TIMBOU-AFRICA PUBLICATION INTERNATIONAL JOURNAL DECEMBER, 2023 EDITIONS.

INTERNATIONAL JOURNAL OF SCIENCE RESEARCH AND TECHNOLOGY

VOL. 2 NO. 2 E-ISSN 3026-8796 P-ISSN 3026-8095

OILFIELD DRILLING AND WELL COMPLETION PRACTICES TO INVESTIGATE THE HYDROCARBON POTENTIAL OF THE RESERVOIRS: A CASE TUDY OF ATLAS WILDCAT WELL 25/5-7 IN THE NORTH SEA

ENGR. DR. UMAR MUAZU TADAMA (PhD)[1], DR. MUAZU HALIRU TADAMA (PhD)[2] ENGR. DR. BALA G. MONTANG (PhD)[3]

[1]Chemical Engineering Department, Federal Polytechnic Mubi. [2]Geography Department, Kaduna State University. [3]Civil Engineering Departments, Federal Polytechnic Mubi.

umarmuazutadama@gmail.com

ABSTRACT

This study focuses on oilfield drilling practices, well construction and completion with particular reference to exploration of Atlas wildcat well 25/5-7. Located on the North Sea to investigate the hydrocarbon potential of the Brent reservoirs, Stratford and tertiary formations. This well was spudded up with semisubmersible ocean vanguard and drilled to total depth at 3045m. The well

INTRODUCTION

The fundamental analyses for this study performed using outstep data belonging to Atlas field well 25/5-7 in offshore environment in the North Sea. The available data that has been provided by the Norwegian Petroleum Directorate as well as the other data from the nearby wells, as shown in Fig 1. The wells were directionally drilled from fixed points. The drilling objective was to reach production target levels with relatively high inclinations. The well was drilled to investigate the hydrocarbon potential of the Brent and Stratford reservoirs and sand in the tertiary section. It was spudded with semi-submersible rigs ocean vanguard and drilled to TD at 3045m at first and later to 1160m. a $9^{7/8}$

was drilled with sea water and mud with higher rheology to sweeps down to 1160m with oil based mud from 1160m to TD. The results shows that all potential tertiary reservoir were found water based, Stratford was found water wet while the Brent found gas bearing reservoirs, Gas condensate were taken at 2708m and 2689m. The well was drilled for 61 days, however the rig experienced a power shutdown while drilling and opening up tight spots at 438m and was on repair for 5 days from 31 August until September 2010.

Keywords: Drilling, Atlas Fields, Well 25/5-7, Wildcat, North Sea, Oil and Gas, exploration, Sandstones.

pilot hole was drill first and later open to $17^{1/2}$. There was no shallow gas encountered but several tight spot were encountered while drilling and opening up hole. The well was drilled with sea water and mud which has higher rheology to sweeps down to 1160m with oil based mud from 1160m to TD (NPD 2017; SEA 2001a). All potential tertiary reservoir were found water based, Stratford was found water wet while the Brent found gas bearing reservoirs and that the gas density is 0.26 g/cc. The Brent has a net-to-gross of 93%, an average effective porosity of 17.5%, with water saturation of 12%. The well also encountered the middle Jurassic Brent sandstones at 2684m 40m shallower than predicted, the Brent thickness was 27.5m, 45m less than expected (NPD 2017; DWSSP 2012).

Table 1: Field Well Info Summary

Field & Wellbore Name	Atla 25/5-7
Type	Exploration
Purpose	Wildcat
Main Area	North Sea
Drilling Time,Days	61(123.750 hrs)
Content	Gas/Cond.
1st level HC Age & Formation	Middle Jurassic & Brent Gp
Total Depth,TVD [m]	3045.0
Total Depth, MD [m]	3045.0
Trajectory	Directed
Water Depth,[M]	119.0
Drilling Facility	Semi-Submersible Ocean Vanguard
Gas Density, g/cc	0.26
Max Inclination [°c]	2.2
Drilling Fluid	Seawater & Oil Based Mud
Bottom Hole Tempt [°c]	110

Casing and Leak-Off Test

Casing Type	Casing Dia. [inch]	Casing Depth [m]	Hole Dia. [inch]	Hole Depth [m]	Lot Mud Eqv., g/cm³	Form. Test Type
Conductor	30	220.0	36	223.0	0.00	Lot
Surf.Cond.	13 3/8	1149.0	17 1/2	1157.0	1.50	Lot
Interm.	9 5/8	2560.0	12 1/4	2570.0	1.60	Lot
Open Hole		3045.0	8 1/2	3045.0	0.00	Lot

Lithostratigraphy

Top depth [m]	Lithostrat. unit
141	NORDLAND GP
326	UTSIRA FM
964	HORDALAND GP
1243	GRID FM
1294	HORDALAND GP
1314	GRID FM
1407	HORDALAND GP
2135	ROGALAND GP
2135	BALDER FM
2155	SELE FM
2169	LISTA FM
2333	VÅLE FM
2391	TY FM
2489	SHETLAND GP
2647	VIKING GP
2647	DRAUPNE FM
2677	HEATHER FM
2685	BRENT GP
2712	DUNLIN GP
2995	HEGRE GP

Drilling mud

Depth MD [m]	Mud Weight [g/cm3]	Visc. [mPa.s]
158	1.04	16.0
227	1.03	15.0
438	1.20	20.0
1160	1.21	18.0
1165	1.21	21.0
2280	1.21	21.0
2444	1.17	23.0
2496	1.30	31.0
2570	1.30	28.0
2633	1.13	18.0
2727	1.11	
3040	1.15	22.0
3045	1.16	20.0

Source: (NPD 2017)

LITERATURE REVIEW

Most of the oil and gas deposits in the North Sea originate from a thick layer of black clay several thousand meters under the seabed and contains significant organic residue (Fact 2013). The field is unique in that the source rock at the seabed was weak and stationary while the upper basing is full of life. (Fact 2013; SEA 2001a; BSEE 2011; Akgun 2002). Fig 2 shows oil formation cycle.

Obtaining Consent to Drill from Authorities

Exploration and production in the oil and gas industry is regulated solely through a licensing system managed by the exploration and licensing branch of the ministry of petroleum and energy in the UK (Fact 2013; SEA 2001a).

Application licensing phases:

- Applicant can apply as person or in groups as company to the directorate's exploration and licensing, in the ministry of petroleum and energy in order of section 23 of subsection 4-4 of the petroleum act.
- Submission of status reportwith content to separate guidelines as production permit for new fields in order of section 26 resource management of subsection 23 of petroleum regulations.
- This application must be submitted a minimum of six weeks before production start-up and must be of the current calendar year.
- The award of production must be of the application received and its free and fair non-discriminatory pre-announce criteria.
- A permit is not granted until POD is approved or an exemption for such plan has been granted.
- A regular fixed cycle is planned for licensing for rounds in mature fields, ten annual round had been carried out between 2003-2012 for both types of licensing.

Establishment of Pressure Regimes

There are significant pressure related issues of concern in oil and gas well drilling and production. Both high and low pressure conditions are indicative of problems that must be tackle to maintain well safety and performance. The pressure varies from well to well with offshore pressures typically higher than onshore (Bassey 2017a; Oilfield review 1998).

E-ISSN 3026-8796
P-ISSN 3026-8095

Table 2: Calculated table of values for pressures regimes

S/N	MD [m]	MW [g/cm3]	TVD	Phyd [psi]	Pf [psi]
1	158	1.04	3045	8.54464	8.54464
2	227	1.03	3045	**12.15812**	12.1581
3	438	1.2	3045	27.3312	27.3312
4	1160	1.21	3045	**72.9872**	72.9872
5	1165	1.21	3045	73.3018	73.3018
6	2280	1.21	3045	**143.4576**	143.458
7	2444	1.17	3045	148.693	148.693
8	2496	1.3	3045	**168.7296**	168.73
9	2570	1.3	3045	173.732	173.732
10	2633	1.13	3045	**154.7151**	154.715
11	2727	1.11	3045	157.4024	157.402
12	3040	1.15	3045	**181.792**	181.792
13	3045	1.16	3045	183.6744	183.674

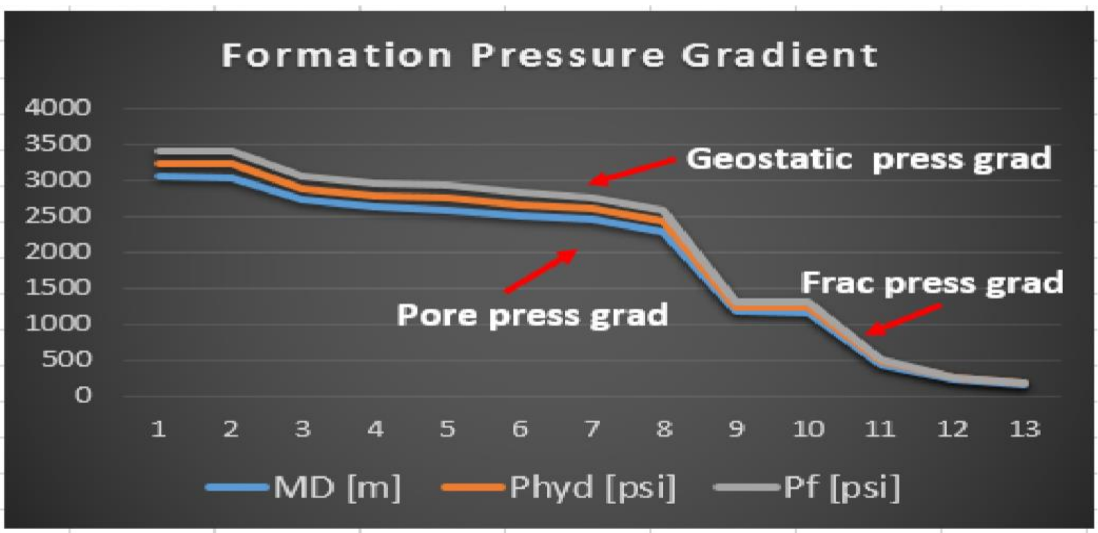


Fig 1: Plotted pressure regimes

The Formation Pore Pressures

The pressure increases with increase in mud density as well as depth, see Fig 3. The real hydrostatic value for sea water is very close to 0.45 psi/ft, and that of fresh water would be 0.433 psi/ft. This is so because sea water is denser with higher pressure gradient than fresh water for the dissolve salt in sea water. The North Sea water which is of interest is approximately 0.45 psi/ft. (IWCF n.d.; Bassey 2017c). Fig 5 and 6 shows hydrostatic pressure representations.

The calculations

The hydrostatic pressure exerted by fluid (mud) with a gradient of 1.04 g/cm3 in a well 3045 meter true vertical depth (TVD). Hydrostatic pressure = mud gradient x TVD =1.04 x 3045 =3166.8 psi

The hydrostatic pressure calculation using density in API system units we measure fluid in pounds per gallon (ppg). There will be the need for conversion between psi/ft and ppg. The constant 0.052 are used for the conversion (IWCF n.d.; Bassey 2017c). See more hydrostatic pressure calculations Fig 4 in appendices.

Establishment of Formation Fracture Gradients

The force at which an exposed formation will rupture and allow the seepage of drilling fluid from the wellbore within it, the consequences of this is the lost circulation, or lost returns, Fig 8 (i.e fracture formations) (Bassey 2017a) hydrostatic pressure gradient ranges from 0.433 psi/ft for pure water and about 0.50 psi/ft (Bassey 2017a). The density of void water in sedimentary rocks is usually 8.95 Ibm/galUS [1.073kg/m3], that establishes a normal pressure gradient of 0.465 psi/ft. Fig 7 shows abnormal pressures.

Table 3: Calculated table of values for fracture gradients

S/N		MD [m]	MW [g/cm3]	TVD	Phyd [psi]	Pf [psi]
	1	158	1.04	3045	8.54464	8.54464
	2	227	1.03	3045	**12.15812**	12.1581
	3	438	1.2	3045	27.3312	27.3312
	4	1160	1.21	3045	**72.9872**	72.9872
	5	1165	1.21	3045	73.3018	73.3018
	6	2280	1.21	3045	**143.4576**	143.458
	7	2444	1.17	3045	148.693	148.693
	8	2496	1.3	3045	**168.7296**	168.73
	9	2570	1.3	3045	173.732	173.732

TIJSRAT E-ISSN 3026-8796 P-ISSN 3026-8095

	10	2633	1.13	3045	**154.7151**	154.715
	11	2727	1.11	3045	157.4024	157.402
	12	3040	1.15	3045	**181.792**	181.792
	13	3045	1.16	3045	183.6744	183.674

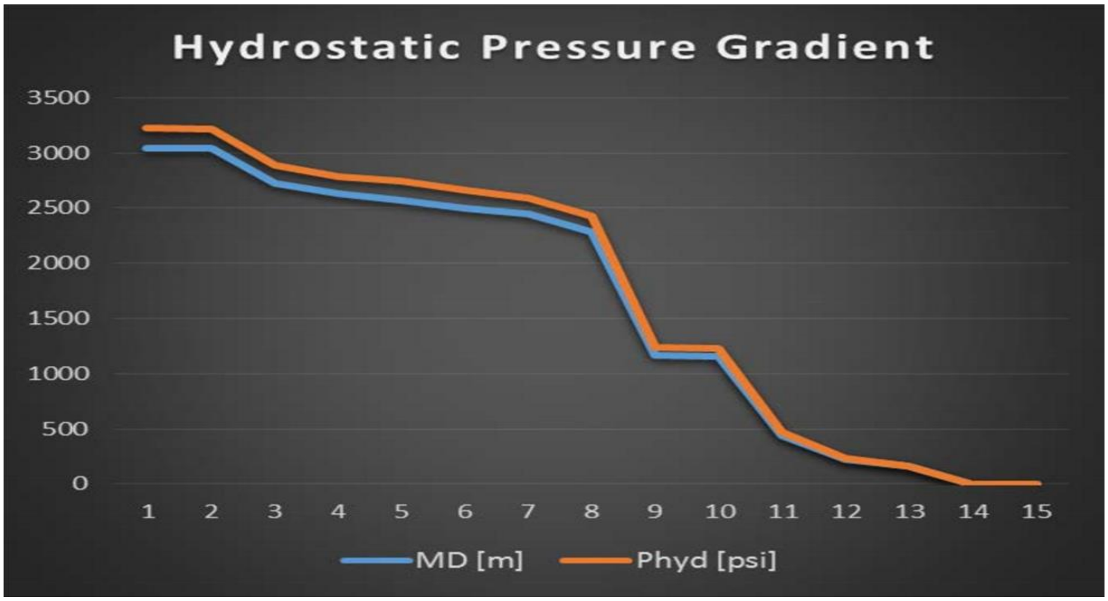


Fig 2: Plotted Fracture Gradient

METHODOLOGY

Drilling Programme Preparation and procedures

Objectives of well: Exploration of Atlat wildcat well 25/5-7, to investigate the hydrocarbon potential of the Brent reservoirs, Statfjord and tertiary formations.

Depth of well: 3045m

Well location: UK North Sea

Targets Location: Lat: 59° 39" 43.26" N
Long: 2° 34" 15.39" E
X: 6614003.76 NS
Y: 475823.34 EW

Drilling rig: semi-submersible ocean vanguard, bingo 3000 type drilling facility was chosen for Atla exploration well

Drilling days: The well was drilled for 61 days, however the rig experienced a power shutdown while drilling and opening up tight spots at 438m and was on repair for 5 days from 31 August until September 2010. (Bassey 2017b; Quaife 2017a; Teodoriu&Cheuffa 2011; Warren et al., 2001; Vaughan 2012; NPD 2017). Fig. 9 and 10, shows well drilling performance and process from the North Sea, while Table 2 shows drilling technologies.

Table 4: Atla Exploration Well Casing Design and Selections.

Hole Depth [M]	**Hole Dia. [M]**	**Casing Dia [M]**	**Casing Depth [M]**	**Casing Type**
Drill to 223.0 and run anchors	hole section 36''	run and cement 30''	Cased to 220.0	Conductor casing **Note:** for deep water drilling
Drill to 1149.0 and run anchors	Hole section $9^{7/9}$ ''	Run and cement $9^{7/8}$ ''	Cased to 1140.0	Surface casing **Note:** due to shallow gas low risk, sea water
Drill to 1157.0 and run anchors	Hole section $17^{1/2}$ ''	Run and cement $13^{3/8}$ ''	Cased to 1150.0	Surface casing **Note:** Run BOP and test
Drill to 2570.0 and run anchors	Hole section $12^{1/4}$ ''	Run and cement $9^{5/8}$ ''	Cased to 2560.0	Intermediate casing **Note:** log drilling, as per loging programme
Drill to 2800.0 and run anchors	Hole section $8^{1/2}$	Run and cement'' $7^{1/2}$ ''	Cased to 2755.0	Production casing
Drill to 3045.0 and run anchors	Hole section $6^{1/2}$ ''	Run and cement $5^{1/2}$ ''	Cased to 3045.0	Liner casing **Note:** abondonment indicative

Sources: (NPD 2017)

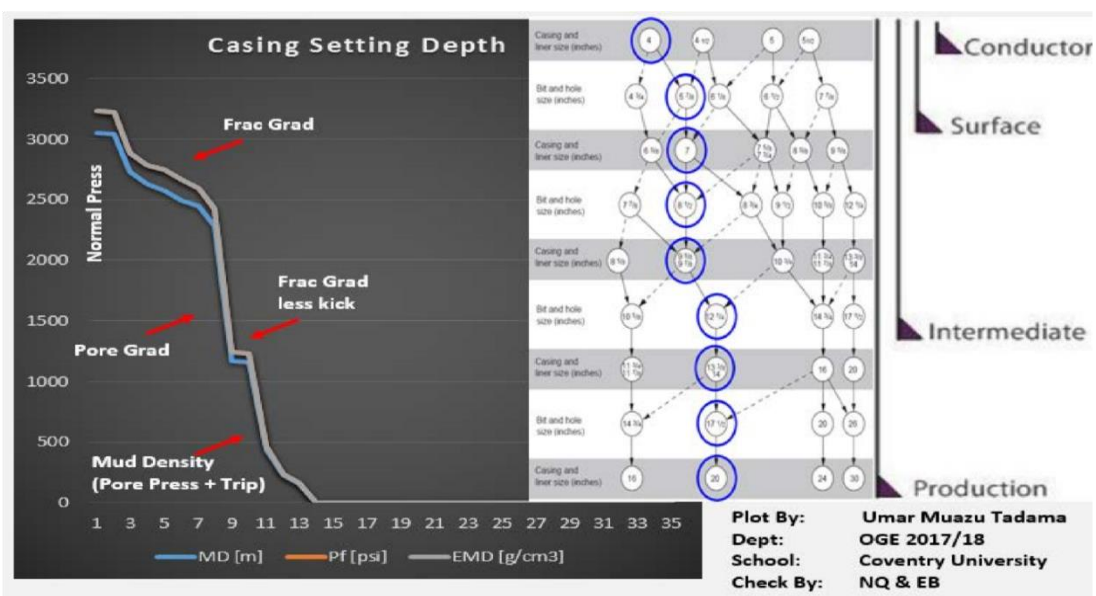


Fig 3: Plotted Casing Depths against Sizes

These casing were tested for the following design factors: P_B; P_C; P_T; and P_{TR}, for ranges of factors 1.0-1.33, 1.0-1.125, 1.0-2.0, and 1.25 respectively.

1 **Burst load**
$(P_B) = Pi - Pe2$
Collapse load
$(P_C) = Pe - Pi$
3 **Tensile load** $(P_T) = Ptb - Pta$
4 **Triaxial loads** $(P_{TR}) = pr + pa + pt$

Where Pi = internal loads; Pe = external loads; Pta = tension in casing above; Pta = tension in casing below; Pr = radial loads; Pa = axial loads; Pt = tangential loads.

Sample calculations

The external and internal pressures for a surface casing are measured at 2704psi and 1788.8 psi respectively.
Calculate the burst and collapse pressures within the casing.
$\mathbf{P_B}$ = Pi - Pe = 2704-1788.8 = 915.2 psi
$\mathbf{P_C}$ = Pe - Pi = 1788.8-2704 = -915.2 psi

These Casing runs from the top surface up till the bottom of the TVD, firmly connected to the formation using cement. (Bassey 2017c; Devold 2013; Vaughan 2012). Fig 9 shows typical casing design for central North Sea while Fig 23 and 14 gives casing sizes and selections, as table 4 shows the design.

Wellhead Selection Programme

They are different types of well head ranging from surface wellheads such as jack up, fixed or movable platform rig to subsea wellheads such as semi-submersible ocean vanguard, (Ifelebuegu 2017a&b). Fig 15 shows types of wellheads. **Atlas Wellhead**

Semi-submersibles ocean vanguard was chosen for Atla exploration well drilling up of 119m water depth for conventional vanguard system. Derrick rig hoisting was employed and the rig rotation was top drive, circulatory system was adequate and maintain (Bassey 2017b; Adams 2012).

E-ISSN 3026-8796
P-ISSN 3026-8095

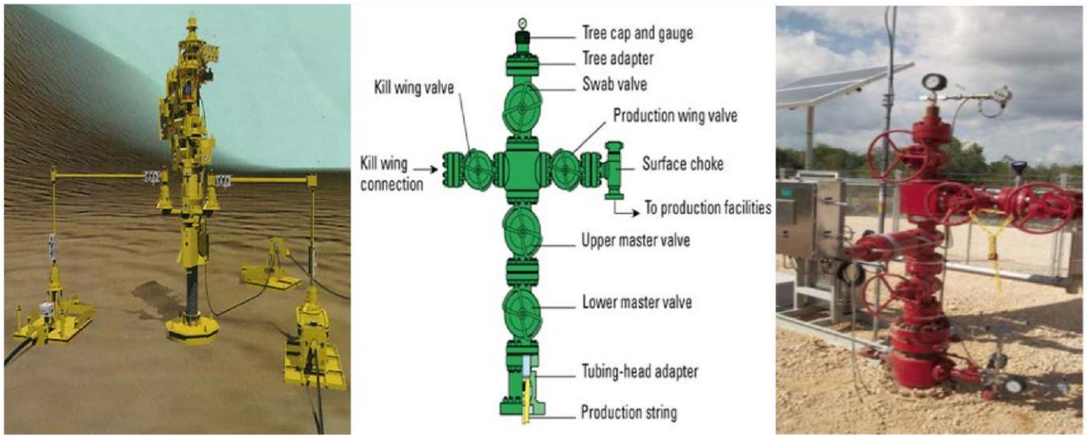


Fig 5: wet and dry wellheads with the sectional view of its components (ifelebuegu 2017a&b)

Blow out Preventer (BOP) Requirement

This is a defensive mechanism for operators and the well to prevent the escape of underground fluids and subsequent blowout that may occurred due to excessive pressure within the formation, it consist of BOPs and associated safety valves installed on the casing head before drilling forward after rigging (Bassey 2017b; OSHA 2017; NAS 2017). See Fig 6 subsea BOP.

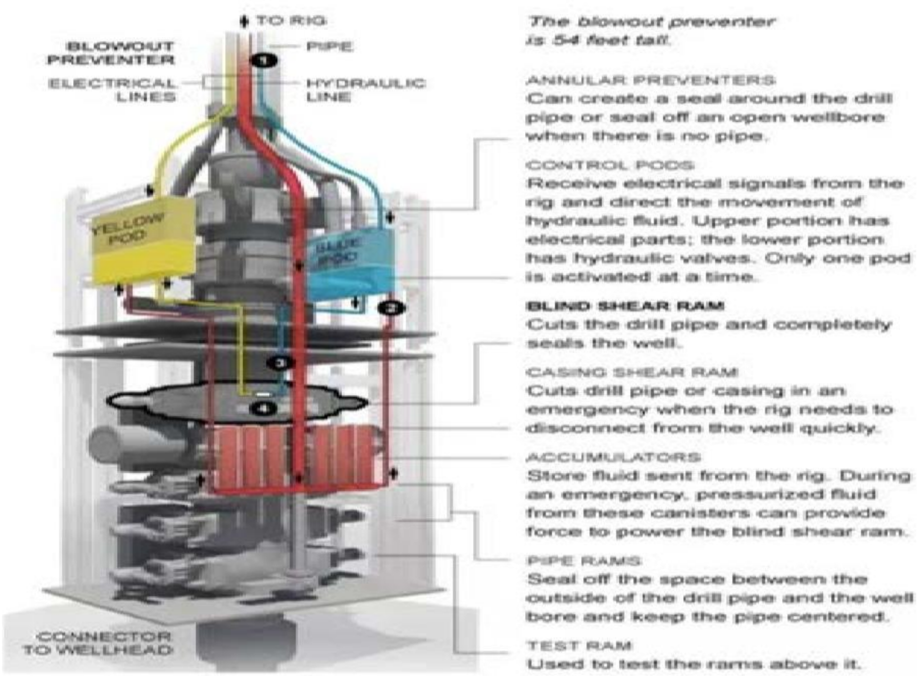


Fig 6: Deepwater horizons BOP showing different sections (OSHA 2017)

E-ISSN 3026-8796
P-ISSN 3026-8095

Cementing Programme

Atla is an oil exploration well hence API class G cement was used because of its moderate and high sulphate resistance as well as its moderate and high pressure and temperature resistance.

Table 5: Calculated Water- to –cement ratio for class G cement

Slurry Weight [ppg]	Cement Required [Ib]	Water Required [US gal]	Bentonite Required [Ib]
14.2	8.2	0.66	0.33
13.2	6.7	0.73	0.54
12.6	5.6	0.76	0.67

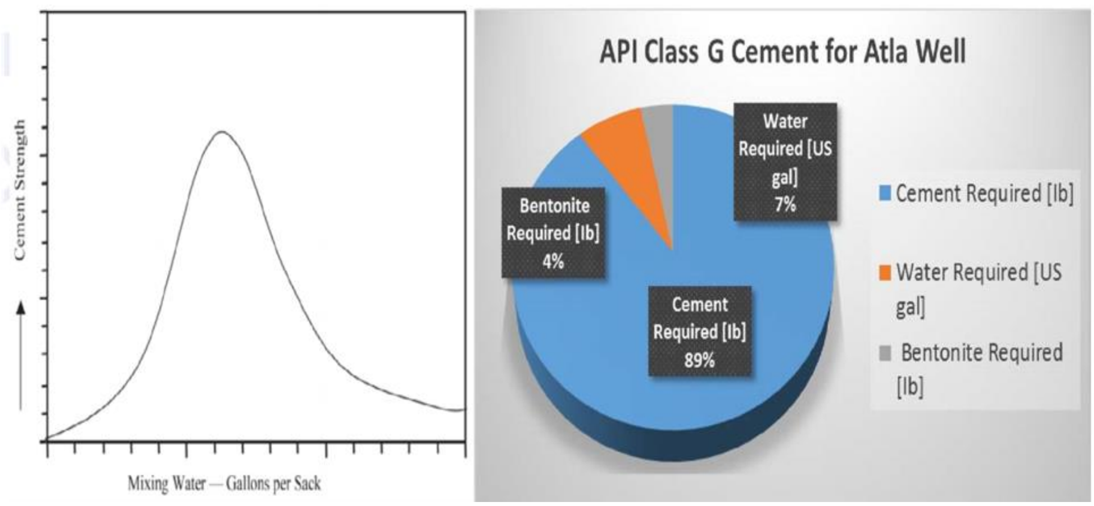


Fig. 6: plotted cement requirement and composition for API class G cement atlas well.

Sample Calculations Atla Well Cementing

Consider a class G single stage cementing job for $9^{5/8}$'' casing in Atla well below, with slurry density 15.9ppg, cement density of 1.14ft/sk, water to cement ration of 4.96gal/sk, with 2% retarders and 1% friction reducers, and assume 20% excess in open hole.

Casing Type [inch]	Casing Depth [ft]	Volume of Slurry [Ib/ft]	Volumetric Capacity. [ft^3/ft]
$9^{5/8}$	14,100	47	0.411
$12^{1/4}$	14,110	58	0.8185
$13^{3/8}$	6500	68	0.3132

E-ISSN 3026-8796
P-ISSN 3026-8095

Volume between casing and hole
Volumetric = $0.3132ft^3/ft$
Annular vol.= 2800 x 0.3132 = $877ft^3$
20% excess = $175ft^3$
Total vol. = $1052ft^3$

Tota volume = 1052 + 25 + 10 = $1085ft^3$
= total cement slurry volume

Volume below the float collar
Volumetric = $0.4110ft^3/ft$
Vol. 60 x 0.4110 = $25ft^3$

Volume in the rat hole
Volumetric = $0.8185ft^3/ft$
Vol = 10 x 0.8185 = $8.19ft^3$
20% excess = 1.8ft3

Number of sacks of cement = 1087/1.14 = 954 sacks

Volume of mixwater = 954 x 4.96 = 4732gal

Amount of additives = retarders D13R (0.2%)
0.002 x 954 x 94 = 180ib

= reducers D65 (1%)
0.01 x 954 x 94 = 897ib
0.02

Displacement volume = 0.4110 x 14040 = 5770ft = 1028bbls
surface liner 1028 + 2 = 1030bbls

Number of strokes = 1030/0.138 = 7464strokes

The maximum strength for water-to-cement ratio for this design is found at about 2.8 gal/sack of class G cement.

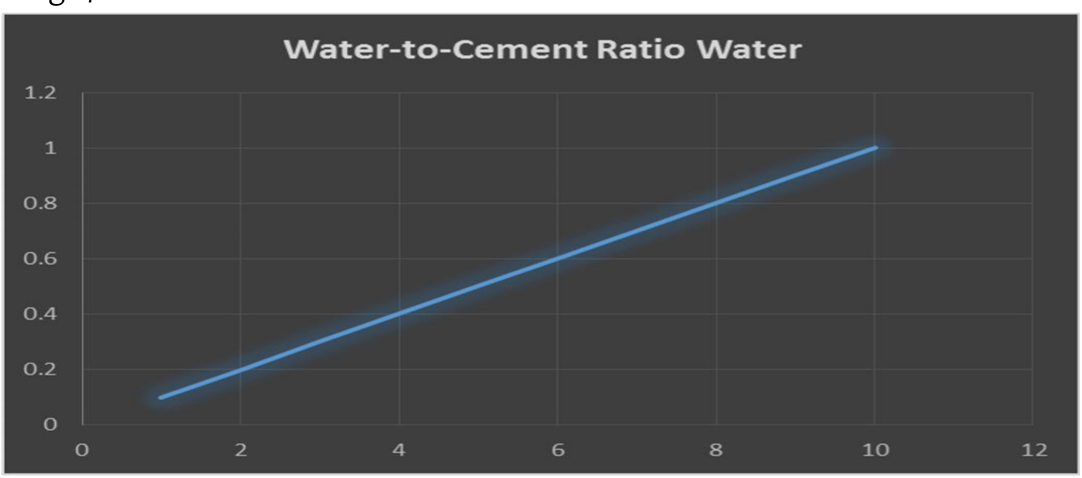


Fig 7: Plotted water-to-cement ratio for class G cement

Cementing is pumped down to the annulus throught the casing into the open holebeneat the casing string Fig 17 (Bassey 2017d). Table 5 shows the info summary for cement while table 6 mension the cementing operating techniqus.

E-ISSN 3026-8796
P-ISSN 3026-8095

Directional Well Drilling Programme

Majority wells drilled for oil and gas exploration or production objectives are vertical wells-drilled straight down into the earth. However, drilling at an angle other than 90° to obtain information, hit targets and to stimulate reservoirs in manners that can not be achieved vertically. Sidetrack well are of two forms as shown in the Fig 18 and 19. below (Bassey 2017d; Vaughan 2012).

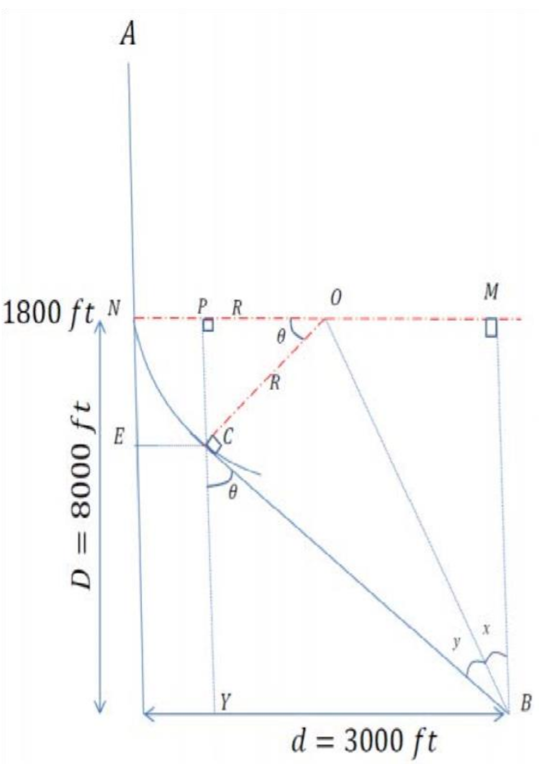
Side tracking Atlaexploratiuon well from 1800 ft with the build and hold profile with the following details: Build up rate: 2.2°/100 ft

Target depth: 3045 ft

HD: 3000 ft

The radius of buildup section:

$$\frac{v}{360} \quad \frac{100ft}{2\pi R} \qquad R = \frac{36000}{2\pi(2.2)} = 2291 \text{ ft}$$



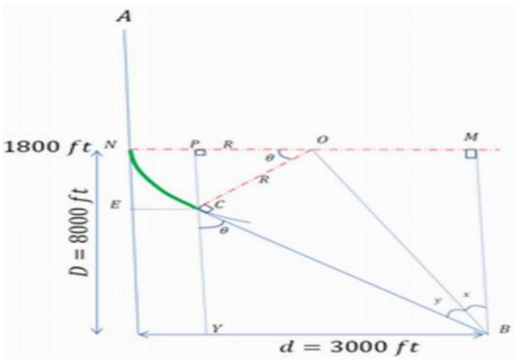
$$R = 2292\,ft$$

$$\tan x = \frac{d - R}{D} = \frac{3000 - 2292}{8000} = 0.0885 \rightarrow x = 5.1$$

$$\sin y = \frac{R}{\frac{D}{\cos x}} = \frac{R\cos x}{D} = \frac{2292\cos(5.1)}{8000} = 0.285$$

$$y = 16.6$$

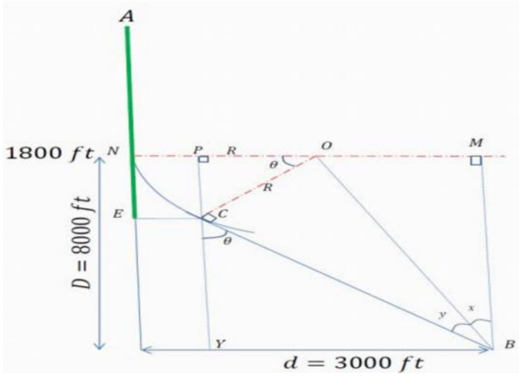
$$\theta = x + y = 5.1 + 16.6 = 21.7$$



MD of build section

R = 2292 ft Θ = 21.7

$$\frac{\theta}{360} = \frac{NC}{2\pi R} = \frac{\theta}{360} = \frac{NC}{2\pi(2292)} \quad NC = 867.6\ ft$$

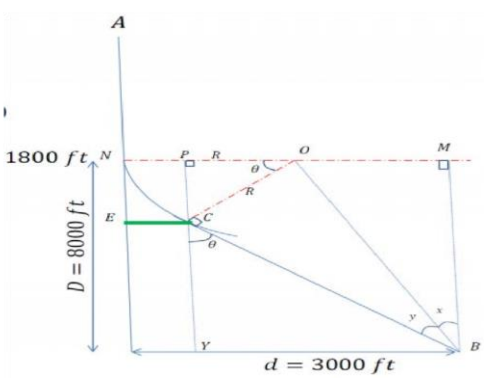


TVD at the end of build section:

R = 2292ft Θ = 21.7

AE = AN + NE = AN + RcosΘ

AE = 1800 + 2292sin21.7 = 2647.5ft

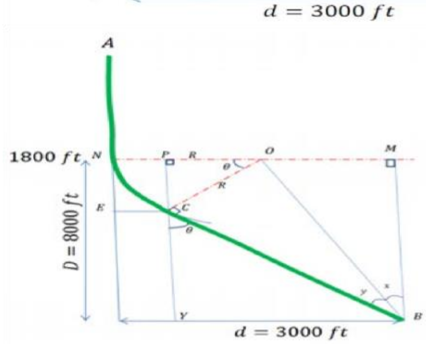


Displacement at the end of build section:

R = 2292ft Θ = 21.7

EC = ON - OP = R- RcosΘ = R(1 - cosΘ)

EC = 2292(1 – cos21.7) = 162.4 ft



Total measurement depth:

R = 2292ft Θ = 21.7

AB = AN + NC + CB

AB = 1800 + 867.6 + (OC/tan y) = 10359ft

Drilling Fluids (Mud) Programme

E-ISSN 3026-8796
P-ISSN 3026-8095

Table 6: Principle components and characteristics of atlas well drilling fluids

Fluids Type	Principle Components	General Characteristics	Coments
Simple seawater	Sea water and hi-vis sweeps down to 1160m	Low cost, offshore applications, bentonite and barite may be added to increase cuttings-carrying capacity	Several tight spots were encountered because of the thin viscosity and insufficient cleaning by the seawater. The rig experienced a shutdown at 438m for 123.75 hrs, because of tight spots.
Spud mud	Non-aqueous oil based mud from 1160m to TVD	Moderate cost, low press shallow reservoirs, water used to increase density and cuttings-carrying capacity	Reached the targets depth because of its thick viscosity and weighting properties. Strong environmental restriction may apply

Source: (Quaife 2017 a,b,&c; IOM n.d.).

Drilling Bit Programme

Selecting the bit for Atla well using the outstep data available for three nearby well to determine which bit gives the lowest drilling cost at an operating cost of $400/hr for trip time of 7 hours.

Note that:

- All three bits are hybrid bit that combined the used of both PDC to shear formations and rollers to crush it.
- Each bit operates at near minimum cost per foot attainable for it.
- F=mean penetration rate (ft/hr) x rotating time (hr)

Table 7: Types of drill bit operation and cost implication

Bit	Bit Cost ($)	Rotating Time (hours)	Connection Time (non-rotating) (hours)	M. Penetration Rate (ft/hr)
A	800	14.8	0.1	13.8
B	4,900	57.7	0.4	12.6
C	4,500	95.8	0.5	10.2

Solutions:

The cost per foot drilled for each bit are calculated using the equation below.

E-ISSN 3026-8796
P-ISSN 3026-8095

$$C = \frac{C_b + (T_r + T_{nr} + T_t)\, C_r}{F}$$

Where:

- C = overall cost per foot ($/foot)
- C_b = cost of bit ($)
- T_r = rotating time with bit on bottom (hrs)
- T_{nr} = total non-rotating time, hrs
- T_t = round Trip time (hrs)
- C_r = Cost of operating rig ($/hrs)
- F = Footage

Bit **A** cost per foot $= \dfrac{800\ (14.8 + 0.1 + 7)\ 400}{13.8\ (14.8)}$

=

$46.81/ft Results for bit **B** and **C** below:

Bit **B**: $42.56/ft

Bit **C**: $46.89/ft

The lowest drilling cost per foot was obtained from bit B, however it has the highest operating cost but longest life span and an intermediate ROP. It is therefore chosen for Atla well drilling (Quaife 2017b; Pessier and Damschen 2010). Fig 22 shows type of bits. Fig 23 shows drill bit performance while Table 8 shows bit selection for Atla well.

Well Evaluation and Test Requirement Programme

There are number of factors and events seeable and un-seeable which affect the time and cost to drilling a well (Kaiser, 2007; Bassey 2017c&d).

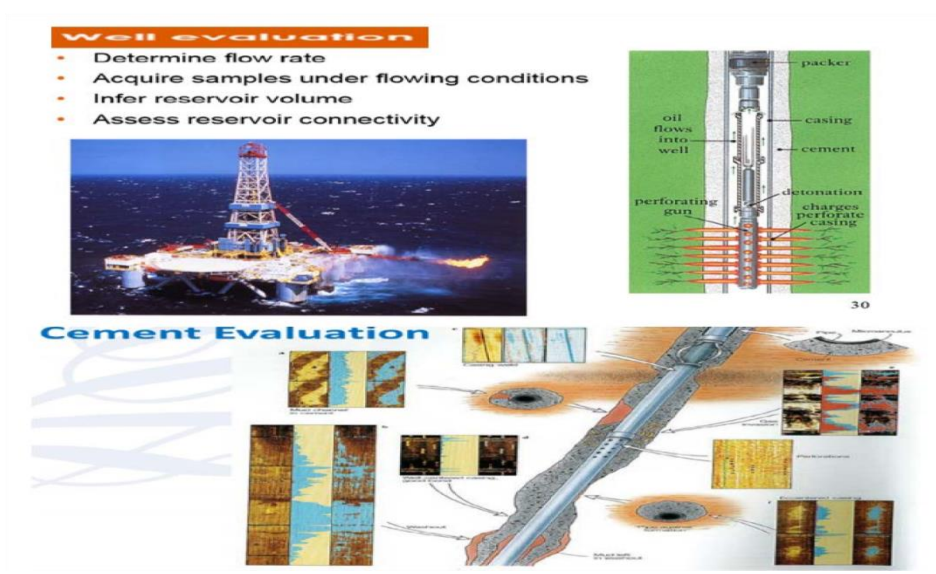
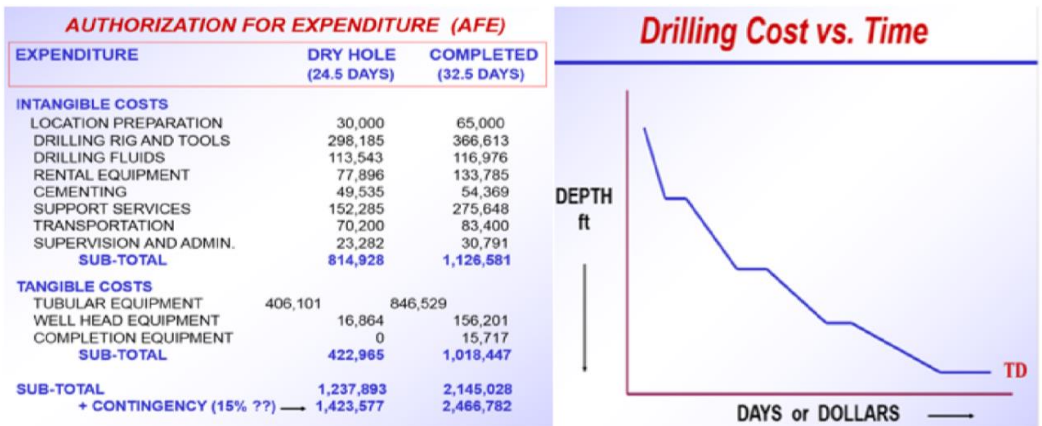


Fig 7 well and cement evaluation (Bassey 2017c&d)

TIJSRAT E-ISSN 3026-8796 P-ISSN 3026-8095

Authorization for Expenditure (AFE)

AFE involves the preparation of cost estimates for drilling a well and obtaining management approval as the final step in well planing. AFE are often accompanied together with projected payout schedule or forecast (Quaife 2017a). see table 10 and 11. Before getting the approval to drill a well the drilling operator must prepare an AFE- Fig 25 shows operational procedures and time depth graph. Graphs A, B, and C Fig 25 is arranged clockwise starting from top left and are described as follows: (A) Comparisison planned versus actual Time of each section in Atla well; (B) Graph of planned and actual day versus depth of Atla well (C) Comparison of productive time versus non-productive time of Atla well.



AUTHORIZATION FOR EXPENDITURE (AFE)

EXPENDITURE	DRY HOLE (24.5 DAYS)	COMPLETED (32.5 DAYS)
INTANGIBLE COSTS		
LOCATION PREPARATION	30,000	65,000
DRILLING RIG AND TOOLS	298,185	366,613
DRILLING FLUIDS	113,543	116,976
RENTAL EQUIPMENT	77,896	133,785
CEMENTING	49,535	54,369
SUPPORT SERVICES	152,285	275,648
TRANSPORTATION	70,200	83,400
SUPERVISION AND ADMIN.	23,282	30,791
SUB-TOTAL	814,928	1,126,581
TANGIBLE COSTS		
TUBULAR EQUIPMENT	406,101	846,529
WELL HEAD EQUIPMENT	16,864	156,201
COMPLETION EQUIPMENT	0	15,717
SUB-TOTAL	422,965	1,018,447
SUB-TOTAL	1,237,893	2,145,028
+ CONTINGENCY (15% ??) →	1,423,577	2,466,782

Fig 8: authorization for expenditure and dept time graph

RESULTS AND DISCUSSIONS

The results showed that all potential reservoirs in the tertiary were found water bearing. The Brent reservoir was found gas bearing. The statfjord was found water wet. Petrophysical interpretation indicated that the Brent reservoir has a net-to-gross of 93%, an average effective porosity of 17.5% and water saturation of 12%. The MDT results showed that the mobility in reservoirs are high and that the gas density is 0.26 g/cc. One 54m core with 100% recovery was cut from 2690m down to 2744m covering most of the Brent reservoir sands. MDT gas samples with condensate were taken at 2708m and at 2689m. New rules and regulations following the Deepwater Horizon, and other subsea incidences have really resulted in significant changes to subsea well design, especially in the design of casing, to achieve casing collapse integrity, heavy wall $14^{1/2}$ inch casing is now commonly used at the intermediate casing strings (Bassey 2017c; Quaife 2017a). According to (Decom World 2017) a recent estimate suggested that 34% of North Sea wells face integrity issues today.

CONCLUSIONS AND RECOMMENDATIONS

Atlat well info summary in Fig 1, has a long history of oil and gas discovery, Atla is an exploration well dug to determine the presence of petroleum hydrocarbons and to provide geological data for wire, cores and logs evaluation and testing production potential (Quaife 2017a; DWSSP2012; Fact 2013; NPD 2017; SEA 2001; SEA 2001a).

- Subsea drilling, horizontal and directional allow producers to tap reserves in old reservoirs or areas previously not considered economically feasible.
- Oil producers should reconsidered ways to downsize the number of physical devices utilization in control circuit in order to improve the reliability of local control, by using network node and PID controller all in one package.
- Oil producers should ensure that critical components are operating safely and the process shuts down if any incident should occur.
- All produce fluids, drill chips, cement, cement returns, acid wash, scaling and other solids should be captured, and classified, recycled or disposed, hazardous waste should be segregated to prevent contamination of non-hazardous materials

REFERENCE

Adams A. (2012) *Well design and construction I, Nexen Petroleum UK, 29 Sep.* <https://www.slideshare.net/YalnDalg/well-design-and-construction-i-14517067>

Akgun F (2002) *Drilling Variables at Technical Limit of Drilling Rate, Canadian International Petroleum Conference 2002, Calgary, Alberta, Canada, June 11 – 13,*

Marbun,B. T. H. Purba,N. P. and . Fadholi, B. Z (2015) *An Integrated Management of Drilling Design and Operational of Geothermal Wells, Proceedings World Geothermal Congress 2015 Melbourne, Australia, 19-25 April.*

Bassey E. (2017a) *lecture note on Drilling and Well Completion-Formation Pressures. M100ged,*<https://cumoodle.coventry.ac.uk/pluginfile.php/1571481/mod_resource/content/3/Formation%20Pressures.pdf>

Bassey E. (2017b) *lecture note on Drilling and Well Completion-The Drilling Processes and WellControl.M100ged,*https://cumoodle.coventry.ac.uk/pluginfile.php/1571482/mod_resource/content/3/Well%20Control.pdf

Bassey E. (2017c) *lecture note on Drilling and Well Completion-The Casing. M100GED,* <https://cumoodle.coventry.ac.uk/pluginfile.php/1571482/mod_resource/content/3/Well%20Control.pdf>

Bassey E. (2017d) *lecture note on Drilling and Well Completion-The Cementing. M100GED*, <https://cumoodle.coventry.ac.uk/pluginfile.php/1571483/mod_resource/content/4/Drilling%20Fluid s.pdf>

Bassey E. (2017e) *lecture note on Drilling and Well Completion-The Directional Drilling. M100GED*,<https://cumoodle.c oventry.ac.uk/pluginfile.php/1571492/mod_resource/content/3/Direct ional%20Drilling.pdf>

BSEE (2011) *Bureaus of safety and environmental enforcement, Effects of Water Depth on Offshore Equipment and Operations Topic #3: Well Drilling & Completion Design and Barriers, November 2011*

Teodoriu, C. Cheuffa, C. (2011) *A Comprehensive Review Of Past And Present Drilling Methods With Application To Deep Geothermal Environment, Proceedings, Thirty-Sixth Workshop on Geothermal Reservoir Engineering Stanford University, Stanford, California, January 31 - February 2,* Dec. 11, 2012, NYSE:PXD <www.pxd.com>

DecomWorld (2017) *The World's Largest Decommissioning, Abandonment and Late-Life AssetManagement Conference, March 14-15, Omni Houston Hotel, Texas*<http://www.decomworld.com/gom/>

Devold H. (2013) *Oil and gas production handbook, an introduction to oil and gas production, transport, refining and petrochemical industry, Edition 3.0 Oslo, August.* DWSSP, (2012) *Deepwater and Subsea Project, available at*: <http://subseaiq.com/(X(1)S(zaozsh45qmcnjhzfdoonr4bd))/data/PrintProject.aspx?project_id=847&AspxAutoDetectCookieSupport=1>

Eren T. (2010) *Real-Time-Optimization of Drilling Parameters during Drilling Operations, A Thesis Submitted to the Graduate School of Natural and Applied Sciences of Middle East Technical University February, 145 pages*

FACT (2013) *the Norwegian Petroleum Sector*: <http://www.npd.no/Global/Engelsk/3Publications/Facts/Facts2013/FACTS_2013.pdf><https://www.gov.uk/government/uploads/system/u ploads/attachment_data/file/197333/TR_SEA2_Geology.pdf>

Ifelebuegu A. (2017a) *A lecture note on: Offshore Systems and Deepwater Drilling*, https://cumoodle.coventry.ac.uk/pluginfile.php/1643295/mod_resource/content/1/Riserless%20Drilling.pdf

Ifelebuegu A. (2017b) *A lecture note on: riserless drilling in deepwaters*, <https://cumoodle.coventry.ac.uk/pluginfile.php/1643295/mod_resource/content/1/Riserless%20Drilling.pdf>

IOM *The Institute of Material, Mineral and Mining, An Introduction to Oil & Gas Drilling and Well Operations, Educational Material from the IOM3 Oil and Gas Division*,<ttp://www.iom3.org/>ISBN 978-82-997886-3-2

IWCF (n.d.) *United Kingdom Branch, Drilling Calculations Distance Learning Programme, Part 3 –Well Control*, <http://www.iwcf.org/programmes/drilling-well-control>

Jones, S., &Sugiura, J. (2008, January 1). *Concurrent Rotary-Steerable Directional Drilling and Hole Enlargement Applied Successfully: Case Studies in North Sea, Mediterranean Sea, and Nile Delta. Society of Petroleum Engineers.* <http://www.drillingformulas.com/directional-well-planning-andwell-profile/>

Kaiser, Mark J., Pulsipher, and Allan G.: *(2007)Generalized Functional Models for Drilling Cost Estimation, SPE Journal Paper,*

NAS (2017) *National Academy of Sciences. Blowout Preventer System*, <https://www.nap.edu/read/13273/chapter/6>

NPD (2017) *Norwegian Petroleum Directorate, Factpages*.

NPD, (2010) *Total E&P Norge AS Discovers Gas/condensate Near the Heimdal Field October 18, 2010; available at*:<http://www.offshoreenergytoday.com/norway-total-ep-norge-as-discovers-gascondensate-near-the-heimdal-field/>

OSHA (2017) *Occupational Safety and Health Administration, Oil and Gas Well Drilling and Servicing etoo* <https://www.osha.gov/SLTC/etools/oilandgas/drilling/wellcontrol_bop.html>

Pessier, R., Damschen, M. (2010) *Hybrid Bits Offer Distinct Advantages in Selected Roller-Cone and PDC Bit Applications, IADC/SPE Drilling Conference and Exhibition, 2-4 February, New Orleans, Louisiana, USA*

Quaife N. (2017a) *lecture note on Drilling and Well Completion-Overview of Drilling Operations and Rig Components. M100GED* <https://cumoodle.coventry.ac.uk/pluginfile.php/1643294/mod_resource/content/1/Introduction%20t o%20Offshore%20%20Systems.pdf>

Quaife N. (2017b) *Alecture note on Drilling And Production Technology-Drilling String and Drilling Bits. M100GED* <https://cumoodle.coventry.ac.uk/pluginfile.php/1571491/mod_resource/content/4/Cementing.pdf>

Quaife N. (2017c) *A lecture note on Drilling Fluids M100GED available at* https://cumoodle.coventry.ac.uk/pluginfile.php/1571491/mod_resource/content/4/Cementing.pdf

SEA (2001) *Strategic Environmental Assessment –North Sea Geology, Technical Report TR_008*

SEA (2001a) *Strategic Environmental Assessment of the Mature Areas of the Offshore North Sea, SEA 2 Consultation Document September 2001 Report to the Department of Trade and Industry*

Vaughan A. (2012) *How to drill a well in five easy steps AOGA Legislative Seminar*

Warren, T.,M., et al. (2000) -"Casing Drilling Application Design Considerations", presented at the 2000 IADC/SPE Drilling Conference, New Orleans, Louisiana.