Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 10 Issue 11, November - 2023

Optimization Of Rig Operating Time With Plug Modification On Tubing Pressure Test For Pre Fracturing Work In Sangasanga Field Well Case Study

KRT Nur Suhascaryo, Harry Budiharjo S., Nadir Faisal Almadani

Petroleum Engineering, UPN Veteran Yogyakarta, Indonesia
Correspondences e-mail: nadir.almadani@pertamina.com

***Abstract*— Sangasanga Field is one of 22 fields in PT. Pertamina EP with oil production target of 5670 BOPD in 2019. The Field well work plan in 2019 includes 32 wells workover and 77 Well Intervention which are expected to support the achievement of production targets in 2019. One of the Well Intervention jobs is fracturing which requires a tubing pressure test process. Sangasanga field plans fracturing on 6 wells from 2019 to 2022, in the fracturing process there is a pre-fracturing process whose purpose is to determine the quality of the tubing, because of this, the importance of pressure testing. tubing in pre-fracturing work prompted Sangasanga Field to develop plug modifications to improve process efficiency. The modification involved Mandrel pump RW and cage top standing valve TH, supported by Jar and on-off to facilitate fishing process after pressure test. Sinker bars were also added for additional weight. The procedure starts with a surface pressure test using Mandrel and Cage top at 2000 psi, held for 30 minutes. Once successful, the tool is run with the tubing and placed in the tubing shoe. The pressure test is run at 6000 psi, held for 10 minutes with a maximum pressure drop of 3% every 20 tubing joints. After all tubing is tested, the modification plug is pulled out with a fishing tool involving an on-off, jar, and sinker bar.**

The plug was applied to 6 wells, NDR-1, NDR-2, NDR-3, NDR-4, NDR-5, and NDR-6. The results showed an average time reduction of 56% for pre-fracturing: NDR-6 57% (18.95 hours), NDR-5 57% (19.55 hours), NDR-4 55% (10.85 hours), NDR-3 56% (13.55 hours), NDR-2 58% (29 hours), and NDR-1 57% (18.8 hours). This success resulted in a cost reduction of approximately USD 70,476 & from 6 wells performing the tubing pressure test process.

Keywords—Pre-fracturing, Modified Plug, Pressure test, Fishing, Rental Rig

I. INTRODUCTION

Sangasanga Field is one of 22 fields in PT. Pertamina EP which produces oil with a target of 5670 BOPD in 2019. The Sangasanga field has 3 own rigs and 1 lease rig to support the achievement of oil production targets in 2019 with a target of 5670 BOPD. The Sangasanga Field Work Plan for 2019 includes 32 Well Workovers, 77 Well Interventions and 120 Well Services. One of the jobs to support Well Intervention is tubing testing before cementing and fracturing. In the tubing test activity, there are activities that contribute a high loss time, namely circuit unplugging. This process is to unplug the circuit to open the plug. The tubing test aims.

to determine which tubing to be used for cementing or fracturing. Whether it is in good condition or not and will not leak when high pressure is applied. The end of the tubing is plugged manually, then inserted into the well and given a pressure test with a pressure according to the design of cementing and fracturing and for 10 minutes. If the pressure drops, it indicates the tubing is leaking and if after being held for 10 minutes, then the tubing is in good condition. The problem occurs because the time is not optimal for the work to remove the manual plug at the end of the tubing. The tubing that has been tested must be pulled back to remove the manual plug, the average time it takes to remove the tubing series is 14 hours.

II. METHODS

First The idea of plug modification arose when due to the problem of using manual plugs requiring POOH and RIH time again after conducting a tubing pressure test, PT Pertamina EP Sangasanga field found a solution, namely by modifying the plug consisting of:

1. *Plug modification core equipment according to API 11AX standard.*
   a. *Mandrel RW Pump*

Figure 1.1 Mandrel RW Pump

   b. Cage Top TH Pump

Figure 1.2 Cage Top TH Pump

2. Aditional Equipment (fishing tools) in accordance with API 11B
   a. On and Off

Figure 1.3 On-Off Tools

   b. Spang Jar Type

Figure 1.4 Jar Type spang

   c. Sinker Bar

Figure 1.5 Sinker Bar 10 feet

The working method of this plug modification is that the fabricated Mandrel RW pump and Cage top TH pump will be pressure tested on the surface with 2,000 psi on a 30-minute hold.

Figure 1.6 Pressure test modifikasi plug di surface

After the results are no leakage and declared good, the plug modification is ready to run along with the tubing where the plug modification will be in the tubing and sit on the tubing shoe, then after the tubing is run, a pressure test of 6,000 psi per 20 joints will be carried out to the depth that has been determined.determined with a pressure drop tolerance not exceeding 3% of the injected pressure. After the pressure test is carried out and the results are good, the plug modification will be fished using additional tools (on-off, jar, sinker bar) connected to the sandline, the sandline will be run to the top of the plug where the jar and sinker bar will provide weight and impact to the on-off so that it can latch with the plug modification, after the on-off with the plug modification latches, the plug modification is ready to be pulled to the surface.

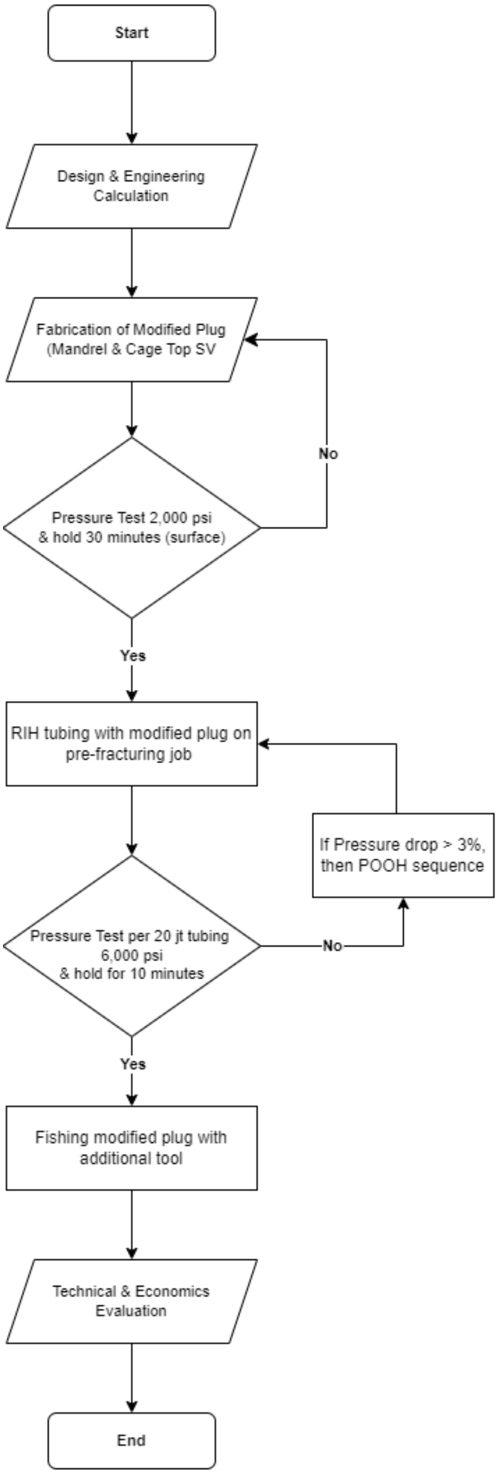

Figure 1. 7 Flowchart

III. Calculations and Design

- Determine the thread strength of the mandrel and cage top standing valve **Metric Size M 56.**
  - Depth Thread (Le)

    = 20 mm
  - Material strength of (r)

    = 655 MPa (Alloy Steel)

- Pitch diameter (d0)

= 5.50 mm^2 (**from table 1. metric ISO 724 on attachment**)

- Tensile stress area (At)

$= \frac{\pi}{4} \times (d0^2)$

$= \frac{3.14}{4} \times (5.5^2)$

= 23.74 mm^2

- Shear area (Ath)

= 0.5 $x\ \pi\ x\ d0\ x\ Le$

= 0.5 x 3.14 x 5.50 x 20

= 172.7 mm^2

- Shear strength (F)

$= r\ x\ Ath$

= (655 x 172.7)/1000

= 113.1185 kN

- Tensile stress (σ)

$= \frac{F}{At}$

$= \frac{113.185}{23.74}$

= 4.7636 kN/mm^2

= 690,901.7 $lbf/inch^2$

= 690,901.7 $lbf/inch^2$ x 0.0368 $inch^2$ (konversi 23.74 mm^2 to $inch^2$)

= 25,425.18 lbf

- The steps in determining the design of supporting equipment for pulling out the plug modification are as follows:
  1. Weight given for on and off to latch for the weight required by on off type T-110HD with Alloy steel (4140) and size 2.15" then in order to latch it requires a load of 8480.3 lbs. (Don - Nun Catalogue)
  2. Determining the weight produced by the Fishing Jar
  3. The weight that can be produced from a spang type fishing jar with a diameter of 1.6" can provide a maximum of 9,000 lbs (Oil Services LTD).
  4. Determining the resulting weight of the Sinker Bar

$$L = \frac{Fext}{Wrf}$$

DESCRIPTION:

L = require sinker barsection length, ft

Fext = External force of compressive, lb

Wrf = bouyant weight of the selected sinker bar, lb/ft

Calculations:

Wrf = (40 x 2.2) / 10

Wrf = 8.8 x 0.8

Wrf = 7.04

Fext = L x Wr

Fext = 10 ft x 7.04 lbf/ft

Fext = 70.4 lb

5. The total compressive strength of the fishing tool given to the on-off was:

= Maximum compressivestrength jar + Fext

= 9,000 lbf + 70.4 lbf

= 9,070.4 lbf

Based on the fishing tools we use, namely the sinker bar and spang type jar, the sinker bar can provide a weight of 70.4 lbs during the plug modification removal process and the spang type jar is 9,000 lbs, so the resulting weight is 9,070.4 lbs and from the on off tool used, it is known that the weight required for the on-off tool to latch with the plug modification requires weight, so the weight generated by the sinker bar and fishing jar is enough to make the on-off latch with the plug modification. From the above calculations, it can also be confirmed that the strength of the thread mandrel with cage top standing valve can withstand loads up to 25,425.18 lbf and this value is very sufficient to withstand the load of the fishing tool which is only 9,070.4 lbf.

- Design

The equipment for plug modification consists of :

1. Plug equipment in accordance with API 11AX standard:

- Mandrel RW pump and Cage top TH pump are the main components of the modified plug where this plug withstands pressure up to 6,000 psi from the experimental results that have been carried out. The following is a sketch (Figure 8) and 3D (Figure 9) of the Mandrel RW pump and Cage top TH pump.

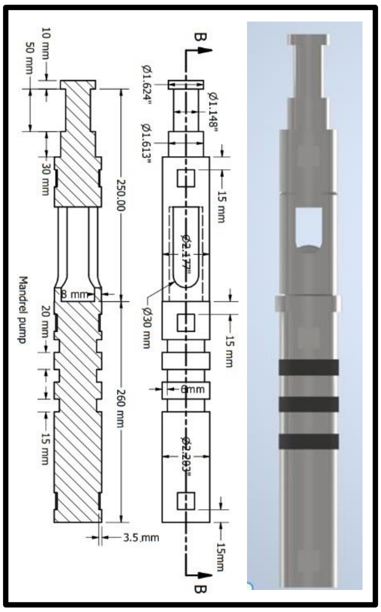

Figure 1. 8 Mandrel RW & Cage Top TH Sketch & 3D

2. Supporting equipment (fishing tools) according to API 11B and VT5 standards
   - On and off
     Is a supporting equipment that functions to unplug/release the plug modification from the well when the pressure test process has been completed. The following is a sketch and 3D of the On-off tool.

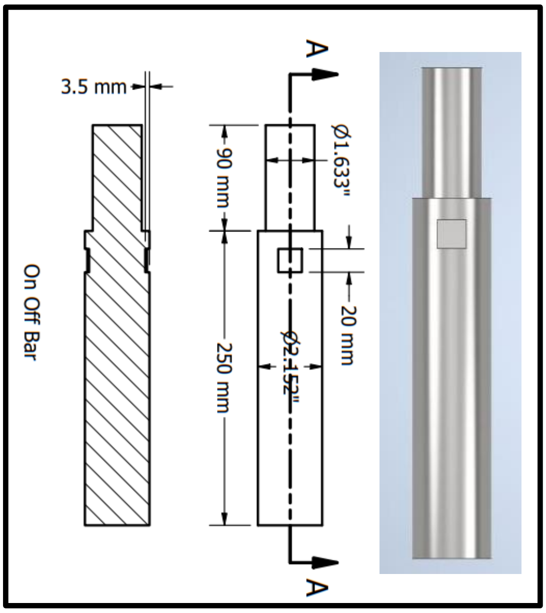

Figure 1. 9 On-Off Tools Sketch & 3D

   - Fishing Jar
     it is a supporting tool for the plug removal/release process from the well which functions as a pounder so that the on and off can latch with the plug modification. The following is a sketch and 3D (Figure 10) of the Jar.

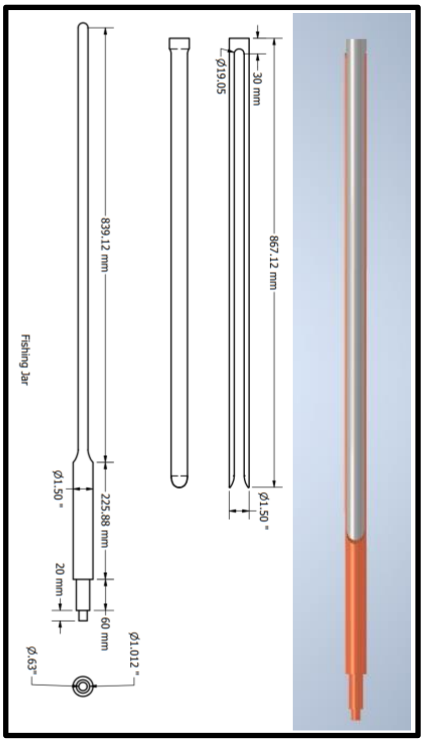

Figure 1. 10 Jar Sketch & 3D

   - Sinker Bar

Is the top circuit of the plug modification additional equipment which functions as a weight on the jar so that it can latch perfectly with the plug during the plug modification removal process. The following is a sketch and 3D (Figure 11) of the Sinker Bar**.**

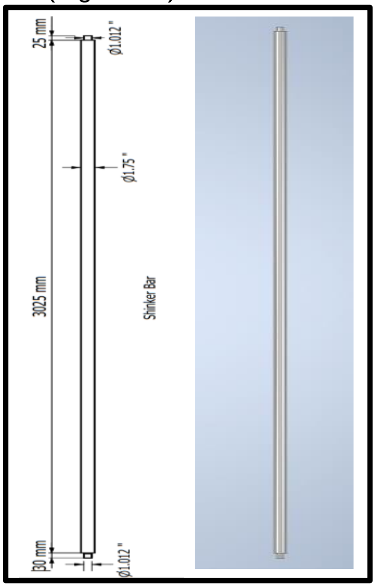

Figure 1. 11 Sinker Bar Sketch & 3D

IV. Application and Evaluation

Modified plugs have been implemented in several wells since 2019 to date. The following are some of the wells that have been installed with plug modifications

Date	RIG	Well
13-Aug-19	RIG KR250-2	**NDR-1**
13-Aug-19	RIG KR250-2	**NDR-2**
16-Dec-20	RIG SS-02	**NDR-3**
20-Feb-21	RIG SS-01	**NDR-4**
21-May-21	RIG SS-01	**NDR-5**
28-Jun-22	**RIG SS-02**	**NDR-6**

carried out in the pre-fracturing work, namely:

Table 2. Well Data Using Modified Plug

KNOWN TO:

Table 3. Field Data For Pre-Fracturing Tubing Test

Data	Value	Unit
Connection time / joint	4.5	Minutes
fill up and pressure	30	Minutes
Tubing	133	Joint
Repetition fill up and Pressure test	7	times
Modified Plug fishing times	1	Hour

Plug Conventional (NDR-6)

1.TIME RIH 133 TBG + FILL UP AND PRESSURE TEST

= (connection time per joint x number of joints) + (fill up and pressure test 20 tbg x Repetition of fill up and pressure test)

= (4.5 x 133) + (30 x 7)

= (598.5) + (210)

= 808.5 minutes

= 13.475 hours

2.POOH 133 TBG

= connection time per joint x number of joins

= 4.5 x 133

= 598.5 minutes

= 9.975 hours

3.RIH 133 TBG

= connection time per joint x number of joins

= 4.5 x 133

= 598.5 minutes

= 9.975 hours

The time it takes for RIH to return when it has done a manual plug release is 9.975 hours. So, from the above calculations, it can be calculated that the length of time for a pressure test using a conventional plug is:

= (Time RIH 133 tbg + Fill up and pressure test) + (POOH 133 tbg) + (RIH 133 tbg)

= (13.375 hours) + (9.975 hours) + (9.975 hours)

= 33.325 hours

Total time needed to complete the pressure test using a conventional plug with 133 tubing, it takes 33.325 hours.

- MODIFIED PLUG (NDR-6)

1. Time RIH 133 tbg + Fill up and pressure test = (connection time per joint x number of joints) + (fill up and pressure test 20 tbg x Repetition of fill up and pressure test)

   = (4.5 x 133) + (30 x 7)

   = (598.5) + (210)

   = 808.5 minutes

   = 13.475 hours

2. (TOTAL TIME RIH 133 TBG + FILL UP AND PRESSURE TEST) + FISHING

   = 13.475 + 1

   = 14.475 Hours

The RIH time of 133 tbg with fill up and pressure test is 13.475 hours plus the fishing time of plug modification which is 1 hour. So for pressure test 133 tubing with a modified plug is **14.475 hours**, there is no POOH and RIH time again because the tubing and plug are not in one series.

The time required between conventional plug and modified plug can be seen in table 3 and also figure 1.12 on attachment.

In activities that test tubing pressure conventioanal this process is less than optimal because it spends a lot of time when pulling out and entering the tubing circuit. The problem when using this conventioan plug can be overcome by modifying the plug with a Mandrel and Cage Close which functions as a plug where this plug can be pulled out with the help of additional tools, namely on & off combined with a jar and also a singker bar. Proven from the experiments that have been carried out in 6 wells. In the NDR-6 pre-fracturing process, the time efficiency results were obtained for 14,475 hours. So that rig rental costs can be reduced because the time required to unplug and enter the circuit which takes 18.95 hours (0.79 days) can be eliminated.

The following is the calculation of the economics of well NDR-6:

1. Rig rental price

= Difference in conventional time x Rig rental price per day

= 0.79 x $5,600

= $4,424

2. Cost of oil loss

= Difference in conventional time x Production opportunity x oil price based on ICP

= 0.79 x 64 x 86.07

= $4,352

3. Solar Cost

= Difference in conventional time x Amount of diesel per day x diesel price (IDR) x convert currency (USD/IDR).

= 0.79 x 240 x 11,500 x 15,000

= $145

4. Total saving cost

= Rig rental cost + Oil loss cost + Solar cost

= $4,424 + $4,352 + $145

= $8,921

By saving rig rental costs of $4,424 so that the time for the well to produce can be faster so that it can reduce oil loss $4,352 and also reduce the use of diesel fuel by $145 so that the total that can be saved is $8,921 and the quality of the tubing connection will be the same as the quality of the tubing connection both before and after the tubing pressure test because there is no work to pull out and enter the tubing circuit and can reduce the potential for accidents such as pinching and so on during the activities of pulling out and entering the tubing circuit. The following table shows the economics in Table 4 and Figure 1.13 on attachment of the six wells where the plug modification was installed.

V. CONCLUSION

- The Pressure test tubing process is important to determine the quality of the tubing.
- The components of the plug modification are the Mandrel RW Pump and Cage Top TH Pump.
- Supporting components are on-off, jar and sinker bar.
- The force required to remove the modification is 8,480.2 lbf, based on the calculation of the thread strength of the mandrel & cage top pump which is 25,425.18 lbf, and the calculation of the total compressive strength of the fishing tool for on-off is 9,070.4 lbf so that the on-off tool can be released due to the weight of the fishing tools meet and fishing tools will not fail because the thread strength meets the total load requirements.
- From the experimental results, the percentage of pressure test time reduction is 56% on average.
- Of the 6 wells that have used plug modifications, the total cost that can be saved is **USD 70,476**

REFERENCES

[1] Afdal Hidayat. Evaluasi Penggunaan Retrievable Packer Pada Pekerjaan Squeeze Cementing di Sumur X. Universitas Islam Riau. 2019

[2] Archard, J.F, (1953), Contact and Rubbing of Flat Surfaces, Journal of Applied Physics, 24, 981-988.

[3] Asthana, Abhishek, Abuhatira, A. and Alboueshi, A. Sheffield Hallam University Research. Tubing specifications selection and its effect on the results of hydraulic fracturing treatment in oil formations. 2016

[4] API 11AX, Specification for Subsurface Sucker Rod Pump Assemblies, Components, And Fittings, 12th Edition – 2006.

[5] API 11B, Standard Specification for Sucker Rod, Polishedrods and Liners, Couplings, Sinker Bars, Polished rod Clamps, Stuffing Boxes, and Pumping Tees, 2nd edition – 2010 API VT5, Wireline Operations and Procedures, 3rd Edition – 1994.

[6] Artificial Lift Services (Q2), Latch On-Off Tool Catalogue Lufkin Don-Nun On-Off Tool Catalogue.

[7] Cukup Mulyana, Aswad Hi Saa), Otong Nurhilal, M. Farhan Yusuf. Universitas Padjajaran. Penentuan Umur Sisa Pipa (Tube) Pada Pengilangan Minyak. 2015

[8] Hojjati, M.H., & Lukasiewicz, S.A. (2005). Modeling of sucker rod string. Journal of Canadian Petroleum Technology , 44(12): 55-58. DOI: 10.2118/05-1202.

[9] Jingyuan Li and Zifeng Li., 2013. Mechanical Analysis of Tubing String in Fracturing Operation, The Open Petroleum Engineering Journal, Petroleum Engineering Institute, Yanshan University, Qinhuangdao 066004, China

[10] Joseph Norman, Forty A&M LLC., O. Lynn Rowlan, Echometer Company., James N. McCoy, Echometer Company., Carrie Anne Taylor, Echometer Company (2016). “Tubing & Wellhead Integrity Pressure Test”

[11] McCoy J. N. , A. L. Podio, J. Jennings, and Bill Drake, “Motor Power, Current and Torque Analysis to Improve Efficiency of Beam Pumps,” Proceedings of the 39th Annual Meeting of the SWPSC, 1992

Attachment

Table 1 Basic Dimension ISO 724

BASIC DIMENSIONS

Dimensions in millimeters - Ref: ISO/R 724-1968

NOM. THREAD DIA.	PITCH P	MAJOR DIA. D d	PITCH DIA. D2 d2	MINOR DIA. D1 d1
M 0.3	0.08	0.300	0.248038	0.213397
M 0.35	0.09	0.350	0.291543	0.252572
M 0.4	0.1	0.400	0.335048	0.291747
M 0.45	0.1	0.450	0.385048	0.341747
M 0.5	0.125	0.500	0.418810	0.364684
M 0.55	0.125	0.550	0.468810	0.414684
M 0.6	0.15	0.600	0.502572	0.437620
M 0.7	0.175	0.700	0.586334	0.510557
M 0.8	0.2	0.800	0.670096	0.583494
M 0.9	0.225	0.900	0.753858	0.656430
M 1	0.25	1.000	0.837620	0.729367
	0.2		0.870096	0.783494
M 1.1	0.25	1.100	0.937620	0.829367
	0.2		0.970096	0.883494
M 1.2	0.25	1.200	1.037620	0.929367
	0.2		1.070096	0.983494
M 1.4	0.3	1.400	1.205144	1.075241
	0.2		1.270096	1.182494
M 1.6	0.35	1.600	1.372668	1.221114
	0.2		1.470096	1.383494
M 1.8	0.35	1.800	1.572668	1.421114
	0.2		1.670096	1.583494
M 2	0.4	2.000	1.740192	1.566987
	0.25		1.837620	1.729367
M 2.2	0.45	2.200	1.907716	1.712861
	0.25		2.037620	1.929367
M 2.5	0.45	2.500	2.207716	2.012861
	0.35		2.272668	2.121114
M 3	0.5	3.000	2.675240	2.458734
	0.35		2.772668	2.621114
M 3.5	0.6	3.500	3.110289	2.850481
	0.35		3.272668	3.121114
M 4	0.7	4.000	3.545337	3.242228
	0.5		3.675240	3.458734
M 4.5	0.75	4.500	4.012861	3.668101
	0.5		4.175240	3.958734
M 5	0.8	5.000	4.480385	4.133975
	0.5		4.675240	4.458734
M 5.5	0.5	5.500	5.175240	4.958734
M 6	1	6.000	5.350481	4.917468
	0.75		5.512861	5.188101
M 7	1	7.000	6.350481	5.917468
	0.75		6.512861	6.188101
M 8	1.25	8.000	7.188101	6.646835
	1		7.350481	6.917468
	0.75		7.512861	7.188101
M 9	1.25	9.000	8.188101	7.646835
	1		8.350481	7.917468
	0.75		8.512861	8.188101
M 10	1.5	10.000	9.025721	8.376202
	1.25		9.188101	8.646835
	1		9.350481	8.917468
	0.75		9.512861	9.188101
M 11	1.5	11.000	10.025721	9.376202
	1		10.350481	9.917468
	0.75		10.512861	10.188101
M 12	1.75	12.000	10.863342	10105569
	1.5		11.025721	10.376202
	1.25		11.188101	10.646835
	1		11.350481	10.917468
M 14	2	14.000	12.700962	11.834936
	1.5		13.025721	12.376202
	1.25		13.188101	12.646835
	1		13.350481	12.917468
M 15	1.5	15.000	14.025721	13.376202
	1		14.350481	13.917468
M 16	2	16.000	14.700962	13.834936
	1.5		15.025721	14.376202
	1		15.350481	14.917468
M 17	1.5	17.000	16.025721	15.376202
	1		16.350481	15.917468
M18	2.5	18.000	16.376202	15.293671
	2		16.700962	15.834936
	1.5		17.025721	16.376202
	1		17.350481	16.917468
M 20	2.5	20.000	18.376202	17.293671
	2		18.700962	17.834936
	1.5		19.025721	18.376202
	1		19.350481	18.917468
M 22	2.5	22.000	20.376202	19.293671
	2		20.700962	19.834936
	1.5		21.025721	20.376202
	1		21.350481	20.917468
M 24	3	24.000	22.051443	20.752405
	2		22.700962	21.834936
	1.5		23.025721	22.376202
	1		23.350481	22.917468
M 25	2	25.000	23.700962	22.834936
	1.5		24.025721	23.376202
	1		24.350481	23.917468
M 26	1.5	26.000	25.025721	24.376202
M 27	3	27.000	25.051443	23.752405
	2		25.700962	24.834936
	1.5		26.025721	25.376202
	1		26.350481	25.917468
M 28	2	28.000	26.700962	25.834936
	1.5		27.025721	26.376202
	1		27.350481	26.917468
M 30	3.5	30.000	27.726683	26.211139
	3		28.051443	26.752405
	2		28.700962	27.834936
	1.5		29.025721	28.379202
	1		29.350481	28.917468
M 32	2	32.000	30.700962	29.834936
	1.5		31.025721	30.376202
M 33	3.5	33.000	30.726683	29.211139
	3		31.051443	29.752405
	2		31.700962	30.834936
M 35	1.5	35.000	34.025721	33.376202
M 36	4	36.000	22.401924	31.669873
	3		34.051443	32.752405
	2		24.700962	33.834936
	1.5		35.025721	34.376202
M 38	1.5	38.000	37.025721	36.376202
M 39	4	39.000	36.401924	34.669873
	3		37.051443	35.752405
	2		37.700962	36.834936
	1.5		38.025721	37.376202
M 40	3	40.000	38.051443	36.752405
	2		38.700962	37.834936
	1.5		39.025721	38.376202
M 42	4.5	42.000	39.077164	37.128607
	4		39.401924	37.669873
	3		40.051443	38.752405
	2		40.700962	39.834936
	1.5		41.025721	40.376202
M 45	4.5	45.000	42.077164	40.128607
	4		42.401924	40.669873
	3		43.051443	41.752405
	2		43.700962	42.834936
	1.5		44.025721	43.376202
M 48	5	48.000	44.752405	42.587341
	4		45.401924	43.669873
	3		46.051443	44.752405
	2		46.700962	45.834936
	1.5		47.025721	46.376202
M 50	3	50.000	48.051443	46.752405
	2		48.700962	47.834936
	1.5		49.025721	48.376202
M 52	5	52.000	48.752405	46.587341
	4		49.401924	47.669873
	3		50.051443	48.752405
	2		50.700962	49.834936
	1.5		51.025721	50.376202
M 55	4	55.000	52.401924	50.669873
	3		53.051443	51.752405
	2		53.700962	52.834936
	1.5		54.025721	53.376202
M 56	5.5	56.000	52.427645	50.046075
	4		53.401924	51.669873
	3		54.051443	52.752405
	2		54.700962	53.834936
	1.5		55.025721	54.376202
M 58	4	58.000	55.401924	53.669873
	1.5		57.025721	56.367202
M 60	5.5	60.000	56.427645	54.046075
	1.5		59025721	58.376202
M 62	4	62.000	59.401924	57.669873
	1.5		61.025721	60.376202
M 64	6	64.000	60.102886	57.504809
	4		61.401924	59.669873
	3		62.051443	60.752405
	2		62.700962	61.834936
	1.5		62.025721	62.376202
M 65	4	65.000	62.401924	60.669873
	1.5		64.025721	63.376202
M 68	6	68.000	64.102886	61.504809
	1.5		67.025721	66.376202
M 70	6	70.000	66.102886	63.504809
	1.5		69.025721	68.376202
M 72	6	72.000	68.102886	65.504809
	4		69.401924	67.669873
	3		70.051443	68.752405
	2		70.700962	69.834936
	1.5		71.025721	70.376202
M 75	4	75.000	72.401924	70.669873
	1.5		74.025721	73.376202
M 76	6	76.000	72.102886	69.504809
	1.5		75.025721	74.376202
M 78	2	78.000	76.700962	75.834936
M 80	6	80.000	76.102886	73.504809
	4		77.401924	75.669873
	3		78.051443	76.752405
	2		78.700962	77.834936
	1.5		79.025721	78.376202
M 82	2	82.000	80.700962	79.834936
M 85	6	85.000	81.102886	78.504809
	2		83.700962	82.834936
M 90	6	90.000	86.102886	83.504809
	4		87.401924	85.669873
	3		88.051443	86.752405
	2		88.700962	87.834936
M 95	6	95.000	91.102886	88.504.809
M 100	6	100.000	96.102886	93.504809
	4		97.401924	95.669873
	3		98.051443	96.752405
	2		98.700962	97.834936
M 105	6	105.000	101.102886	98.504809
M 110	6	110.000	106.102886	103.504.809
	4		107.401924	105.669.873
	3		108.051443	106.752405
	2		108.700962	107.834936
M 115	6	115.000	111.102886	108.504809
M 120	6	120.000	116.102886	113.504809

10-1004

Table 4 Time Reduction for Two Plug Methods

Date	Well	Joint	Conventional Plug	Modified Plug	Time Difference (Conventional - Modified)		Percentage Reduction
			Hours	Hours	Hours	Day	
28-Jun-19	NDR-1	132	33.2	14.4	18.8	0.78	57%
13-Aug-19	NDR-2	200	50.0	21.0	29.0	1.21	58%
16-Dec-20	NDR-3	97	24.3	10.8	13.6	0.56	56%
20-Feb-21	NDR-4	79	19.8	8.9	10.9	0.45	55%
21-May-21	NDR-5	137	34.3	14.8	19.6	0.81	57%
28-Jun-22	NDR-6	133	33.4	14.5	19.0	0.79	57%

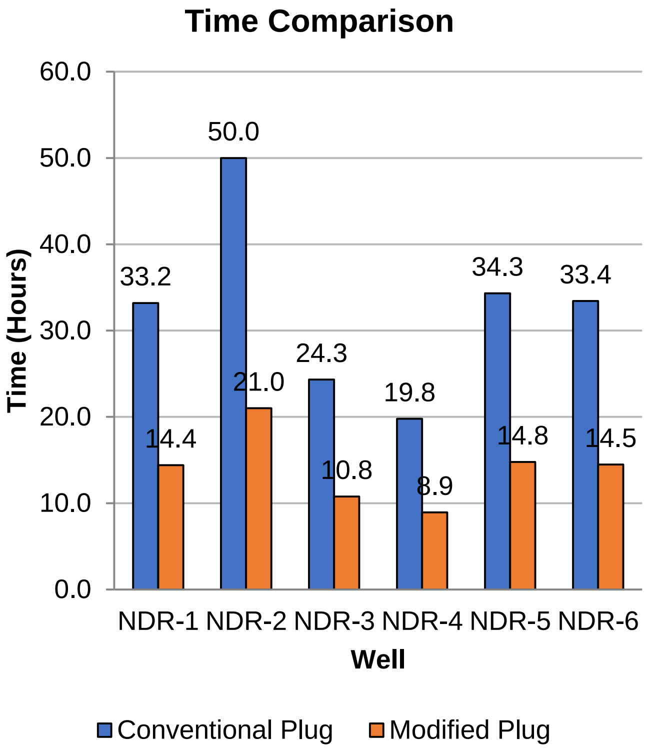

Figure 1.12 Time Comparision Between Plug Methods

Table 5. Economics Evaluation Of Modified Plug

Well	Time Difference	Rent Rig	Production Opportunity (loss)		Fuel	Total	Total Cost Modified Plug	Total Saving
	Days	USD/Days	Bbls	USD	USD	USD	USD	USD
NDR-1	0.78	$ 5,600	65	$ 4,364	$ 144	$ 8,875	$ 2,008	$ 70,476
NDR-2	1.21	$ 5,600	150	$ 15,622	$ 223	$ 22,620		
NDR-3	0.56	$ 5,600	143	$ 6,892	$ 103	$ 10,132		
NDR-4	0.45	$ 5,600	137	$ 5,306	$ 83	$ 7,909		
NDR-5	0.81	$ 5,600	134	$ 9,342	$ 149	$ 14,027		
NDR-6	0.79	$ 5,600	64	$ 4,352	$ 145	$ 8,921		

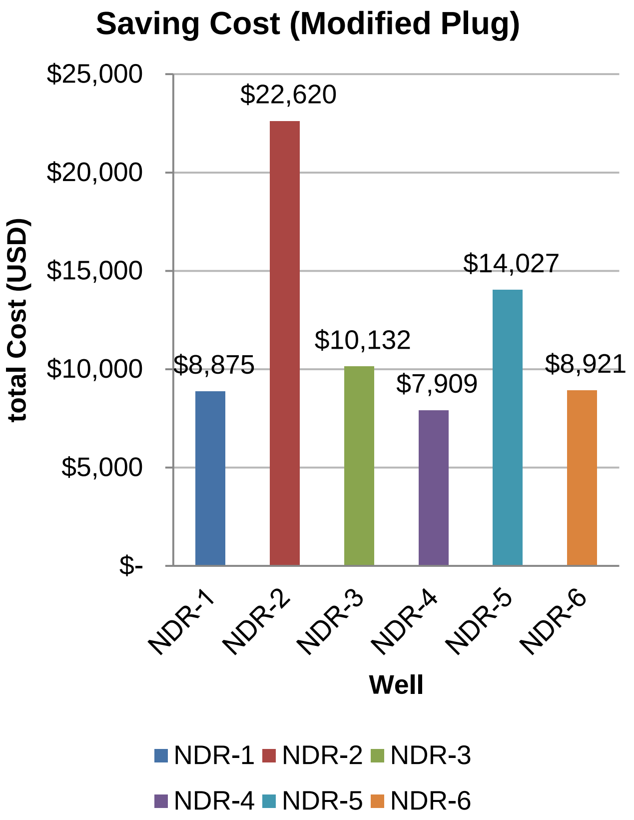

Figure 1.13 Saving Cost With Modified Plug