International Journal of Scientific Research and Engineering Development– Volume 2 Issue 3, May-June 2019

Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

CASING AND CEMENTING JOB IN AN OIL WELL (A CASE STUDY OF BENIN BASIN WELL 16A OF MARO OIL COMPANY)

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Abstract

For a drilling operation to be considered successful, the well must be capable of producing hydrocarbon to the surface. For this to be possible, the well must be cased and cemented using cement slurry. Also, additives play significant role in oil and gas well cementing operations. Cement additives selected for cementing operations are an integral part of sound well design, construction and well integrity. Additives are available to enhance the properties of oil well slurries and achieve successful placement between the casing and the geological formation, rapid compressive strength development and adequate zonal isolation during the lifetime of the well. This research work is focused on casing and cementing operation which is an integral and in dispensable part of drilling and completion process. The type of casings used during the actual operation went according to the proposed programme and the cementing job which was of the primary type was highly successful and went according to design. The development of the cements lurry was carried out in an ideal way based on the conditions of the formations encountered. In light of the successful nature of the casing and cementing programme carried out on Benin Basin Well 16A of Maro Oil Company, it was discovered that the practice of developing a casing strings to withstand burst, tension and collapse pressure was properly done. Thus, the developed casing strings can withstand any forceencountered.

Keywords: *Casing, Cementing, oil well, force, additives, Benin Basin Well 16A*

INTRODUCTION

To have a successful casing and cementing job,the design and selection of the casing should be carefully and technically done using facts gotten from calculations and bearing in mind factors such as collapse pressure, tensile load and burst pressure. After the casing has been run into the hole, there is every need for a substance (i.e., cement slurry) to be introduced between the casing and the wall of the formation to strengthen and hold the casing in place. This substance Cementing is defined as the application of a liquid slurry to various points inside or outside the casing[1-4].

A casing is a strong cylindrical pipethatisputin to the well bore after drilling to ensure a tight connection from the sub- surface to the surface [5-8]. It performs the following functions:

i. It prevents cave-in or wash out of the wall of theformation.
ii. It strengthens the wellbore.
iii. It prevents the contamination of fresh water sand by the drilling mud.
iv. It prevents the influx of formation fluid into the wellbore.
v. It provides a means of controlling the well.
vi. It provides a flow path for the movement of the produced fluid.
vii. It helps to confine production to the wellbore.
viii. It provides a base for the attachment of the blow-out preventer.
ix. It permits selective production of the pay zone.
x. It excludes water from the producing formation.
xi. It helps to furnish a permanent bore-hole of precisely known diameter.

More over, depending on the condition of the formation and the engineer's requirement, additives can be introduced into the cements lurry to modify and give it different characteristics such as increasing the setting time, decreasing the setting time etc.[9-12].It is very important that a good cementing job be done because the cost of a poor cementing job is very high. A good and successful cementing job depends on detailed knowledge of cement slurry, cement types, evaluation procedures and use of additives. A good cementing job performs the following function

i. It protects the casing from corrosion and enables it to be plugged.
ii. It strengthens and holds the casing in place.

MATERIALS AND METHODS

2.1 Well Description

20" Casing Cement Slurry (Class G)

Fluid description	Lead cement
Density	11.5ppg
Cement yield	1.69ft^3/sk
Total cement	1507sack
Slurry volume	438bbls
Water volume	287barrels
Excess	150%
Height	1118ft
Fluid description	Tail cement
Density	15.8ppg
Cement yield	1.15ft^3/sk
Total cement	736sack
Slurry volume	151bbls
Water volume	88barrels
Excess	150%
Height	381.94ft

$13\frac{3}{8}$" Casing Cement Slurry (Class G)

Fluid description	LeadSlurry
Density	12.8ppg
Cement yield	1.69ff^3/sk
Total cement	3,286sack
Slurry volume	954bbls
Water volume	626barrels
Excess	150%
Height	5172.3ft
Fluid description	Lead cement
Density	15.8ppg
Cement yield	1.15ff^3/sk
Total cement	1,647sack
Slurry volume	338bbls
Water volume	196barrels
Excess	150%
Height	827.7ft

$9\frac{5}{8}$"Casing Cementing Slurry (Class G)

Fluid description	Leads lurry
Density	12.5ppg
Cement yield	1.69ff^3/sk
Total cement	2,079sacks
Slurry volume	604bbls
Water volume	396barrels
Excess	150%
Height	8800.5ft
Fluid description	Tail Slurry
Density	15.8ppg
Cement yield	1.15ff^3/sk
Total cement	1771sack
Slurry volume	363bbls
Water volume	211barrels
Excess	150%
Height	4299.44ft

2.2 Casing Cementing Job Procedure

20" Surface Casing Cementing Job Procedure

The cementing job began with apre-job meeting, after which the cement lines were flushed, and pressure tested to 500 psi. The hole was thoroughly conditioned.The casings were picked up and installed using rubber "quickie" protector. Before the installation, the float shoe was made up on first joint to be run while the float collar was made on top of the second joint. The centralizers and mechanical wall scratchers were made up to the casing at appropriate points. The casing was run, filled with mud at every three joints. After the casing had been successfully installed, drilling mud was circulated twice using the same mud condition as the annular velocity when drilling. The pressure was recorded at various circulating rates and the pressure checked for loss throughout circulation. The cement lines were flushed, and pressure tested to 500psi. The cementing job proper commenced with the pumping of water up to 400ft followed by spacer up to 600ft.Thebottomplug was dropped and pressured down with water. 438bbl of 11.5ppg leads lurry of class "G" cement+5%BWOC$CaCl_2$ as accelerator. This was followed by 151 bbls of 15.8 ppg tails lurry consisting of class"G"cement+ 5% BWOC $cacl_2$ as accelerator + 20 gal of Asp 742 (defoamer). The top plug was dropped and pressured down with water up to 500ft in casing. After bumping with bottom plug, the casing was pressure tested to 500psi for 5 minutes and no back flow was indicated.

$13\frac{3}{8}$" Intermediate Casing Cementing Job Procedure

The casing ($13\frac{3}{8}$")was made up with $13\frac{3}{8}$" casing shoe + float collar. After the casing has been installed, drilling mud was circulated twice using the same mud condition as the annular velocity when drilling. The cementing lines were pressure tested to 2500psi. The cementing job proper commenced with the pumping of water up to 400ft followed by spacer up to 600ft. The bottom plug was dropped and pressured down with water. 954bbls of 12.5ppg lead slurry of class "G" cement + 57.6gal ASP 742 + 576.3gal We ix + 550bbls marabond 21+ 1% BWOC Hec 10. This was followed by 338bbls of 15.8ppg tail slurry consisting of class "G" cement + 62gals ASP 742 + We – ix 11 drums + 12 sksmarabond 21 + 35sks Hec 10. The top plug was dropped and pressured down with water up to 500ft inside casing. After bumping the top plug, the casing was tested to 3000psi for 10 minutes and no back flow was indicated.

$9\frac{5}{8}$"Production Casing Cementing Job Procedure

After the casing and its accessories have been installed, the cement lines were flushed, and pressure tested to 5000psi. The cementing job proper commenced with the pumping of water upto 400 ft followed by spacer upto 600ft.The bottom plug was dropped and pressured down with water. 604bbls of 12.5pgg lead slurry of class "G" cement + Marabond 21 7bbls+7galASP742. This was followed by 363bbls of 15.8ppg tails lurry consisting of class "G" cement +70galsASP 742 + 5% BWOC $cacl_2$. The top plug was dropped and pressured down with water up to 500ft inside casing. After bumping the top plug, the casing was tested to 5000psi for 10 minutes and no back flow was indicated.

2.3 Drilling Objectives

The well is programmed to achieve the following objectives:

i. Serve as a replacement well for Benin Basin Well 16A.
ii. Provide drainage points for the A8.2, A8.3 and the B1.0reservoir
iii. Produce from the oil column in the above-mentionedreservoirs

2.4 Slurry Composition and Job Quantities

20" Casing and Cementing

Table1 shows the data of 20" casing cementing.

Table1 Data of 20" Casing Cementing

Component	Description	Concentration	Job quantity
438 bbls 11.5ppg lead slurry			
ASP 742	Defoamer	0.04gal/sk	53gals
We – ix	Extender	0.4ga/sk	530gal
$Cacl_2$	Accelerator	5% BWOC	113.3sks
Hec 10	Viscosifier	2% BWOC	45.3sks
Cement	Class "G"		1507sks
151bbls 15.8ppg tail slurry			
Cement	Class "G"		736sacks
ASP 742		0.04gal/sk	20gal

$13\frac{3}{8}$" Casing Cementing

Table 2 shows the data of $13\frac{3}{8}$"casing cementing.

Table 2 Data ofCasing Cementing

Component	Description	Concentration	Job quantity
954 bbls 12.8ppg lead slurry			
ASP 742	Defoamer	0.03gal/sk	57.6gals
We – ix	Extender	0.3ga/sk	576.3gal
Marabond 21	Retarder	0.305% BWOC	550bbls
Hec 10	Viscosifier	1% BWOC	1805.7Ibs
Cement	Class "G"		3286sks
338bbls 15.8ppg tail slurry			
Cement	Class "G"		1647sacks
ASP 742	Defoamer	0.014gal/sk	7gal
Lomad D	Dispersant	1% BWOC	9sks
Marabond 21	Retarder	0.0128% BWOC	6.016 Ibs
Diacelfl	Fluid loss additive	0.3gal/sk	3 drums

$9\frac{5}{8}$"Casing Cementing

Table 3 shows the data of $9\frac{5}{8}$"casing cementing

Table 3 $9\frac{5}{8}$"Casing Cementing

Component	Description	Concentration	Job quantity
604bbs of 12.5ppg lead slurry			
ASP 742	Defoamer	0.02gal/sk	41.58gals
We-ix	Extender	0.2gal/sk	415.8gals
Cement	Class, G		2,079 sacks

363bbls 15.8pgg tail slurry

Component	Description	Concentration	Job quantity
Cement	Class "G"		1771 sacks
ASP 742	Defoamer	0.012gal/sk	21.252gals
Cacl2	Accelerator	5% BWOC	151.34 sks
Hec 10	Viscosifier	2% BWOC	60.536sks

RESULTS AND DISCUSSION

Data Analysis used for 20" Casing and Cementing Operation

Hole size	26"
Casing size	20"
Previous casing size	30"
Open hole excess	150%
Water per sack of lead cement	8gal/sack
Water per sack of tail cement	5gal/sack

Annular Volume of Slurry Calculation

Open hole capacity between 20" casing and 26" open hole

$$\frac{D^2 - d^2}{1029.4}$$

where,

D^2 = diameter of open hole, and

d^2 = diameter of 20" casing

$$\frac{26^2 - 20^2}{1029.4} = 0.268bbl/ft$$

For cased hole capacity

$$\frac{27.6152\ ^2 - 20^2}{1029.4} = 0.352bbl/ft$$

$$Inside\ casing\ volume\ (shoe\ track) = \frac{Internal\ diameter\ of\ 20''\ OD\ casing}{1029.4}$$

$$= \frac{19.1242}{1029.4} = 0.355bbl/ft$$

Lead Slurry Volume

Open hole = 0.268bbl/ft x 876.06ft x 1.5 excess

= 352.176bbls Cased hole = 0.352bb/ft x 242ft

= 85.184bbls

Total lead slurry =437.36bbls

$\simeq$ 438bbls

Tail Slurry Volume

Open hole = 0.268bbl/ft x 321.94ft x 150%
excess = 129.42bbls Shoe track = 0.355bbl/ft x
60ft = 21.3bbls
Total tail slurry = 150.72bbls ~ 151bbls

$$Sacks\ of\ cement\ for\ lead\ slurry\ = \frac{437.36\ bbls\ \times\ 5.615ft3/bbl}{1.63ft3/sk} = 1506.6\ sacks$$

For tail slurry, sacks of cement required will be:

$$= \frac{150.72bbls\ \times \frac{5.615ft3}{bbl}}{1.15ft3/sk} = 735.907\ sacks$$

Total amount of cement required = 2242.507 sacks = 2243 sacks

Amount of mix water required

$$For\ lead\ cement\ slurry\ \left(\frac{8gal}{sack}of\ cement\right) = \frac{1506.6\ sacks\ x\frac{8gal}{sk}}{\frac{42gal}{bbl}}$$

$$= 286.97bbls\ of\ water$$

$$For\ tail\ slurry\ \left(\frac{5gal}{sack}of\ cement\right) = \frac{735.907\ sacks\ \times\frac{5gal}{sk}}{\frac{42gal}{bbl}} = 87.608bbls\ of\ water$$

Total barrels of water required = 374.578 bbls ofwater
Sacks of bentonite required
For lead slurry
Mix water contains 6% bentonite BWOCbent = 1506.6 sacks x 94Ib/sk x 0.06 = 8,497.224lb
If each sack of bentonite weighs 50 lb/sk,
Then;

$$= \frac{8{,}497.224\text{lb}}{50Ib/sk} = 169.94\ sacks\ =\ 170\ sacks$$

Holesize	17½”
Casing size	$13\frac{3}{8}$"
Previouscasingsize	20”
Openholeexcess	150%
Water per sack ofleadcement	8gal/sack
Water per sack oftailcement	5gal/sack

Annular Volume of Slurry Calculation

Open hole capacity between$13\frac{3}{8}$"casing and 17½” open hole= $\frac{D^2-d^2}{1029.4}$

where,

D^2 = diameter of open hole,

d^2 = external diameter of casing being cemented

$$\frac{17.5^2 - 13.375^2}{1029.4} = 0.1237bbl/ft$$

$$Cased\ hole\ capacity\ between\ 13\tfrac{3}{8}\ casing\ and\ 20''\ casing\ = \frac{19.124^2 - 13.375^2}{1029.4}$$

$$= 0.1815 \text{bbl/ft}$$

$$Inside\ casing\ volume\ (shoe\ track\ = \frac{Internal\ diameter\ of\ 13\tfrac{3}{8}''\ casing}{1029.4}$$

$$= \frac{12.515^2}{1029.4} = 0.1522 \text{bbl/ft}$$

Lead Slurry
Cased hole = 0.1815bbl/ft x 1500ft = 272.25bbls
Open hole = 0.1237bbl/ft x 3,672.3ft x 150% excess = 681.395bbls Total lead slurry = 953.65bbls

Tail slurry volume
Open hole = 0.1237bbl/ft x 1,767.7ft x 150% excess = 327.977bbls Shoe track = 0.1522bbl/ft x 60ft = 9.132bbls
Total tail slurry volume = 337.129bbls

$$Sacks\ of\ cement\ for\ lead\ slurry\ = \frac{953.65\ x\ 5.615ft3/bbl}{1.63ft3/sk} = 3{,}285.119\ sacks$$

For tail slurry, sacks of cement required will be:

$$Sacks\ of\ cement\ for\ lead\ slurry\ = \frac{337.129bbls\ \times 5.615ft3/bbl}{1.15ft3/sk} = 1{,}646.06899\ sacks$$

Total amount of cement required = 4,931.18799 sacks Amount of mix water required *= For lead cement slurry (8gal/sack of cement =*

$$\frac{3{,}285.119\ sacks\ x\ 8gal/sk}{42gal/bbl} = 625.737bbls\ of\ water$$

$$For\ tail\ slurry\ (5gal/sk)\ = \frac{1646.06899sacks\ x\ 5gal/sk}{42gal/bbl} = 195.961bbls$$

Sacks of bentonite required
For lead slurry
Mix water contains 6% bentonite BWOC bent = 3285.119 x 94 x 0.06 = 18528.07lb
If each sack of bentonite weighs 50 lb/sk, then;

$$= \frac{18528.07lb}{50Ib/sk} = 370.5614\ sacks$$

Data Analysis used for $9\frac{5}{8}$"Casing and Cementing Operation

Hole size	12¼"
Casing size	$9\frac{5}{8}$"
Open hole excess	150%
Water per sack of lead cement	8gal/sack
Water per sack of tail cement	5gal/sack
Previous casing size	$13\frac{3}{8}$"

Annular Volume of Slurry Calculation

Open hole capacity between$9\frac{5}{8}$"casing and 12¼" open hole= $\frac{D2-d2}{1029.4}$

Where,

D^2 = diameter of open hole,

d^2 = diameter of production casing

$=\frac{12.252-9.6252}{1029.4}=0.656bbl/ft$

Cased hole capacity between$9\frac{5}{8}$"casing and $13\frac{3}{8}$"casing

$$=\frac{12.6152-9.6252}{1029.4}=0.0646bbl/ft$$

Inside casing volume (shoe track)

$$=\frac{8.8352}{1029.4}=0.0758bbl/ft$$

Lead Slurry Volume

Cased hole = 0.0646bbl/ft x 7000ft = 452.2bbls

Open hole = 0.056bbl/ft x 1800.56ft x 150% excess = 151.247bbls Total lead slurry = 603.447bbls = 604bbls

Tail Slurry Volume

Open hole = 0.056bbl/ft x 4239.44ft x 150% excess = 358.0207bbls Shoe track = 0.0758bbl/ft x 60ft = 4.548bbls

Total tail slurry volume = 362.5687bbls

$$Sacks\ of\ cement\ for\ lead\ slurry\ =\frac{603.447bbls\ \times 5.615ft3/bbl}{1.63ft3/sk}=\ 2{,}078.745\ sacks$$

For tail slurry, sacks of cement required will be:

$$=\frac{362.5687bbls\ \times 5.615ft3/bbl}{1.15ft3/sk}=\ 1770.28\ sacks$$

Total amount of cement required = 1770.28 + 2078.745 = 3849.026 sacks

Amount of mix water required

$$For\ lead\ cement\ slurry\ \left(\frac{8gal}{sack} of\ cement\right) = \frac{2{,}078.747\ sacks\ x\ \frac{8gal}{sk}}{\frac{42gal}{bb}}$$

$$= 395.95 bbls\ of\ water\ =\ 396 bbls$$

For tail slurry (5gal/sk)

$= \frac{1770.28 sacks\ x\ 5gal/sk}{42gal/bbl}$ =210.748bbls = 211bbls

Sacks of bentonite required

For lead slurry

Mix water contains 6% bentonite BWOC

bent = 2078.745sks x 94lb/sk x 0.06 = 11724.1218b

If each sack of bentonite weighs 60 lb/sk, then;

$$= \frac{11724.1218 lb}{50 Ib/sk} = 234.48\ sacks\ =\ 235\ sacks$$

The oil well penetrated in the course of the development work differs in their condition of lithology, permeability, degree of saturation and other characteristics. Besides, the diversity of these factors called for the elaboration and application of various placement techniques for cementing oil wells. The effective handling of these operations leads to the reduction of well cost, increased production minimizes hazards and elimination of secondary or remedial job. In order to achieve these objectives, single stage cementing placement technique was used.

Additives Description Class G Cement (API)

It is an Api special all-purpose oil well cement designed for use up to 8000ft without activities. It is moderately to highly sulphate resistant cement, which can be modified to cover a wide range of well depths and temperature.

ASP 742 (Defoamer)

It is a liquid cement defoamer (anti – foam) used to improve slurry density control and mixability by reducing foaming.

WE – IX (Extender)

It is a liquid cement additive used in the production of a greater volume of slurry from the powered cement.

HEC 10 (Viscosifier)

This is an additive hat is used to increase the viscosity and density of cement slurry.

Lomad D (Dispersant)

It is liquid high molecular weight dispersant used to lower slurry viscosity and helps provide turbulent flow properties at reduced pump rates. It also assists in fluid loss control.

$CaCl_2$ (Accelerator)

This is used to quicken the thickening time of cement slurry

Marabond 21 (Retarder)

It is a medium to high temperature liquid cement retarder used to control the thickening time of cement slurry at temperature from 80^0F to 300^0F.

Diacelfl (Fluid Loss Control)

It is a liquid cement fluid loss and gas migration control agent used up to 3500F

CONCLUSION

Based on my findings, and the result of the analysis of the case study, it was concluded that the practice of designing strings to withstands burst, tensional and collapse pressure were properly carried out. The development of the cement slurry was carried out in an ideal way based on the conditions of the formation encountered. Also, proper description and use of additives according to laboratory analysis was also done.

RECOMMENDATIONS

Based on a careful analysis using Benin Basin Well 16A as a case in this research work, we therefore recommend the following:

i. Good practice for designing casing strings that can withstand any force (burst, tension and collapse) should be maintained.
ii. Type and quantities of additives to be used in a cementing operation should be followed strictly as that is an indispensable part of the cementing operation.

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