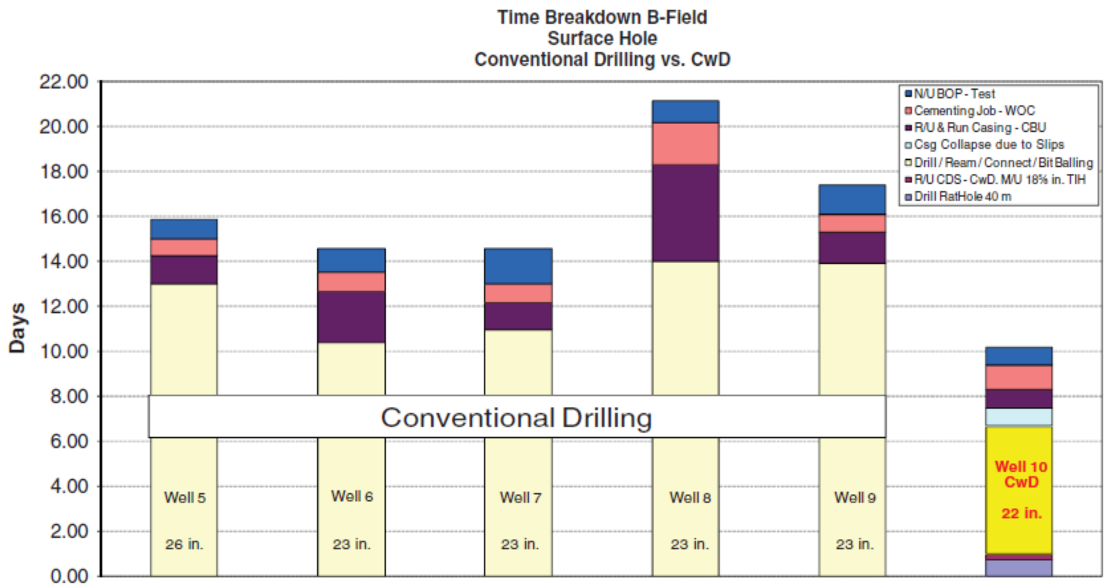
Fig. 6 shows that the drill/case efficiency in the previous nine well campaigns with conventional drilling methods of 23- or 26-in.hole size averaged 53.32 m/d, but in Well B10, the drill/case efficiency was 88.2 m/d. It included the rat-hole, casing collapse and connection damage owing to TDS misalignment and related NPT, and the drill out of the drillable bit. As explained for Field A, drilling conventionally for the first 40 m prevented premature bit damage and early borehole deviation.

The lessons captured in Field A and the implementation of good drilling practices resulted in a 65% improvement in drill/ case performance. The use of an automatic drilling instrument system, along with the best possible and steady ROP range, permitted the drilling team to optimize the total mechanical energy. Common practices used in the previous nine wells, such as back reaming and circulation for hole cleaning, were eliminated.



Well #	Depth (mt)	Days Drill/Case	mt/day	Average (mt/day)
Well 3	787	16.38	48.05	53.32
Well 4	698	14.01	49.82	
Well 5	919	16.98	54.12	
Well 6	1040	16.00	65.00	
Well 7	966	13.92	69.40	
Well 8	985	21.04	46.82	
Well 9	760	18.97	40.06	
CwD - Well 10	894	10.14	88.17	

(a)



(b)

Fig. III.8—Drill/case efficiency (a) and time breakdown (b) for surface sections in Field B. CwD-Well 10 includes rat-hole and NPT.

III.11.Ability of drilling with casing in Algeria

Drilling in Algeria needs a lot of consideration when designing rigs or drilling technology, the challenges for casing while drilling is to overcome the problems encountered while drilling and prove the benefits of this technology in terms of cost, time, reliability and safety. The major problems encountered while drilling with conventional drilling in Algeria is related to the geology. The most important oil basin in Algeria is Hassi Messaoud, so as a case of study we take field from it which is a horizontal development field –OMK46- and analyse a lithology description and hazards.

- ***Lithology of Hassi Messaoud field***

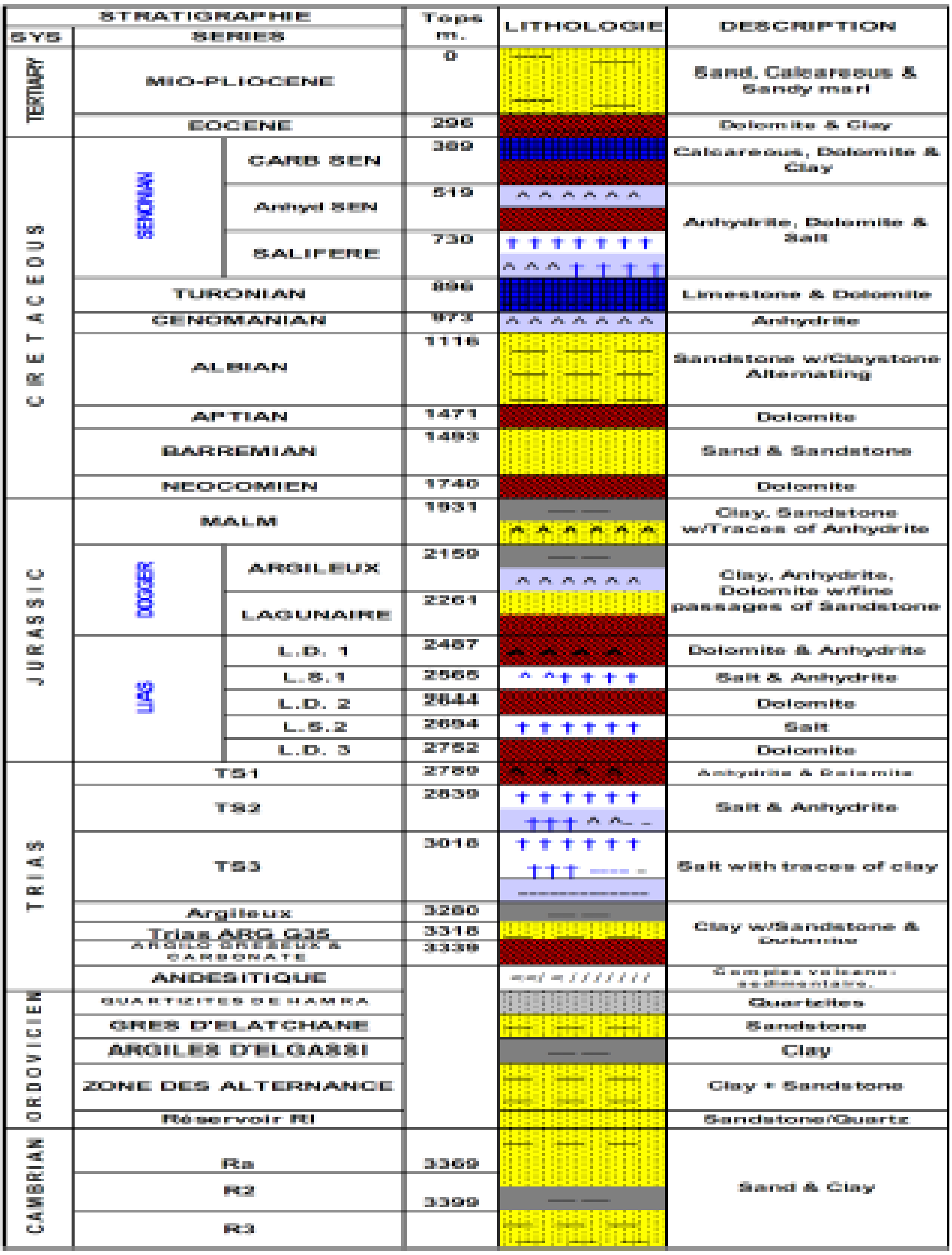


Figure. III.9 - Lithology of Hassi Messaoud field

- **Hazards encountered while drilling with Conventional Drilling in Algeria**

The hazards encountered while drilling in Algeria with conventional drilling are numerous, but some hazards which are mentioned bellow in deferent sections of drilling can be avoided by using casing while drilling technology.

- ***Hazards in 26" Hole Section***

Hazard	Causes	Impact
Partial and Total Losses	-Soft sand -Fractured Limestone -Lower Eocene LMST Carbonate	➢ Hier mud cost ➢ Hole Instability ➢ stuck pipe ➢ Full Well collapse
Tight spots	-Senonian Hard limestone -Pliocene and Eocene/Sen Carbonate	➢ Severe Bit bouncing ➢ Overpull / stuck pipe ➢ Difficulties to run CSG
Poor hole cleaning	-Low annular velocities -High ROP	➢ Stuck pipe ➢ Difficulties / unable to run the casing

Table.III.3. Major conventional drilling hazards in 26" Hole Section

- ***Hazards in 16" Hole Section***

Hazard	Causes	Impact
Abnormal Torque whilst drilling	-Down hole vibrations -Poor Well bore quality - Poor hole cleaning	➢ Slow ROP /lose time ➢ Poor Wellbore quality ➢ Bit / BHA damage
Well Bore instability in Turonian and Cenomanian	-Hard dolomite stringers in Turonian -Thin interbeds of dolomite, Silt-stone and anhydrite in Cenomanian	➢ Hard back reaming ➢ Stuck pipe/fishing ➢ Side track
Influx from	-Over pressured Albian acquifer - Bad filling of drilling string	➢ Fresh water flow ➢ Salt dissolution

Albian	while POOH	

Table.III.4 Major Conventional Drilling hazards in 16" Hole Section

- ***Hazards in 12 1/4" Hole Section***

Hazard	Causes	Impact
Abnormal Torque whilst drilling	-Down hole vibrations -Poor Well bore quality - Poor hole cleaning during drilling	➢ Slow ROP / lost time ➢ Poor Well bore quality ➢ Bit / BHA damage
Influx from LD2 While drilling	-Over pressurized LD2 with CaCl2 brine	➢ CaCl2 water influx ➢ Mud pollution
Salt / Shales swelling In Lias & Trias	-Salt creep and over pressured claystones in Lias / Trias	➢ Difficulties to POOH ➢ Difficulties to RIH CSG
Influx from LD2 While POOH	-Over pressurized LD2	➢ CaCl2 water influx ➢ Kick

Table .III.5-Major Conventional Drilling hazards in 121/4" Hole Section

- ***Prospect of casing while drilling applicability in Algeria***

This technology has a lot of good arguments to be implemented in Algeria such as: solving drilling hazards such as: stuck pipe, tripping and kick. In addition to saving time by eliminating drill pipe, avoiding drilling hazards and eliminating some operations concerning inspection of drill pipe and transportation. Furthermore, it reduces the cost of operations by reducing the crews' number, reducing additional operations related to hazards and improves the safety on the well site by using automated device to handle with casing...etc.

With the solutions given by the casing while drilling, it is useful to implement this technology in deferent Algerian fields in order to test it, and make further specific studies to approve this technology.

CONCLUSION

This report highlights a technical and commercial study related to the casing while drilling. Two casing while drilling rig are compared , the first one is a Converted conventional drilling rig which is basically conventional drilling rig associated with additional device adapted to drill with casing, and the second type is the Purpose built casing drilling rig which has specific and adequate components designed to drill with casing. Through this study, we illustrate the required equipments to install the two concepts, and mention the benefits and the limitation of the CWD system. Casing while drilling has a lot of potential application in Algeria, especially with the several hazards encountered while drilling by the conventional drilling such as: stuck pipe, lost circulation and tripping. All this major problems can be solved by the CWD system, thus the application of casing while drilling in Algeria is suitable, but more specific studies are required involving all area of concern.

ABREVIATIONS

OD Outside Diameter
NPT Non-Productive Time
PSD Particle Size Distribution
TD Total Depth
API American Petroleum Institute
BHA Bottom Hole Assembly
BHP Bottom Hole Pressure
BOP Blowout Preventer
CD Casing Drilling
CDS Casing Drive System
CDM Casing Drive mechanism
CWD Casing While Drilling
DLS Dogleg Severity
ECD Equivalent Circulating Density
EMW Equivalent Mud Weight
HPHT High Pressure High Temperature
HSE Health, Safety & Environment
LCM Lost Circulation Material
LD Liner Drilling
NPT Non-Productive Time
PHAR Pipe-to-Hole Area Ratio
POOH Pull Out Open Hole
RIH Run In Hole
ROP Rate of Penetration
RSS Rotary Steerable System
TD Target Depth
TVD True Vertical Depth
WOB Weight on Bit

Definitions

Annulus	The void between the drill string / production tubing and Wellbore/casing.
Bit Balling	The formation being drilled sticks to the bit, reducing bit efficiency and ROP, and potentially increasing string vibrations which may lead to component/string failure.
Contingency	A provision for a possible event or circumstance. In the case of contingency casing, an intermediate casing intended to bridge the gap between two casing size in case it becomes necessary to set a casing earlier than originally intended.
Dog-leg Severity	A measure of the build-up rate in a well, quantified by well inclination change / length of well, usually $\Delta\alpha/30m$.
Liner	A liner is a casing string that is hanged off at the bottom of the previous casing string, typically with an overlapping section of 100m.
Mud Window	The difference between the formation pore/ collapse pressure and fracture pressure.

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Résumé

De nos jours, l'augmentation du prix et de la demande au pétrole/Gaz dans le monde, a permis aux compagnies pétrolières d'augmenter leur production pour satisfaire la demande. Les compagnies pétrolières essayent également d'explorer de nouveaux réservoirs dans les zone difficiles tel que ; L'eau Profond, les réservoirs HPHT (Haute température Haute pression) et les dômes de sel. L'industrie recherche toujours de nouvelles technologies pour plus de sécurité lors le forage des puits, plus d'efficacité avec le moindre cout. Le Casing Drilling est un processus dans lequel un puits est foré et tubé simultanément, on employant un tubage standard comme garniture. Le but principal de développer la technologie CwD était d'éliminer le Temps Non Productif (NPT), il n'a presque aucune limitation et a un potentiel de gagner 20 – 40 % du temps d'installation en éliminant la manœuvre des tiges et réduisant au minimum les problèmes de forage. Pendant l'exécution tôt de la technologie, d'autres avantages ont été vus en forant avec un tubage de grand diamètre. L'amélioration de stabilité des puits est peut-être la plus importante de ces avantages.
L'effet de Plastering est responsable des améliorations vues dans la stabilité de puits tout en en utilisant le CwD, il empêche la perte de circulation, et renforcer le puits en enduisant et plâtrant les déblais produits lors le forage sur les parois et en scellant les pores.
Dans l'étude de cas, une histoire de succès de Casing While Drilling de deux puits candidats indique qu'elle est la meilleure solution pour forer la formation de Fiqa, ce qui représente une zone de défi concernant le forage des sections supérieurs en raison perte et des argiles fortement réactives (phénomène de gonflement).

Abstract

Nowadays, higher oil price and world demands on oil and gas supplies, have allowed the oil companies increase their production. To meet the demand, oil companies also try to explore new reservoir possibilities in difficult area such as deep water, HPHT reservoir and salt dome reservoir. Industry is continuously searching for new technologies to make the drilling of well safer, more efficient and cheaper. Casing Drilling is a process in which a well is drilled and cased simultaneously a using standard casing as the drillstring.
The original purpose of developing Casing Drilling technology was to eliminate Non Productive Time (NPT), it has almost no limitations and has a potential of saving 20 – 40% of rig time by eliminating drillstring tripping and minimizing downhole problems. During early implementation of the technology, other benefits were seen while drilling with large diameter casing. Wellbore stability improvement is perhaps the most important of these advantages and is a primary driver for selecting intervals where applying Casing Drilling can be most beneficial.
The Plastering Effect is responsible for improvements seen in wellbore stability while using Casing Drilling. It is an inherent benefit of Casing Drilling that strengthens the wellbore, prevents lost circulation, and mitigates formation damage. The Plastering Effect strengthens the wellbore by smearing the generated cuttings and available PSD (Particle Size Distribution) into the formation face and sealing the pore spaces.
In the case study, a success story of Casing While Drilling of two candidate wells indicates that is the best solution for drilling Fiqa formation, which represent a host of drilling challenges in upper-wellbore sections because of loss zones and shale swelling phenomena (highly reactive clay/shale).

ملخص

ارتفاع الطلب العالمي على البترول والغاز فرض على الشركات البترولية رفع معدل الانتاج لتلبية مطالب السوق مما دفع الشركات لمحاولة التنقيب عن مخازن البترول في المناطق الصعبة مثل المياه العميقة و الخزانات ذات الحرارة و الضغط المرتفعين و الطبقات الملحية
ان الصناعة في بحث مستمر عن تكنلوجيات حديثة لجعل عمليات الحفر اكثر امانا
الحفر بانبوب التغليف هو تقنية تسمح بحفر وتغليف البئر في نفس الوقت واما الهدف الرئيسي من تطوير هده التقنية هو التخلص من الوقت الضائع (غير انتاجي) حيث سمحت بتوفير من عشرين الى اربعين بالمائة من الوقت اللازم لعملية الحفر ودلك بازالة عمليات تركيب واخراج انابيب الحفر والتقليل من المشاكل التي تحدث في اعماق البئر ومند بداية ظهور هده التقنية عرف لها فوائد اخرى ابرزها دعم تماسك واستقرار جدران البئر بفضل خاصية التبليط
التبليط ظاهرة تسمح بتقوية البئر بسد التشققات ومنع ضياعات طينة الحفر وتجنيب تلف الطبقات الارضية ودلك بالصاق بقايا الحفر على جدران البئر وتبليطها وتمليسها وبالتالي ملئ مسامات الصخور
في دراسة الحالة تم اثبات نجاح تقنية الحفر بانبوب التغليف ودلك بعد حفر بئرين في منطقة فقة شمال سلطنة عمان وثبت انها افضل حل للحفر في هده المنطقة والتي تعتبر تحدي لكثرة مشاكلها وخاصة الطبقات السطحية بسبب انتفاخ المناطق الطينية و ضياعات طينة الحفر