A TECHNO ECONOMIC STUDY ON CASING DRILLING

By

AJIT TRIPATHI

College of Engineering

University of Petroleum & Energy Studies

Dehradun

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A TECHNO ECONOMIC STUDY ON CASING DRILLING

A thesis submitted in partial fulfilment of the requirements for the Degree of

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By

Ajit Tripathi

Under the guidance of

Mr. Arun S. Chandel

Approved

Dr. Srihari

Dean

College of Engineering

University of Petroleum & Energy Studies

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CERTIFICATE

This is to certify that the work contained in this thesis titled "**A techno economic study on casing drilling**" has been carried out by **Ajit Tripathi (R010206006)** under the guidance of **Mr. Arun S. Chandel (Associate Professor)** and has not been submitted elsewhere for a degree.

Mr. Arun S. Chandel

(Associate Professor)

Date 15/05/10

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Real life isn't always going to be perfect or go our way, but the recurring acknowledgement of what is working in our lives can help us not only to survive but surmount our difficulties.

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Ajit Tripathi

B.Tech (Applied Petroleum Engineering)

University of Petroleum and Energy Studies, Dehradun

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CHAPTER 1
INTRODUCTION

Casing drilling is being employed in many countries as an effective method of reducing the overall drilling costs by reducing drilling time and drill string problems encountered during conventional drilling process. In normal rotary drilling productive drilling time is lost in tripping, whereas unscheduled events during tripping can make the drilling process even more inefficient and even lead to loosing the well. While the potential savings from reducing drill-string tripping and handling times are important, the savings from reducing hole problems may be more significant. There are many situations where problems such as lost circulation, well control incidents, and borehole stability problems are directly attributed to tripping the drill-string and other situations where these problems prevent the drill-string from being tripped. Since the Casing drilling process provides a continuous ability to circulate the well, it is inherently safer than leaving the well static without a means of circulating it while a conventional drill-string is tripped. Reduced pipe tripping with the CDS should also reduce surge and swab pressure fluctuations. There are two basic methods of drilling with casing :

1) a latched retrievable BHA inside the casing that incorporates a motor to drive a conventional bit and under-reamer or

2) a rotate the casing at surface system incorporating an Internal Casing Drive System and a drillable "cement in place" drilling BHA.

Casing drilling system is being used primarily for multi-well offshore platforms, multiwall operations on land, deep-water operations, and for situations requiring operators to drill through and place casing across problem formations quickly.

This type of technology was applied successfully to drill through depleted reservoir (problems: wellbore instability, mud losses into the depleted zones) as an alternative to the underbalanced drilling, which requires special equipment. Casing drilling system has been designed primarily for multi-well offshore platforms, multiwall operations on land, deep-water operations, and for situations requiring operators to drill through and place casing across problem formations quickly. This technology was applied successfully to drill through depleted reservoir (problems: wellbore instability, mud losses into the depleted zones) as an alternative to the underbalanced drilling, which requires special equipment

CHAPTER 2

CASING WHILE DRILLING PROCESS

2.1 CWD TECHNOLOGY:

There are two types of CWD technologies employed:

1) Retrievable

2) Non-Retrievable

1) RETRIEVABLE TECHNOLOGY

Basically it was initially employed by Tesco and this technology employs the use of PDM, Drill Bit and Under Reamer. Casing is lowered in static or rotated mode and is connected with buttress thread and multi torque rings. The BHA is recovered with a special retrievable tool .In these process basically valve system is installed before cementing.

2) NON-RETRIEVABLE TECHNOLOGY

This process was initially employed by Weatherford and in it Casing itself transmits rotary torque and weight to bit. It consist of Drillable drill bit and valve assembly. There is no additional trip required before cementing.

Comparison of Retrievable Vs Non-Retrievable technology –

Weatherford has used non-retrievable technology of Casing drilling on more than 800 project whereas Tesco have used it on more than 1000 intervals.

Weatherford has developed a system where casing can be drilled with proprietary casing bit and can be easily drilled with the help of conventional drill bit because the drill shoe is made up of drillable aluminium. It is less expensive than Tesco and is simple to operate in certain application. However it is not steerable but there are few examples where it had maintained an angle of 70.

On the contrary , Tesco technology of retrievable CD is expensive .It can unlatch and utilizing a wire line system can retrieve the drill bit, bottom hole assembly and steerable motor which make directional casing along with drilling. The BHA can again be re-run, allowing drilling to continue.

In this report basically Tesco technology is discussed

2.2 Casing Drilling Equipment:

The casing drilling process eliminates the use of conventional drill string by using the casing itself as the hydraulic conduit and means of transmitting mechanical energy to the bit. A short wire line retrievable bottom hole assembly (BHA) consisting of a bit and expandable under reamer **(Fig. 1)** are used to drill a hole of adequate size to allow the casing to pass freely.

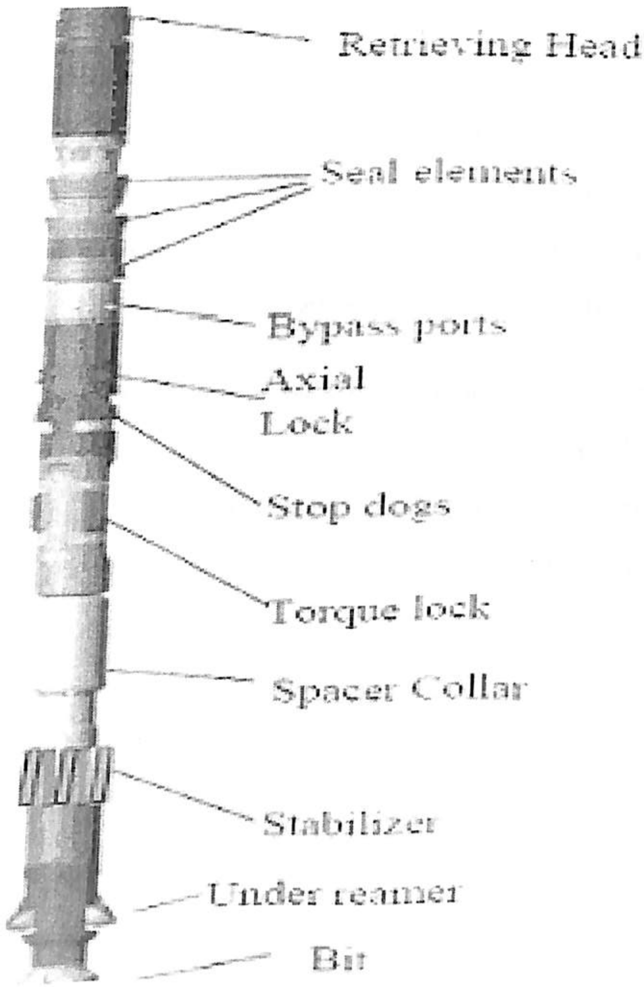


Figure 2.1 Bottom hole Assembly of Casing Drilling

The BHA is attached to a drill lock that fits into a full bore landing sub on the bottom of the casing in such a way that it can be retrieved with a wire line unit without needing to trip pipe out of the well as in case of Tesco. The wire line retrievable drill lock assembly is the heart of the casing drilling system and everything depends on it. It lands in a lower section of casing consisting of a casing shoe, torque lock profile and axial no-go and lock profile located in a specially machined collar section .The drill lock engages both a fluted profile to transmit rotational torque from the casing to the drilling assembly and an internal flush no-go and axial lock profile to transfer compressive and tensional loads to the BHA. A stabilizer on the BHA which is on the opposite of the casing shoe reduces lateral motion of the assembly inside the casing. The casing shoe is normally made with the hard material to ensure that a full gauge hole is drilled ahead of the casing, but it also provides a torque indication if the under reamer drills under gauge. Centralizers on the casing stabilize it within the borehole and prevent wear on the couplings. The BHA basically consists of a pilot bit and under reamer, but may include other tools needed to perform almost any operation that can be conducted with a conventional drill string. The pilot bit and under reamer pass through the drill-casing and drill a hole which provides adequate clearance for the drill-casing and subsequent cementing. Conventional directional tools (bent housing positive displacement motors, MWD tool, and isolation monels) and LWD tools can be suspended below the drill casing shoe for directional drilling. A conventional core barrel can be run for coring.

Designing a well for Casing Drilling is nearly the same as to design a conventional well. One main difference is that the casing is subjected to additional stresses during Casing Drilling, so buckling, fatigue, and hydraulics deserve special attention as it can occur. Figure 2 shows some of forces that affect the integrity of casing used for Casing Drilling.

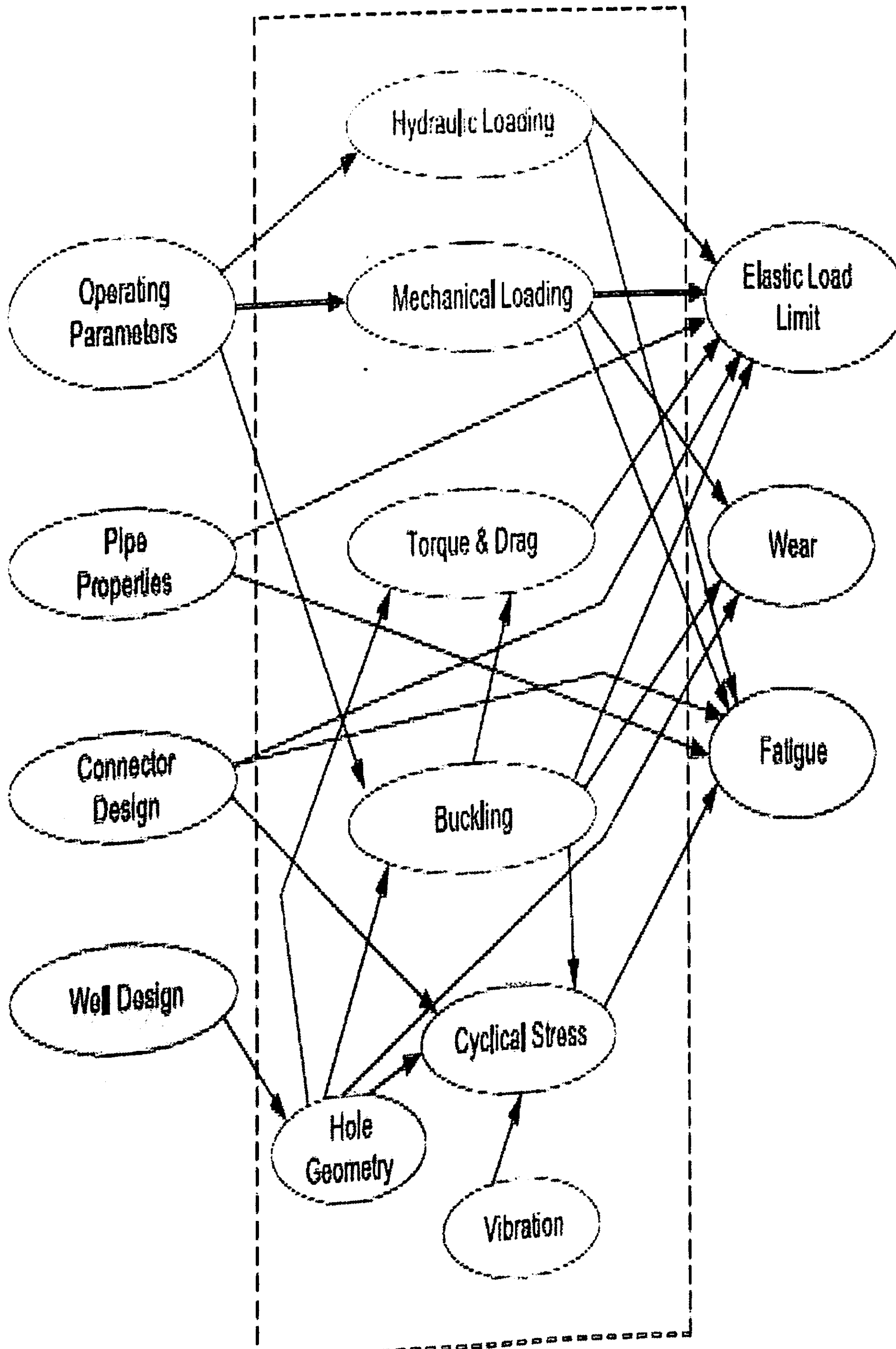


Figure-2.2 Forces affecting Casing integrity for casing drilling application

Buckling

A noteable difference between drilling with a conventional drill-string and casing drilling is that drill collars are not used to provide weight-on-bit. For years drillers were told that they need to run drill collars to make sure their drill-string is not damaged by buckling. An obvious question which arises is that "How can then casing drilling process operate effectively without using drill collars?"

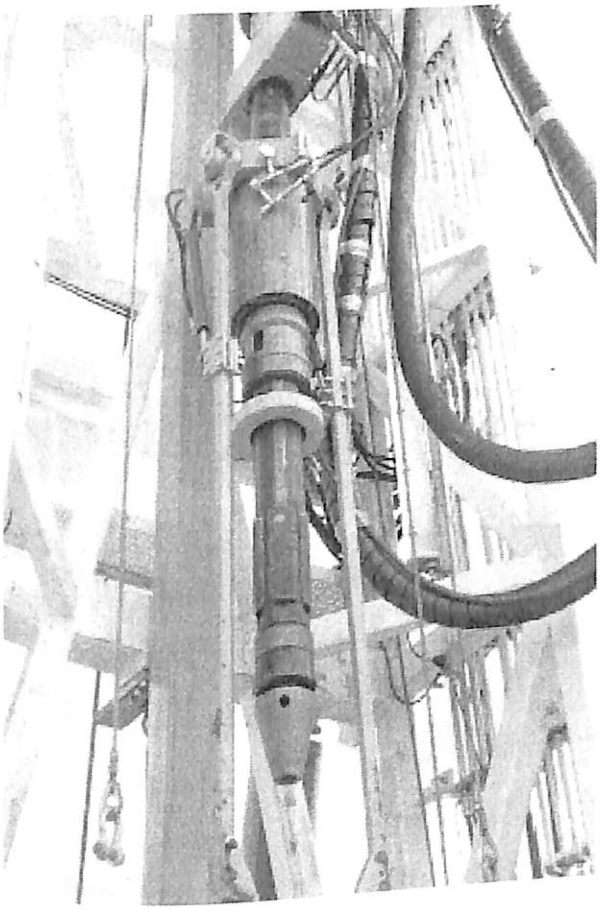
The lower portion of the drill-casing supports only a limited compressive load before it buckles. Buckling occurs only when the compressive load and casing/hole geometry create a sufficient bending moment so that casing becomes unstable. After it buckles (becomes unstable), it is incapable of supporting the compressive load without lateral support, but this does not mean that there is a structural failure. The borehole wall surrounding the casing provides lateral support to limit the lateral deflection for any given set of parameters. There is nothing inherently destructive to the fact that the casing buckles, but the buckling causes two effects that may be detrimental. First, the lateral contact forces between the drill-casing and borehole wall can cause wear on the casing and will increase the torque that is required to rotate the casing. Secondly, the buckling causes the casing to assume a curved geometry within the borehole that increases the stress in the pipe and may increase the tendency toward lateral vibrations. For casing drilling applications it is important to determine whether or not the casing is buckled and if so whether or not the buckling is sufficient to cause a problem (wear, high torque, or high stress). In straight holes, the compressive load that causes buckling is determined by the stiffness of the pipe (EI), the lateral force of gravity (pipe weight and hole inclination) and distance from the bore hole wall (radial clearance). In a perfectly vertical hole, the portion of the drill-casing that is in compression is always buckled if the bore hole does not provide lateral support through centralizers, just as drill collars are buckled in a vertical hole. If the well is straight, but not vertical, the normal wall contact force from the pipe laying on the low side of the hole provides a stabilizing influence and increases the compressive load that can be supported before the drill-casing buckles.

2.3 Casing drilling rig

Drilling rigs to be used for casing drilling can be specially developed for this technology **(Fig 1. 3)**, or can be simply modify the conventional drilling rigs to the casing drilling rig . One of the most important things on these type of rig is casing drive system (CDS) which provides safe, non-threaded connection between top-drive and casing string **(Fig 1.4)**
Casing drive system is run hydraulically, and it basically transmits the torque and mud fluid to the casing string. There are two types of CDS which are generally used:

1) internal – for greater casing radius
2) external – for smaller casing radius.

It is controlled automatically from the drillers cabine with the help of PLC (Programmable Logic Control).
The other changes from a conventional drilling rig are-
(a) The first change is to install a wireline winch which is capable of running and retrieving the BHA. The wireline should include an electric line for future tool actuation. Operation of this wireline winch was integrated into the rig PLC control panel.
(b) The second change is to install a split travelling block and crown and a top drive in order to facilitate running the wireline down through the casing.
(c) The third change is to install a wireline BOP and double pack-off above the top drive in order to seal off around the wireline which is used.
(d) The fourth change is to add pipe-handling tools to handle casing instead of a conventional drill string.



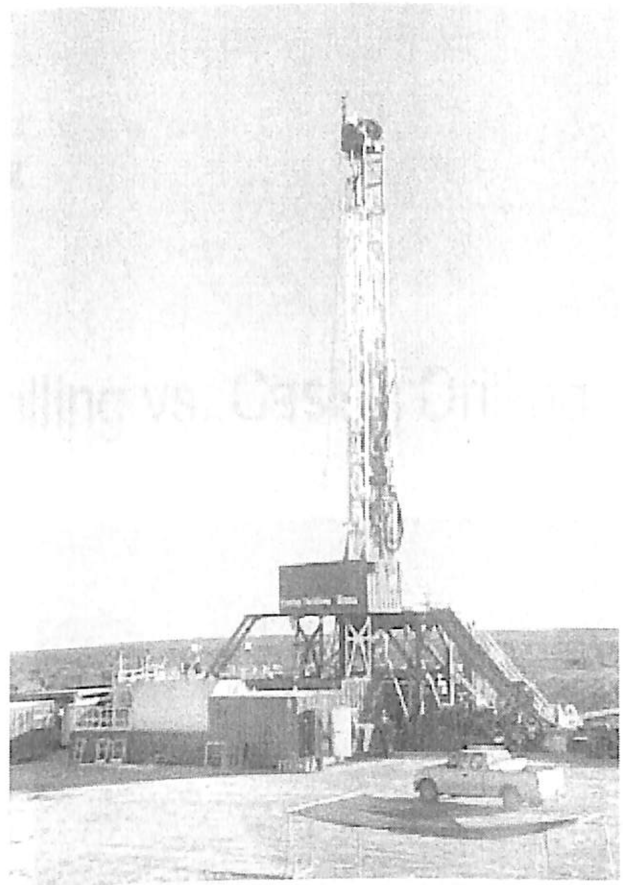


Figure-2.4

Figure-2.3

Thus using the above changes conventional rig can be converted into casing drilling rig. The above 2 diagram shows Casing drilling Rig. These Casing drilling rigs are **smaller in size** and are more efficient and require less mobilization time

2.4 Rotary Drilling vs. Casing Drilling

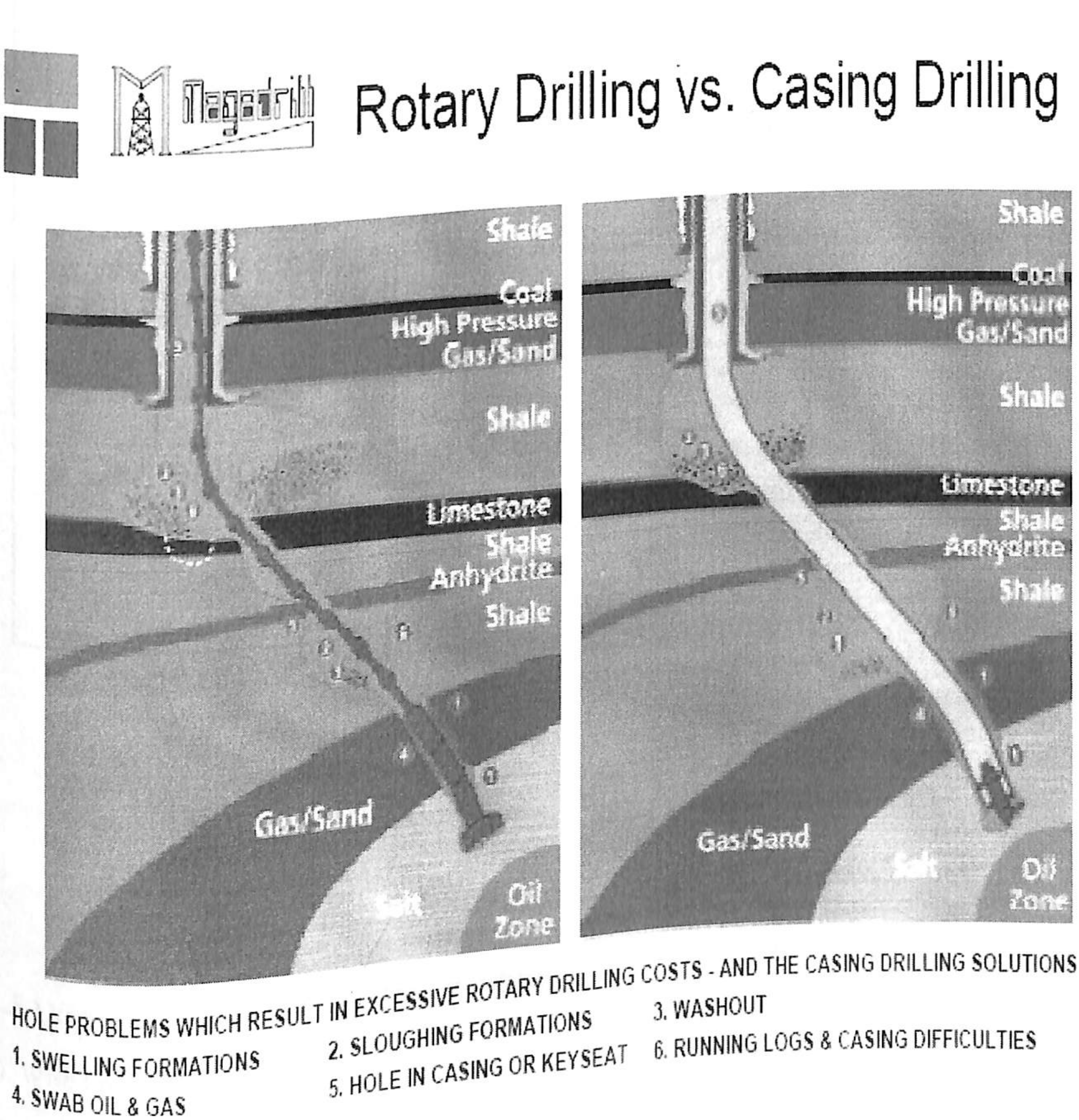


Figure 2.5 – Rotary drilling vs Casing drilling

Casing Drilling Technical Challenges

- Changing the Bit & Bottom Hole Assembly
- Casing Connection
- Bit Cutting Structure
- Formation Evaluation
- Cementing & Drilling Out the Shoe

2.5 Downhole tools for Casing drilling

a) Wire line BHA :

1) Running and Retrieving tool
2) Anchor and Seal Assembly which consist of Axial Dogs, Stops Dogs and torque anchor
3) Mud Motor
4) Under-reamer
5) Bit

b) Casing BHA :

1) Casing

2) Centralizer as required

3) Casing Lock collar

4) Casing torque collar

5) Casing shoe

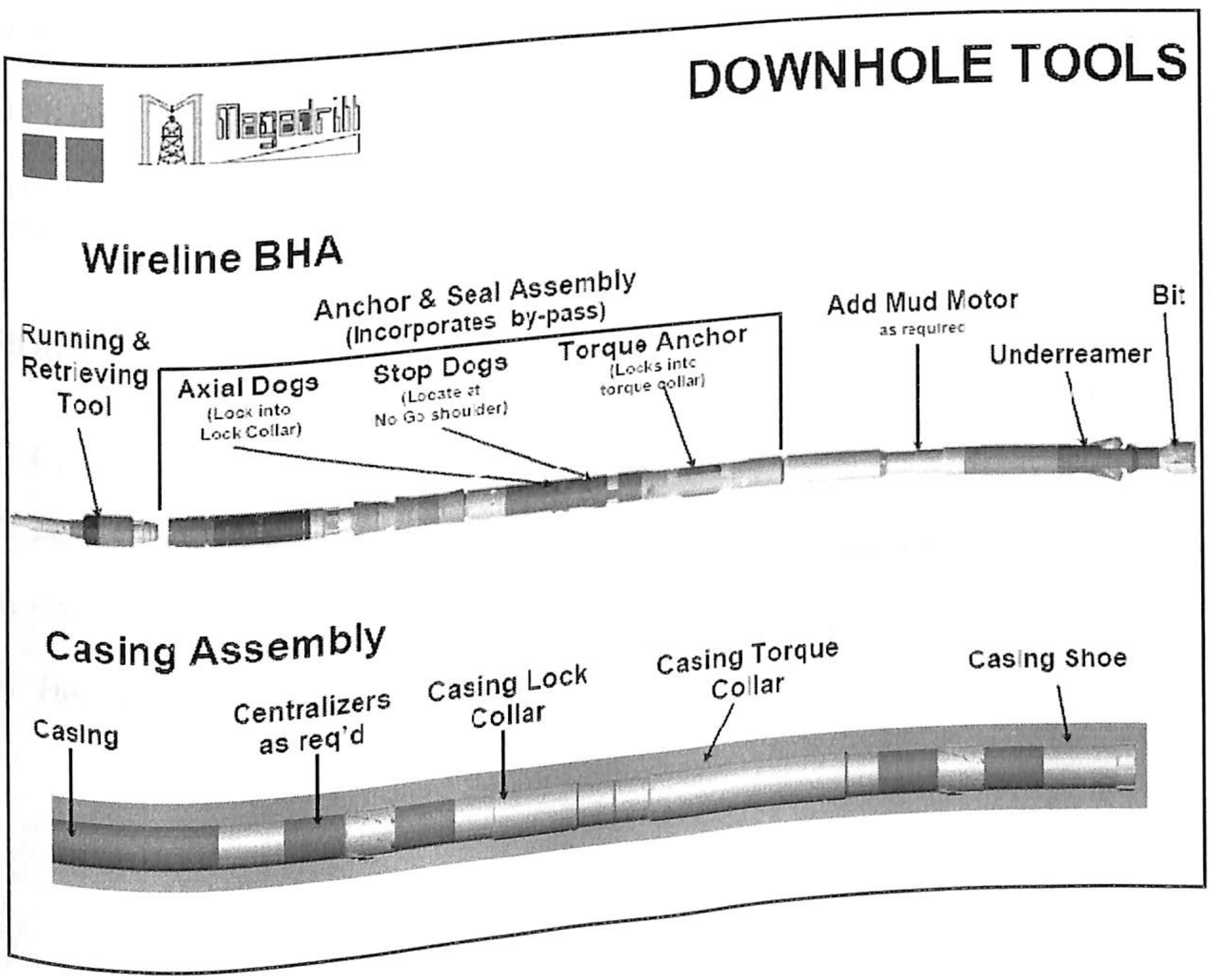


Figure 2.6 Downhole tools of Casing Drilling

Steps in Running & Setting of BHA -:

1) Lower BHA (while circulating and reciprocating) until stop dogs locates at No Go shoulders.

2) Stop pump and jar down to close by-pass and lock axial dogs into lock collar

3) Continue to jar down to release running tool

4). Retrieve running tool while circulating and reciprocating

2.6 Drilling Surface Casing

i) Bottom Hole Assembly:

1) Bit (must pass through casing drill string and drill pilot hole)

2) Under reamer (must pass through casing drill string and under ream pilot hole out to desired diameter)

ii) Retrieving BHA:

1) Latch running tool into BHA

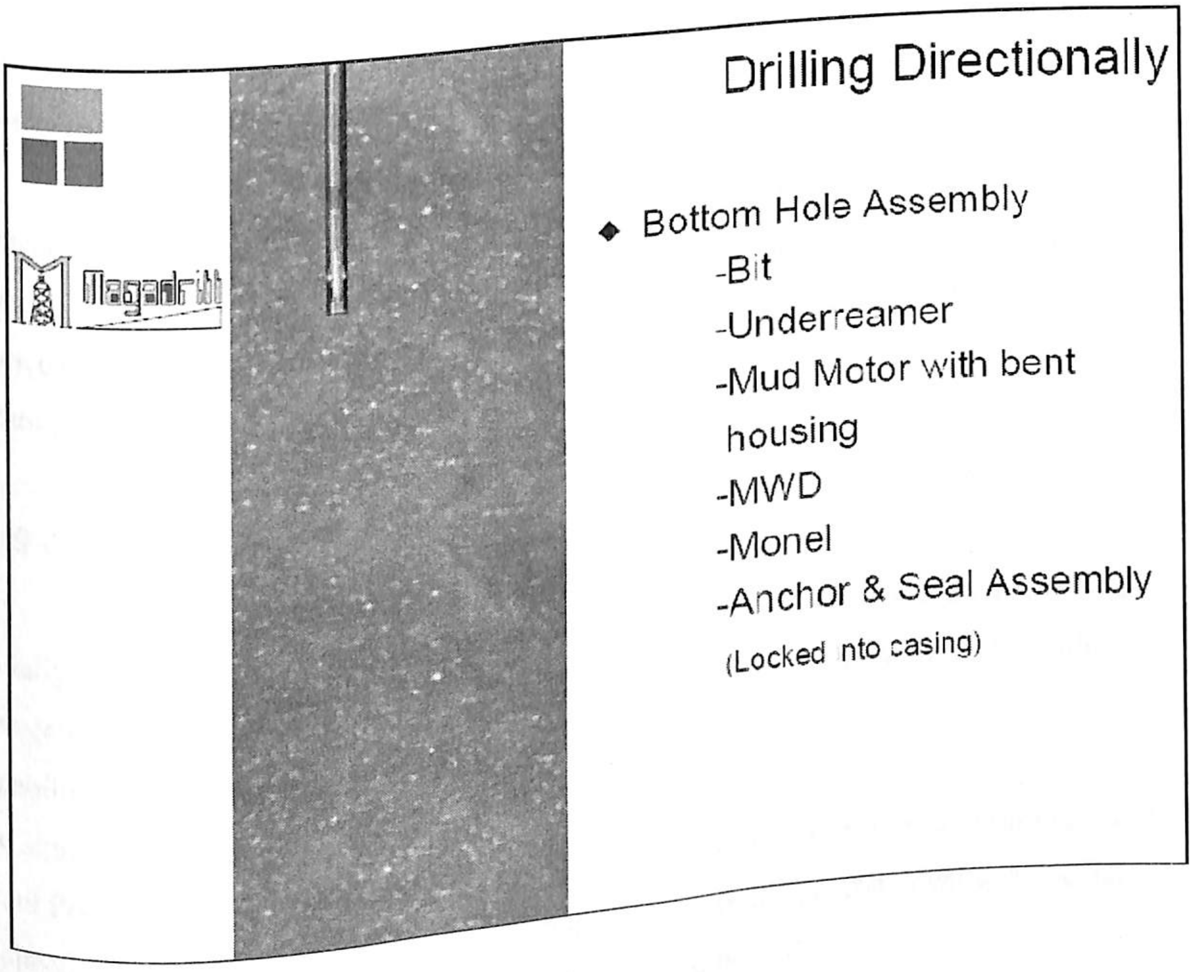
2) Jar up to open bypass and release axial dogs

3) Circulate through by-pass to allow under reaming arms to contract

4) Hoist tool out of casing while circulating and reciprocating

2.7 Casing Drilling and ERD(Extended Reach Drilling) wells

Casing drilling has proven benefits for certain classes of wells. Till date, most of these wells have low deviations. Therefore, low torques and loads are generated during the casing drilling process. It is considered that this approach is unlikely to work for large ERD (Extended- Reach Drilling) wells. However, it is quite possible provided good directional control is achievable on the process, casing drilling would be beneficial for limited step-out, shallow ERD wells



2.8 For Directional Cased Drilling the bottom hole assembly should contain-

1) Bit
2) Under reamer
3) Mud motor with bent housing
4) MWD
5) Monel
6) Anchor and seal Assembly

2.9 Coring and Logging in CWD :

Conventional coring is done after 30-60 ft per run. Coring assembly is retrieve on a wireline assembly and the core is collected. Similarly for logging the BHA is totally retrieved, further-more casing is pulled from the section of the interest. Log conventionally in open hole and technique such as logging while drilling are used.

2.10 Casing Connection

Initially, drilling with casing used traditional casing connections, but these off-the-shelf connections exhibited performance problems because of cyclic-torsion loads, sealing capability to overcome dramatic cyclic loads
and significant fatigue.
Grant Prideco, the North American leader in the development of premium tubulars and connections, was faced with a technical challenge — to design and develop a special connection for casing drilling applications that would provide:

1) Sound economics;
2) High resistance to cyclic torsional loads;
3) Superior sealing capability while subjected to dramatic cyclic loads;
4) Enhanced fatigue resistance; and
5) Field-friendly running procedures.

There are a number of casing connections in the market that provide two, three and sometimes even four of these characteristics. Grant Prideco's drilling with casing coupled (DWC/C™) connection was developed
to meet all five of the requirements dictated by the new emerging marketplace.
The DWC™ technology is a family of semi-premium connections designed for the rigorous conditions seen with casing drilling technology.

Models -

DWC/C and DWC/C-SR are the most common models of the DWC design family and are the recommended connection for most or all of the casing strings in typical casing drilling applications. The DWC/C engineered design incorporates a torque-shouldering system developed specificallyfor the torque and fatigue requirements associated with casing drilling operations. The special coupling element of the torquing system includes a patented Stress Reduction Groove in the center of the coupling that enhances the coupling's resistance to cyclic loading typically generated during casing drilling operations. The DWC/C is also the most economical model of DWC offered for casing drilling applications. The coupling turned ODs are the same as for API connection.

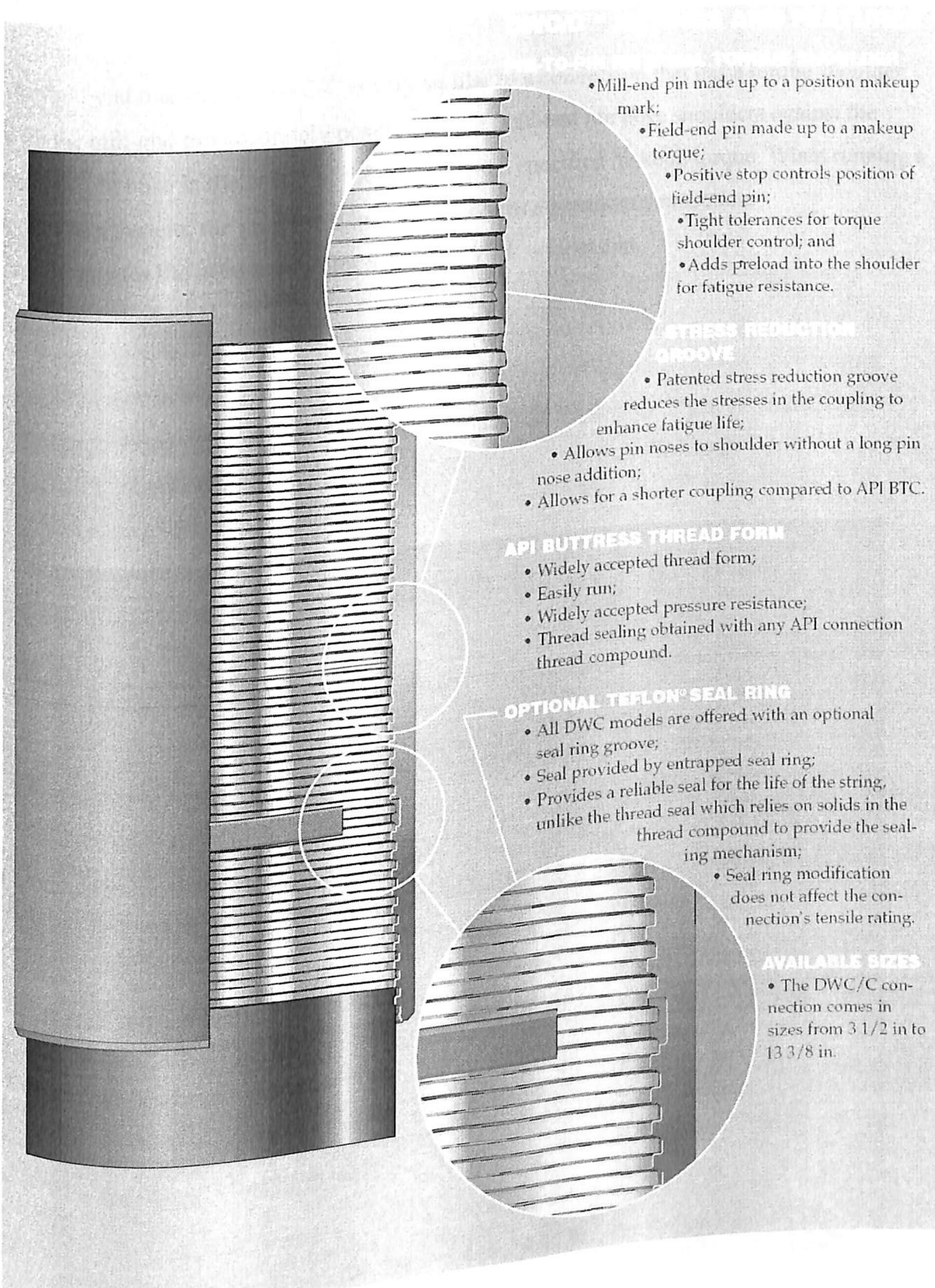


Figure 2.7 DWC/C Rating and Features

Field End-

The field-end makeup of DWC/C is very similar to a connection that has a torque shoulder. With the mill-end pin accurately positioned, the field-end pin nose shoulders against the mill-end pin nose in the center of the coupling to a specified makeup torque. When running a torque-turn system, the graph will be very similar to a premium connection.
This eliminates the need to monitor a makeup mark on location.

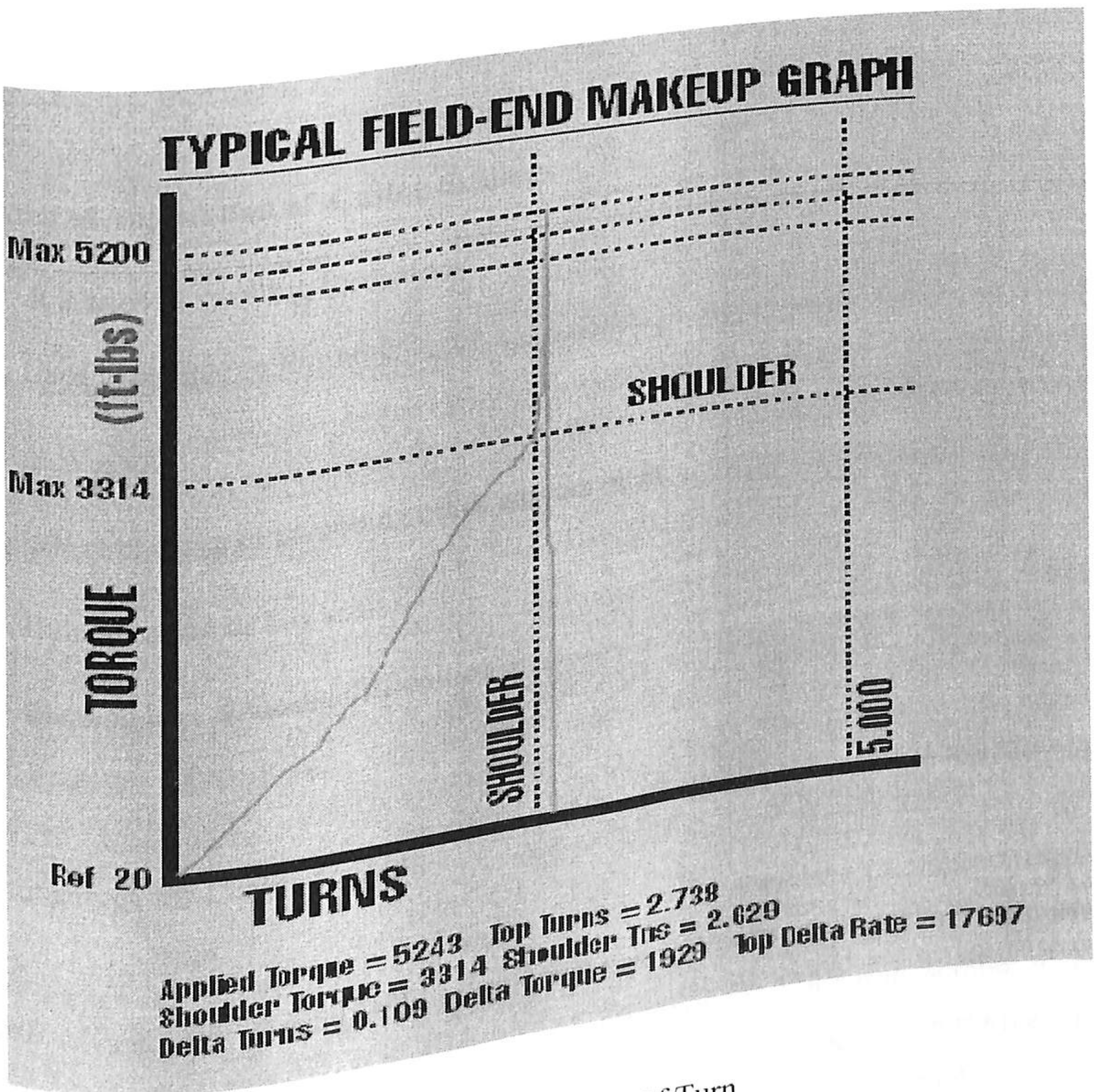


Figure 2.8 Torque vs No. Of Turn

2.11 Type of mud used in Casing Drilling:

The type of mud used in casing drilling is same as that of conventional drilling i.e the same basic mud is used over here. Gel spud mud is used for surface casing as well as for first 5000' of the intermediate hole. However polymer used was greater in quantity than used in simple conventional rig as we have to also consider about ECD. Mud weight is also the same as that of conventional.

A top drive is used to rotate the casing while the casing string is being attached with a Casing Drive System (CDS) without screwing the top casing coupling. The CDS also has a slip assembly which can grip the exterior of the casing and an internal spear assembly to provide a fluid seal to the pipe. The CDS is brought to a new joint from the V-door and is stabbed and made up to the stump with the top drive. For retrieving the BHA, a ½" braided wireline unit is used.

2.12 Area of Application of Casing drilling-

- It is used in swelling formations
- Used in sloughing formations
- In Washout
- Where chances of Swabbing oil & gas can occur
- Hole in casing or key seat
- Running logs & casing difficulties

2.13 Advantages of Casing Drilling :

The main advantage of Casing Drilling system is that it eliminates costs which are related to purchasing, handling, inspecting, transporting, and tripping the drill-string, another advantage is that it also reduce hole problems which are associated with tripping, and thus save time along with rig equipment capital costs and operating costs. The process is such success that it has been used in more than 500 well intervals to drill more than 460 000 meters with casing. It was originated in 1999. The Casing drilling technology is well suited for drilling softer formations with casing sizes of 7" or larger. In such cases, the penetration rate obtained from casing drilling can easily match conventional rates, and the reduced tripping and drillstring handling can be used advantageously. Thus in present situation Casing drilling is basically used for drilling softer formations. Casing drilling is being employed in many countries as an effective method of reducing the overall drilling costs by reducing drilling time and drill string problems encountered during conventional drilling process. In normal rotary drilling productive drilling time is lost in tripping, whereas unscheduled events during tripping can make the drilling process even more inefficient and even lead to loosing the well. While the potential savings from reducing drill-string tripping and handling times are important, the savings from reducing hole problems may be more significant. There are many situations where problems such as lost circulation, well control incidents, and borehole stability problems are directly attributed to tripping the drill-string and other situations where these problems prevent the drill-string from being tripped. Since the Casing drilling process provides a continuous ability to circulate the well, it is inherently safer than leaving the well static without a means of circulating it while a conventional drill-string is tripped.

However it should be noted that prior to application of casing drilling in any particular well, the hole conditions, such as unscheduled events and lithological characteristics of the formations should be examined in order to evaluate the design criteria of the casing and to improve drilling performance. In short the benefit of casing drilling are-

Benefits of casing drilling

1) It improve bore hole stability

2) There is less amount of lost circulation even at high ECDs

3) Trouble time is reduced

4) There is no need for using casing strings

5) Well control is improved

6) Drilling time is saved

7) It improves hole conditioning and production

8) Reduce rig requirement

CHAPTER 3

CASING WHILE DRILLING PROCESS

Case Study

Casing Drilling in practice

The experience gained from drilling with casing in Wyoming, South Texas and Brunei will be presented through several case histories.

i) Wyoming:

BP and Tesco together undertook a project to drill five gas wells in the Wamsutter area of Wyoming using the casing drilling process to evaluate the technology for use at both this location and for broader application in BP's worldwide operations . The project was undertaken specifically as a joint technology evaluation project between an operating company and service company. A multi-well program was approved because it often takes several trials to successfully implement a new technology. Tesco provided the casing drilling services, as well as the rig for the project, under an incentive contract.

Table 1 shows the general lithology encountered in the area. The conventional drilling program is to set 12,19 m of 406,4 mm (16") conductor, drill 279,4 mm (11") hole and set 219,08 mm (8 5/8") casing at 350,5 m, and then drill 200,03 mm (7 7/8") hole to 122 m below the top of the Almond where 88,9 m (3 1/2") tubing is set as the production string (Shepard et al., 2001).

The surface hole in each well was drilled to approximately 365,8 m with the casing drilling system. A Tesco underreamer was used in each well. A roller cone bit was used in wells one and two while a PDC bit was used in the third well. In each case the BHA was installed at the surface and retrieved with the wireline when the casing point was reached. The cement service company was called out before casing point was reached and began rigging up for the cement job while the BHA was being retrieved.

Formation	Typical Depth (m)	Potential Problems
Wasatch	Surface - 762	Hole cleaning in fast drilling
Fort Union	762-1463	Fresh water ows, bit balling
Lance	1463-2195	Fresh water ows, loss zones
Fox Hills	2195-2316	Fresh water ows, loss zones
Lewis	2316-2743	Bit balling tendency, loss zones, hard stringers
Almond	2743-2896	Increased pressure, hard abrasive formations, well control potential, loss in upper zones from weighted mud

Figure 6 shows the time from spud to completion of the cement job for the three casing drilled wells compared to the average offset well (Shepard et al., 2001). A typical offset takes about 8-12 hours to drill the surface hole and a total of about 18,9 hours (based on the average of the last 19 wells in the fi eld drilled since June 2000.) from spud to completion of the primary cement job.

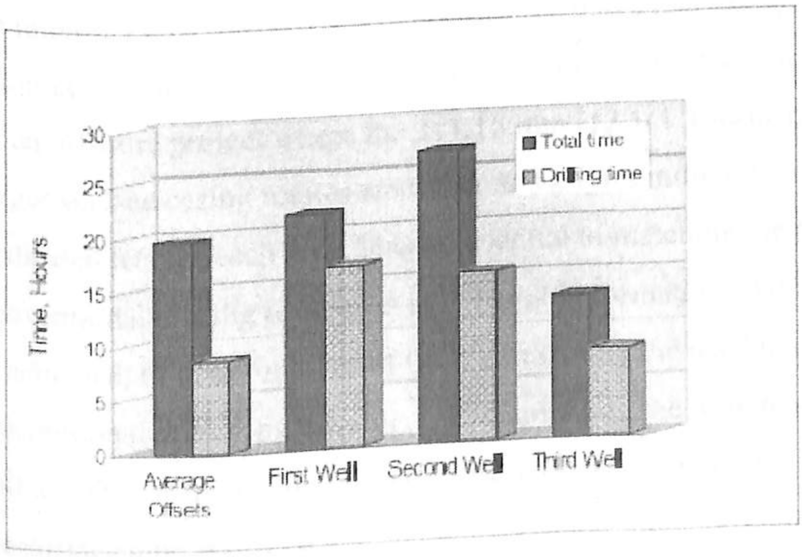


Figure 6 Drilling and cementing time for surface hole

The first casing drilled well required 16,5 hours drilling time and the total time from spud to completing
the cement job was 21 hours. On the second well the WOB and rpm were increased to reduce the drilling time to 15 hours. Difficulties in retrieving the BHA, flow line plugging problems due to gumbo, and a failure of the seal in the casing clamp increased the overall time to 26 hours.
For the third well the rotating time was reduced to 8 hours and the overall time was reduced to 12.5 hours (excluding time waiting on water for the cement).
Successfully drilling the production hole with the casing drilling process proved more challenging than drilling the surface hole. Again difficulties were encountered in achieving an acceptable ROP compared to the offsets. However, an even more challenging problem with lateral drillstring vibrations was encountered. These vibrations resulted in two casing connection fatigue failures. The matrix body shoe and the three bladed steel body bit were selected for the first run in the first well.
Drilling proceeded reasonably well to a depth of 905 m where the ROP fell to zero. The BHA was retrieved assuming that the PDC pilot bit had failed, but the cutting structure was still undamaged except for severe erosion around the cutters. The bit was changed to the more erosion resistant five bladed matrix body PDC bit and the BHA pumped down. The BHA failed to reach the profile
nipple and the casing was pulled to diagnose the problem. The drill lock assembly (DLA) had set prematurely in the slight internal upset of a connection eleven joints above the shoe due to an improper tool set-up. Experience demonstrates that casing drilling can reduce the time required to drill and cement the surface casing. This observation is consistent with the results of an offshore project where the 311,15 mm (12 1/4") surface holes were casing drilled. The larger surface casing rotates smoother and allows more robust underreamers that have dedicated jets for each arm. This is essential to matching the penetration rate of the conventional drilling process in soft, ballable formations. Once a comparable penetration rate is achieved, time savings result from eliminating the need to condition the hole, eliminating conventional drillstring tripping, and eliminating the time required to lay down the drill collars. The casing drilling process also reduces the risk of not getting casing to bottom after the surface hole is drilled.

ii) South Texas

Drilling with casing was identified in early 2001 as a technology that could potentially solve the problems and provide a step change in drilling performances in the mature Lobo field in South Texas. Tesco's casing drilling system was selected to evaluate the potential impact of drilling with casing on Lobo drilling economics.

A five well pilot program was undertaken as phase 1 of the effort to introduce casing drilling technology at Lobo. The objective of these first wells was to determine if casing drilling technology could deal effectively with the specific issues encountered at Lobo to reduce overall drilling cost. Performance on these five wells steadily improved and matched that of conventional drilling by the time the last well was completed. This occured even though there was obviously considerable room for further improvement in casing drilling system.

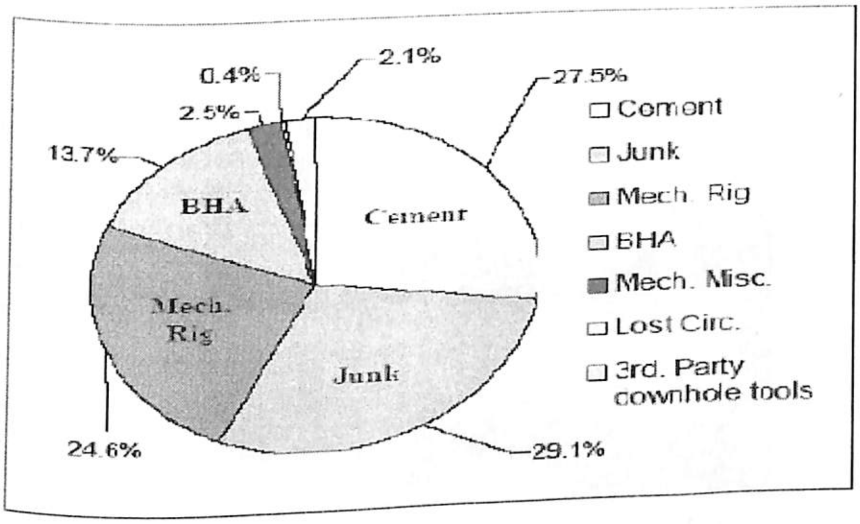


Figure 7 Trouble time for phase two casing drilled wells

The phase two program proved that casing drilling could eliminate the formation related trouble time experienced with conventional rigs. This allowed additional wells to be drilled that would otherwise be uneconomical. The wells were not drilled trouble-free, but the trouble was associated with the mechanical equipment limitations shown in Figure 7 (Fontenot et al., 2003). These mechanical problems can be fixed, as opposed to the formation related problems that are encountered when drilling with conventional rigs. In fact, solutions to most of the problems that caused lost time in phase two have already been implemented.

The third phase of the Lobo casing drilling program has been initiated by bringing in the first of three new rigs to begin full scale implementation of casing drilling at Lobo.

Casing protection. It is important to know that the casing is in good condition after drilling is completed. This issue was evaluated in the phase one Lobo trials when the intermediate casing was tripped out several times. No wear or damage was seen on the pipe body, but some of the couplings in the lower portion of the casing were worn on one side. Wear protection was developed for the couplings that resolved this concern. The couplings are protected against this wear by installing ''wear bands'' on the lower half of the 177,8mm (7'') casing (Fig. 8) (Fontenot et al., 2003). These bands are installed in the field with a portable hydraulic crimping tool. The lower end of the wear bands includes about 25,4 mm (1'') of tungsten carbide hard facing material similar to that used for wear protection on drill pipe.

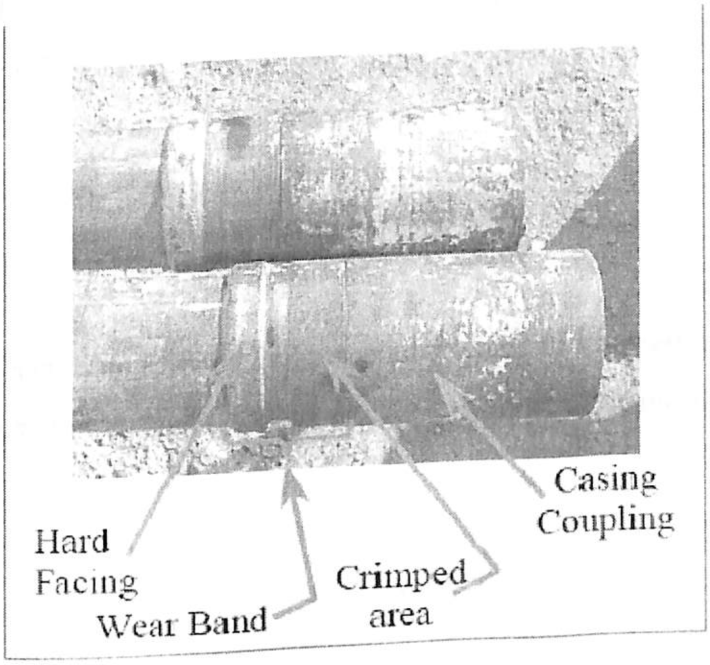


Figure 8 Wear bands installed below couplings

Stabilization. Stabilizers are used on the lower end of all three strings of casing to function as cementing centralizers and on the 177,8 mm (7'') casing as key-seat wipers spaced about every 229 m along the entire length of the casing. Several different custom designed and manufactured stabilizers have been used.

One type is shown on **Figure 9** (Fontenot et al.,2003). They provide a blade structure that does not have the sharp transition between stiff blade and flexible tube material. The heat-affected zone created by the massive welding used on the previous stabilizer design is also minimized.

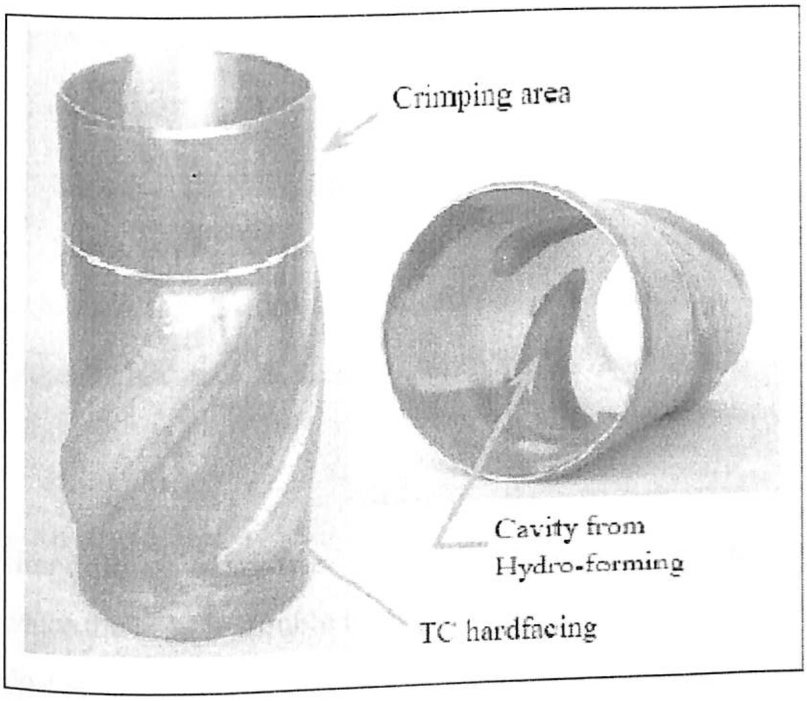


Figure 9 Hydro formed crimp-on stabilizer

Logging. Open hole logging can be accomplished in a variety of ways that involve LWD or memory logs, but these are too expensive to be cost effective at Lobo.

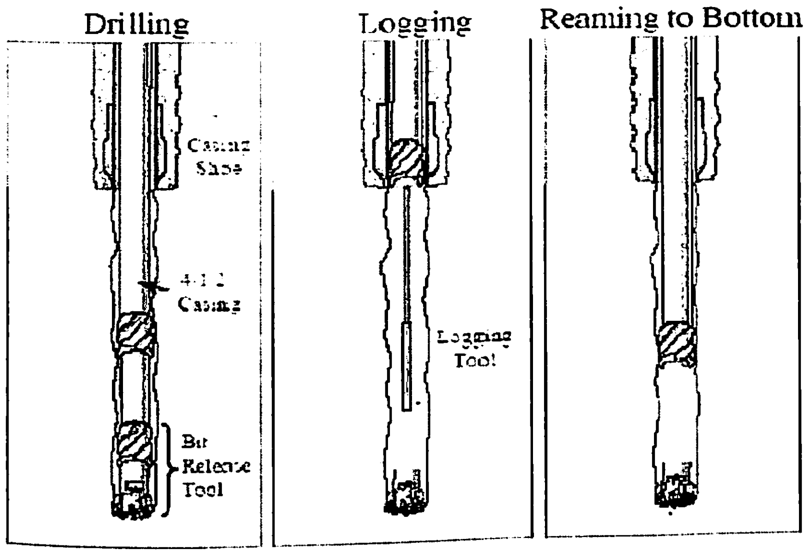


Figure 10 Procedure for logging below 114.3 mm (4 ½") casing

After drilling twenty-two Lobo wells, the casing drilling process has proven to significantly reduce the in-hole trouble time to less than the low value that was already obtained at Lobo. Most signifi cantly, time lost due to lost circulation and stuck pipe has been almost totally eliminated. Even when well locations were selected where the offsets required multiple cement jobs and unscheduled liners to reach TD because of lost circulation problems, the casing drilled wells experienced little lost circulation problem. This has lead to the ability to effectively drill wells in lost cirulation areas that are uneconomical with conventional drilling techniques.

iii) Brunei

Shell Brunei Petroleum (BSP) is an active member of a global Shell Common Interest Network (CIN) for mature technologies, one of which is casing drilling. It performed casing drilling job in September 2003 as a means of reducing well cost in the Seria field on Brunei's western coast (Fisher et al., 2004). The 0,31111 m (12 1/4") surface hole on S-816, a vertical well, was selected as the most appropriate for trialing the CDS. The formations to be drilled were sand and soft shales with some harder silstone stringers. The last casing was the 0,406 m (16") conductor set at 59 m. It was determined that the clearance of the conductor fl ange to the 0,2445 m (9 5/8") casing would allow the casing to be rotated in the wellhead. The

internal casing drive system could be used to land the casing hanger after drilling to TD. The surface casing was 0,2445 m (9 5/8"), 69,94 kg/m (47#), N-80
with New VAM connections.
The 0,2445 m (9 5/8") casing on S-816 was drilled to 721 m, taking 57 hours from spud to casing TD. No recordable incident or accident occurred. The Convertible PDC drilling shoe drilled 662 meters from 59 m to 721 m in 44 drilling hours and 52 circulating hours.
Cementing was carried out without any problems, and a good LOT/ FIT was achieved. After milling the shoe, the 215.9 (8 1/2") drilling assembly passed through the drill shoe and drilled on with no indications of problems. The system maintained excellent bore hole quality with no wellbore related problems, Through fluid volumes it has been established that the well bore was 0,3084 m (12,7"). Good hole cleaning and hole size was maintained without inducing losses, despite higher ECDs. No hole/fluid related problems were noted during drilling with casing.
Conventional drilling on the offset well had encountered bit balling, and back reaming was required on every stand with the same drilling fluid.

Drill shoe

The world's first convertible casing drill shoe job is performed onshore Brunei in September 2003 during a 0,2445 m (9 5/8") surface casing job on S-816 well in the Seria field (Fisher et al., 2004). Convential drill bits are capable of drilling long intervals but are compose of non-drillable materials. The convertible drill shoe has a novel feature that allows the cutting structure and blades to be extruded outwards once section TD is reached. By
this process, the drill shoe converts to a cementing shoe, allowing the casing to be cemented in place. The cementing shoe and next hole section can then be drilled without interference from the casing drill shoe cutting structure and blades. Application of the extrusion process allows a more aggresive and durable cutting structure on the casing drill shoe and hence allows deeper, more resistant formations to be drilled. The standard DrillShoe I and DrillShoe II are composed of drillable materials, but the distance and hardness of formation that can be drilled with this tool are limited. DrillShoeIII (DS III) has attributes of a conventional PDC bit (Fig. 11)

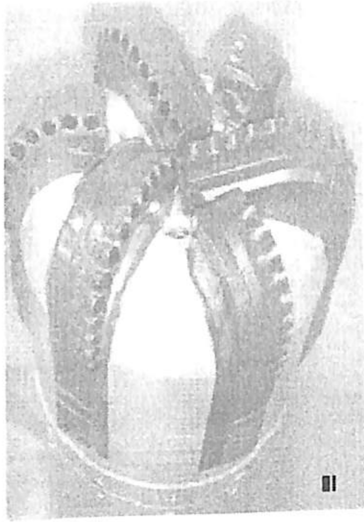


Figure 11 DrillShoe™II and DrillShoe™III

It incorporates PDC cutters mounted on special alloy blades. While drilling, the blades are supported in a matching profile on the inner piston. Prior to cementing the casing string, a ball is dropped which seats in a ball seat at the top of the inner piston, sealing off the fluid ports. The convertible PDC drill shoe requires a 0,762 m (3") ball to be seated in the ball seat to close off the normal fluid passage and the use of a large bore float collar through which the drop ball can pass. The resultant pressure build-up shears the locking mechanism, displaces the inner piston downward and converts the drill bit to a drillable casing shoe. The pressure of 14.5 MPa (2100) psi is required to convert the drill shoe. As the inner piston is pushed out the end of the bit, cement port are exposed. As the inner piston is displaced the cutter blades unfold from the drill shoe face like the fingers opening from a first to rest out of the way of the subsequent bit in the wells annulus. Once the cement ports are opened, circulation is re-established and cementing can begin. The cement stinger receptacle incorporated a 0,0826 m (3 1/4") ID. When lead cement slurry returns is detected at surface the cement stinger is pulled from the receptacle and the cement reversed out of the inner string. The auto fill float valves held backpressure as designed. The actual cementing operation is identical to conventional wells.

TABLE # 1 — **Setting and Retrieving Success Summary**

Interval	Casing Size (in)	Final Depth (ft)	Number of Attempts to Set	Number of Successful Sets	% Successful Sets	Number of Attempts to Retrieve	Number of Successful Retrievals	% Successful Retrievals
Conductor	9 5/8	120	8	3	37.5	8	3	37.5
Surface	7 5/8	565	18	6	33.3	18	9	50
*Main	5 1/2	3040	36	24	66.7	33	30	91

* % Success has increased to 71% Setting (since inception of 3 3/4" Running tools, and 100% Retrieval since switching coupling to Modified Buttress and reduction of overall tool dimensions to 4.625".) Major setting improvements were realized on the subsequent directional drilled intervals and further significant improvements are expected with new generation tools to be used on 2nd test well in 1999.

TABLE # 2 — **Casing and Connection Specifications**

Interval	Casing Size (in)	Casing Grade	Casing Weight (ppf)	Casing Connection	Connection O.D. (in)	Opt. Make-up Torque (ft-lbs)	Max. Yield Torque (ft-lbs)
Conductor	9 5/8	P-110	43.5	WT-IPC	9.625	9700	116000
Surface	7 5/8	N-80	26.5	WT-IPC	7.625	4300	36000
Main	5 1/2	K-55	17.0	WT-IPC	5.5	2500	10800
Main	5 1/2	K-55	17.0	CNV-BTC	6.05	*4200	*8200
Main	5 1/2	K-55	17.0	CNV-BTC-SC	5.875	*4200	*8200

* Torques for Convertible Buttress connections are summation of thread interference torque (2500 ft-lbs) and recommended delta torques.
A minimum delta torque of 1700 ft-lbs is required to generate bearing pressure equal to 3 times the API internal yield pressure.
A maximum delta torque of 5700 ft-lbs is the torque at which the pin nose approaches yield

TABLE # 3 — **Casing and Hole Drilling Performance Data and Summary**

Interval	Drill Casing (in)	Interval Drilled (ft)	Pilot Bit Size (in)	Reamer Hole Size (in)	Weight On Bit (1000lbs)	Top Drive RPM	Pump Rate (gpm)	Annular Velocity (fpm)	Rotating Time (hrs)	Average ROP
Conductor	9 5/8	117	8 1/2	12 1/4	2-5	50-70	210	90	2.50	46.8
Surface	7 5/8	411	6 1/4	10	8-10	120-150	210	123	15.85	25.9
*Main	5 1/2	2413	4 3/4	6 7/8	8-12	120-250	175	252	115.43	20.9
Main	5 1/2	83	6 3/4 Bit	4 3/4 DC's	8-12	120-200	210	165	3.95	21.0

* Includes cored interval of 25 ft in 2.1hrs but excludes 6 3/4" bit and 4 3/4" DC x 4" DP drill rate test

TABLE # 4 — **BHA and ROP Comparisons - Main Hole Interval Detail**

BHA In (ft)	BHA out (ft)	Total Interval (ft)	Rotating (hrs)	Interval ROP (fph)	Pilot Bit	Type of Underreamer	Other Comments
545	685	120	4.53	26.5	4 3/4 MTB	PDC-2BUR	
665	690	25	2.1	11.9	3 27/32" Core	3 1/2" Barrel	Full 25 ft core recovery
690	715	25	2	12.5	4 3/4 MTB	PDC-2BUR	Undergauged UR from Core Rathole
715	1175	460	17	27.1	4 3/4 MTB	PDC-3BUR	
1175	1372	197	7.5	26.3	4 3/4 MTB	PDC-3BUR	4 1/2" Mud Motor
1372	1732	360	20.75	17.3	4 3/4 MTB	None	6 3/4" PDC Drill Shoe
1732	1815	83	3.95	21.0	6 3/4 MTB	None	4 3/4" DC's, 4" DP
1815	2213	398	9.78	40.7	4 3/4 PDC	None	6 3/4" PDC Drill Shoe
2213	2385	172	10.8	15.9	4 3/4 PDC	PDC-3BUR	
2385	2549	164	11.72	14.0	4 3/4 PDC	PDC-2BUR	
2549	2849	300	14.88	20.2	4 3/4 PDC	None	6 3/4" PDC Drill Shoe
2852	3020	168	13.12	12.8	4 3/4 MTB	None	6 3/4" PDC Drill Shoe
3020	3040	20	1.25	16.0	4 3/4 MTB	PDC-3BUR	

TABLE # 5 Formation Evaluation Logging Run Summary

Date	Company	Log Description	Depth From (ft)	Up to (ft)
11/6/1998	Computalog	Borehole Compensated Sonic	2533.0	563.0
11/6/1998	Computalog	Simultaneous Triple Induction	2539.0	563.0
11/6/1998	Computalog	Spectral Pe Density - Compensated Neutron - Gamma Ray	1535.0	563.0
11/6/1998	Computalog	Six-Arm Caliper	1443.0	563.0
11/17/1998	Computalog	(Casing) Pulse Neutron Decay - Gamma Ray - Collar Locator	3005.0	558.0
11/18/1998	Computalog	(OH/Casing) Multi Array Neutron - Gamma Ray - Collar Locator	3005.0	528.0

TABLE # 6 Open Hole Cement Abandonment Plugs

Plug No.	From (ft-KB)	Up To (ft-KB)	Felt At	Cement (tonnes)	Volume (ft3)	Blend	Additives	Excess (%)
1	3040	2712	2739	4.0	141	G	0.5% TIC	30
2	1361	1033	994	5.3	187	G	0.5% TIC	CAL + 20%
3	820	492	400	5.4	191	G	0.5% TIC	CAL + 30%
4(1st Dir. Leg)	1414	1066	1074	5.1	180	G	0.5% TIC	63
5(2nd Dir. Leg)	1394	1066	969	5.1	180	G	0.5% TIC	63

Chapter 4

Conclusion and Recommendation

The Casing Drilling system may eliminate costs related to purchasing, handling, inspecting, transporting, and tripping the drill-string, reduce hole problems that are associated with tripping, and save on rig equipment capital costs and operating costs. Casing Drilling system has been used in more than 500 well intervals to drill more than 460 000 meters with casing since it was
introduced in 1999.
Based on the knowledge gained to date, the CDS in its current state of development is well suited for
drilling softer formations with casing sizes of 7" or larger. In these situations, the penetration rate can easily match conventional rates, and the reduced tripping and drillstring handling can be used advantageously.
Prior to apply casing drilling in any particular well, the hole condition, such as unscheduled events and lithological characteristics of the formations have to be examined in order to evaluate the design criteria of the casing and to improve drilling performances.
Basically CWD technique is good for soft shallow formation where the ROP is not required high. Several method such as downhole motor should be used for deep formation to provide adequate ROP .

Furthermore technique such as under balance CWD drilling should also be used

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