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Dissertation

AMIERUL REDZA BIN MOHD AFFENDI

Comparison Study For Stuck Pipe Detection Method.
Statistical Method & Current Method

Supervisor: Mr. Elias B. Abllah

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Statistical Method & Current Method

By

AMIERUL REDZA BIN MOHD AFFENDI

Dissertation submitted in partial fulfillment of

the requirements for the

Bachelor of Engineering (Hons)

(Petroleum Engineering)

AUGUST 2011

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approve by,

....

(Mr. Elias B Abllah)

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF ORIGINALITY

This is certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and the original work contained herein have not been undertaken or done by unspecified sources or person

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AMIERUL REDZA BIN MOHD AFFENDI

ABSTRACT

This report fundamentally discusses the preliminary research done and the basic understanding of the topic chosen, which is **comparison study for stuck pipe detection method, current method and statistical method.** Stuck pipe in the drilling industry results in hundreds of millions of dollars wasted because of the extra cost to fix the problem and the time delay of the operation. The occurrence of stuck pipe consists of drill pipe, casing, tubing and coiled tubing getting stuck downhole. Amongst the reason why the pipe get stuck is because of mud sticking, sand sticking , key seat sticking, stuck packers, crooked pipe and foreign object in hole. Technology at the moment allows detection of stuck pipe through various method and the method which will be compared to the statistical method for this study is where readings from pressure while drilling tools are read in a flow pattern and then with the experience and the knowledge of the engineer, he or she is will determine whether such occurrences will happen or not. The scope of study for this project covers 3 important parts, literature review, data gathering and analysis of data. The study begins with familiarizing with the theory behind the statistical method, followed by case study of previous tested wells. The study then is continued with familiarizing with the current method used and the gathering of data in order to compare the efficiency of the statistical method with the current method. The data obtained then will be use for the statistical method calculation and the results will then be compared with the results given by the current method.

ACKNOWLEDGEMENT

Upon the completion of this dissertation, I would like to first thank Allah S.W.T for giving me a second chance and the courage to continue on with this study after all that has happen. Special thank goes to thoughtful my supervisor Mr. Elias Abllah, for his patience and support throughout the completion of this study, along with his knowledge and guidance on matters which I was not familiar with. I would like to thank both my parents who have also been supportive. Without them, the time taken to complete this study might take even longer. They have always been there to support me emotionally and spiritually. My next thank goes to Mr. Rahimi Wahab and PCSB-DOMC Team. Without their assistance I would definitely not be able to complete this study. They have been very helpful during the process of acquiring the data and also during the analysis of data. Finally, I would like to thank my friends and colleagues who have always been there for me, cheering and supporting. I thank them all.

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CHAPTER 1

INTRODUCTION

1.1 Project Background:

The occurrences of stuck pipe in during drilling operation are highly unwanted. The situation results in millions of dollars spent on freeing the pipe in order to resume the operation. Worst comes to worst, the pipe and tools downhole needs to be abandon and a new side-track well are required to be drilled. Stuck pipe occurrences consist of drill pipe, casing, tubing and coiled tubing getting stuck down hole for many reasons. Amongst the common reasons it happen are:

Sand Sticking – Can occur with tubing, drill pipe or casing. Sand Sticking occurs when sands from a downhole sand zone leak into the well. When fluids does not circulate properly, wall cakes breaks down, drilling into depleted sand zones the chances for sand sticking increase.

Mechanical Sticking – There are several types of mechanical sticking such as:

- Stuck packers or other downhole assemblies
- Multiple strings (wrap around) – normally tubing
- Foreign object in hole

Key Seat Sticking – This occurs when different angles are present in a well. The pipe working around a corner or dog leg will cause the pipe to wear a groove in the side of the well bore.

Sloughing Sticking – This is a problem encountered in drilling through heaving shale or other formations that have a tendency to break off and fall in the bore hole. The formation lodges around tool joints, stabilizers or drill collars.

Differential Pressure Sticking – Pipe can get stuck in an open hole when the pipe string comes in contact with a permeable formation of lesser pressure than the hydrostatic pressure of the drilling fluid. In this situation, the differential pressure causes the pipe to be held against the wall in the lower pressure zone.

Cement Sticking – Cementing may cause stuck pipe when there is a mechanical malfunction, human error, a lost circulation problem or during cementing to contain a blowout. Pipe can become stuck during cementing due to human or mechanical error. Running the pipe into green cement is the most common issue that is encountered.

These types of stuck pipe can generally be divided into two groups, either stuck pipe that happens because of the unstable formations underneath (differential) or stuck pipe that happens because of mechanical failure.

1.2 Problem Statement:

In oil and gas industry, numerous amounts of tools and techniques have been developed in order to solve this problem. Some developers tackle on the most efficient method or technique or even tools to free the pipes once it happen while other developers head to the prevention method. In this paper, I would be focusing on the preventive method instead of the freeing the pipe after it has gotten stuck. Even though both are highly important, it is believe that prevention is better than cure. The current technology uses readings from Pressure While Drilling (PWD) tools to read the flow patterns of certain data from onshore office and notify the platform personnel of any problems which will occur beforehand while the statistical method will be able to notify without reading the patterns but once the readings reaches a certain value, notification can be done and action can be taken.

1.2.2 Significant of the Project:

The project will be a comparative study between the current method and the statistical method to detect the occurrences of stuck pipe. The main idea of the project is to measure the reliability of statistical method to detect such occurrences. It is also to strengthen the already available detection method of stuck pipe.

1.3 Objective:

The objectives of the project is to come up with a comparative analysis of two different method, the already available method which uses PWD tools data to detect irregularities inside the borehole and determining whether an occurrence of stuck pipe will happen or not with a statistical method way to detect the occurrence of stuck pipe through statistical method which uses the bottom hole or standpipe pressure and surface torque to determine such occurrences. At the end of this project, it will be determine whether the proposed method (statistical method) can be further develop to provide and strengthen the prevention methods available in regards to this problem.

1.4 Scope of Study:

The general scope of study for this comparative study is to understand what stuck pipe is, the types and why it occurs. From then on, we focus on the already available method which uses ECD, ESD and Drag to detect the occurrence of stuck pipe. The theories behind the usage of the data will be studied. The next focus will be on the statistical method, using BHP or SPP and TRQ as input for the detection of stuck pipe scheme. There will be equations which will be discuss later in the report, which will be use to detect the occurrence of stuck pipe.

1.5 Relevancy of Study:

This study is an early approach to the implementation of a method for the stuck pipe occurrences. In Oil and Gas Industry at the moment, most tools and techniques are developed in order to free the pipe instead of preventing it from happening. This study will analyze the efficiency of early detection of stuck pipe using statistical method. This project uses the information of wells in Malaysian region, which are mostly unconsolidated sandstone formation, which will enable the method to be applied for future usage when drilling in Malaysian region and also other formation which consists of mostly sandstones.

1.6 Feasibility Study

The Gantt chart prepared serves of how this study evolves and move through the end of project. Using actual field data, statistical method calculations were started in early May and comparative studies on both methods are currently ongoing. It is expected to be done in the middle of July.

CHAPTER 2

LITERATURE REVIEW

2.1 Bottom Hole Pressure and Torque

Bottom Hole Pressure – Pressure which is usually measured in pound per square inch (psi), at the bottom hole. This pressure may be calculated in a static, fluid-filled wellbore with the equation

BHP = MW * Depth * 0.052

Where MW is the mud weight in pounds per gallon, depth is true vertical depth in feet and 0.052 is the conversion factor if these units of measures are used.

Torque – The tendency of force to rotate an object (drill string) about an axis. Where torque can be calculated with the equation

$\text{Torque} = rF \sin \theta$

Where r is the length or magnitude of the lever arm vector, F is the magnitude of the force and θ is the angle between the force vector and lever arm vector

2.2 Fundamentals of Stuck Pipe

In order to understand further about stuck pipe, below are the type of stuck pipe occurrences.

Sand Sticking – Can occur with tubing, drill pipe or casing. Sand Sticking occurs when sands from a downhole sand zone leak into the well. When fluids does not circulate properly, wall cakes breaks down, drilling into depleted sand zones the chances for sand sticking increase.

Mud Sticking – This type is generally encountered with tubing in a cased hole and also occurs with drill pipe and casing. Mud stuck tubing occurs when well fluids on the back side of the pipe strings settles out. The settling causes the fluids to become thick and heavy which limits the pipes ability to move.

Mechanical Sticking – There are several types of mechanical sticking such as:

- Stuck packers or other downhole assemblies
- Multiple strings (wrap around) – normally tubing
- Foreign object in hole

Key Seat Sticking – This occurs when different angles are present in a well. The pipe working around a corner or dog leg will cause the pipe to wear a groove in the side of the well bore. Often this condition allows the pipe to travel a short distance to the next upset in the pipe. The upset is generally larger than the groove that is worn into the well bore and does not allow tool joint to pass.

Sloughing Hole Sticking – This is a problem encountered in drilling through heaving shale or other formations that have a tendency to break off and fall in the bore hole. The formation lodges around tool joints, stabilizers or drill collars.

Differential Pressure Sticking – Pipe can get stuck in an open hole when the pipe string comes in contact with a permeable formation of lesser pressure than the hydrostatic pressure of the drilling fluid. In this situation, the differential pressure causes the pipe to be held against the wall in the lower pressure zone.

Lost Circulation Sticking – This is an occurrence that normally react to hole sloughing or well blowouts. This sticking is caused when drilling into a depleted or lesser zone that breaks down when exposed to higher hydrostatic pressures. The loss of circulation does not allow the cuttings and sands to be circulated out of the hole. This causes the cuttings to pile up around the downhole assembly sticking the pipe.

The type of pipe stuck can be generally divided into two groups which are differential sticking and mechanical sticking as mention in the introduction. In order to fully utilize this application, data for wells drilled in the Malaysian region will be required. The data will be computed using multivariate statistical analysis to compute the type of stuck pipe which will occur.

2.3 Method of warning of Pipe Sticking During Drilling Operations

This is the statistical method which will be included in the comparative study. This method uses these steps to detect possible stuck pipe occurrences. The method of warning of the onset of pipe sticking in a rotary drilling operation using a drill string compromises of:

a) Monitoring the pressure of a drilling fluid being pumped through the drill string during drilling over predetermined periods of time to obtain series of pressure measurements

b) Monitoring the torque required to rotate the drill string during said periods to obtain series of torque measurements

c) Obtaining the skew (third moment) of each series of pressure measurements according to the relationship of

$$\text{skew} = \frac{1}{N}\,\Sigma[(xi - x\text{mean})/\sigma]^3,$$

Equation 1

wherein N is the number of pressure measurements xi in the series, xmean is the average value of the measurements in the series and σ is the standard deviation of the measurements in the series.

d) Obtaining the normalized standard deviation σn of the torque measurements in each corresponding series of torque measurements according to the relationship σn=(σ/ymean) wherein σ is the standard deviation of the measurements in the series and ymean is the average value of the measurements in the series.

e) Comparing skew and σn for the series so as to identify corresponding changes in both and raising an alarm when the magnitude of said changes pass predetermined alarm values.

The theory behind the method is using the measured or modeled bottom hole pressure and the surface torque as input to the detection of occurrence. If in any case that the bottom hole pressure is unavailable, standpipe pressure signal must be use as a replacement.

In probability theory, skew is a measure of asymmetry of the probability distribution of a real-valued random variable. For a time segment of N samples, the feature sample skew, F_1, can be defined as:

$$F_1 = \frac{\frac{1}{N}\sum_{i=1}^{N}(x_i-\mu)^3}{\left(\frac{1}{N}\sum_{i=1}^{N}(x_i-\mu)^2\right)^{3/2}} = \frac{\mu_3}{\sigma^3}.$$

Equation 2

Here, x_i is a sample within the time segment and μ is the mean value of the time segment..

The feature signal normalized standard deviation of the time segment torque signal F_2 is defined as:

$$F_2 = \frac{\sigma}{\mu}.$$

Equation 3

Here, σ is the standard deviation of the torque time segment and μ is the mean value. The normalized standard deviation provides a dimensionless quantity indicative of relatively large oscillations of the torque signal.

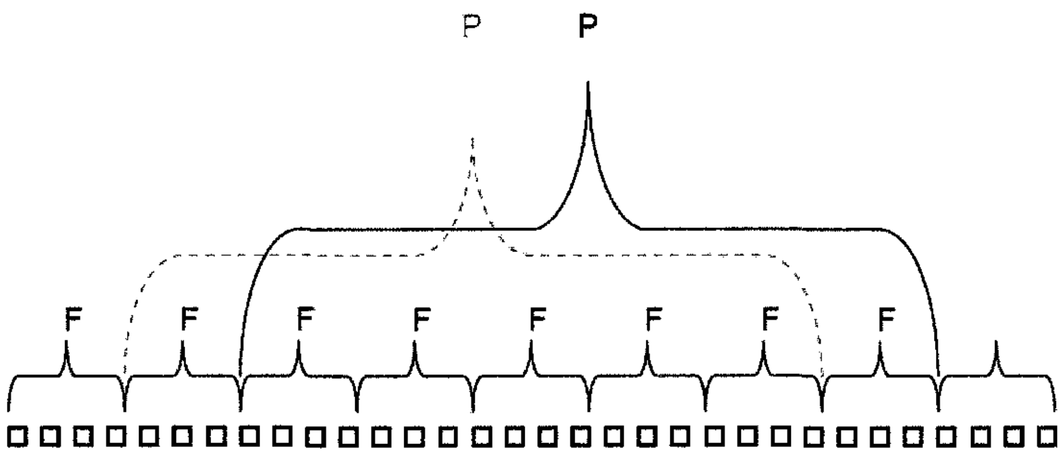

Figure 1: ***F*-values are calculated based on segments of length *N* (Source: Thor O. Gulsrud, Roar Nybø and Knut S. Bjørkevoll, *"Statistical Method for Detection of Poor Hole Cleaning and Stuck Pipe"*, Society of Petroleum Engineers, SPE 123374)**

The diagnosis is carried out using a sliding window of length W, passing over the F-values. The diagnostic signal is thus updated once every N samples. In this figure, $N = 4$ and $W = 6$.

Case Study

The statistical method were tested with data from two different wells before, all two wells are drilled in the North Sea area.

Well A

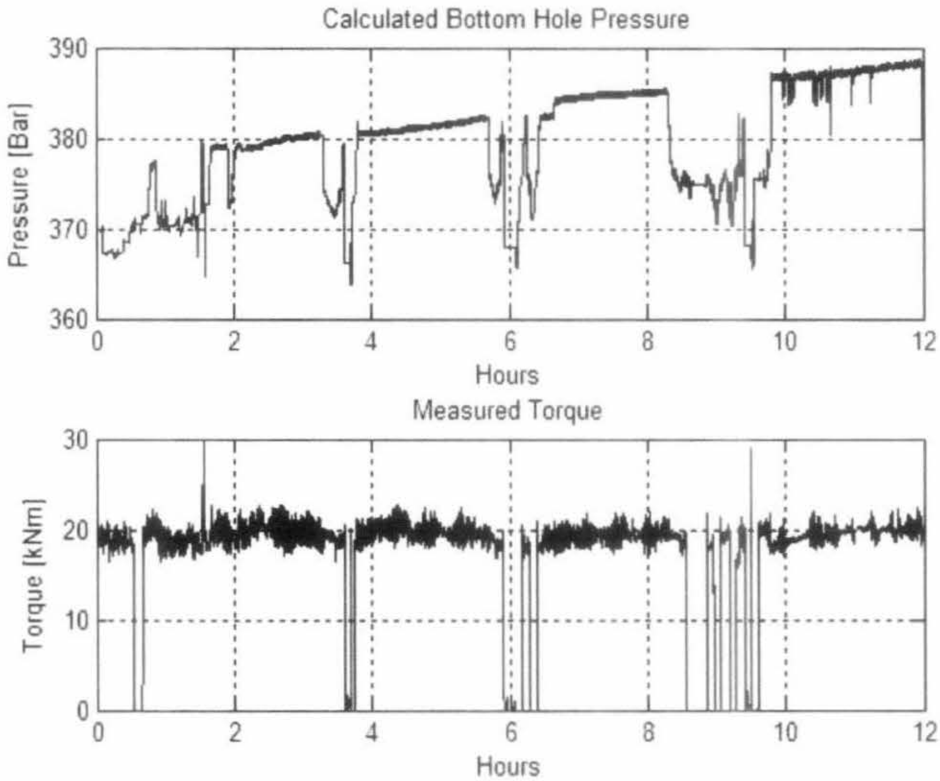

Figure 2: BHP signal and TRQ signal for well A (Source: Thor O. Gulsrud, Roar Nybø and Knut S. Bjørkevoll, *"Statistical Method for Detection of Poor Hole Cleaning and Stuck Pipe"*, Society of Petroleum Engineers, SPE 123374)

Figure above shows the calculated bottom hole pressure signal and the measured torque signal for twelve hours period. The borehole pressure signal drops significantly at about 3.25 hours, 5.67 hours and 8.33 hours. These drops are caused by circulating off bottom, i.e. the bit is lifted off the bottom while circulating in order to transport away the cuttings from the annulus.

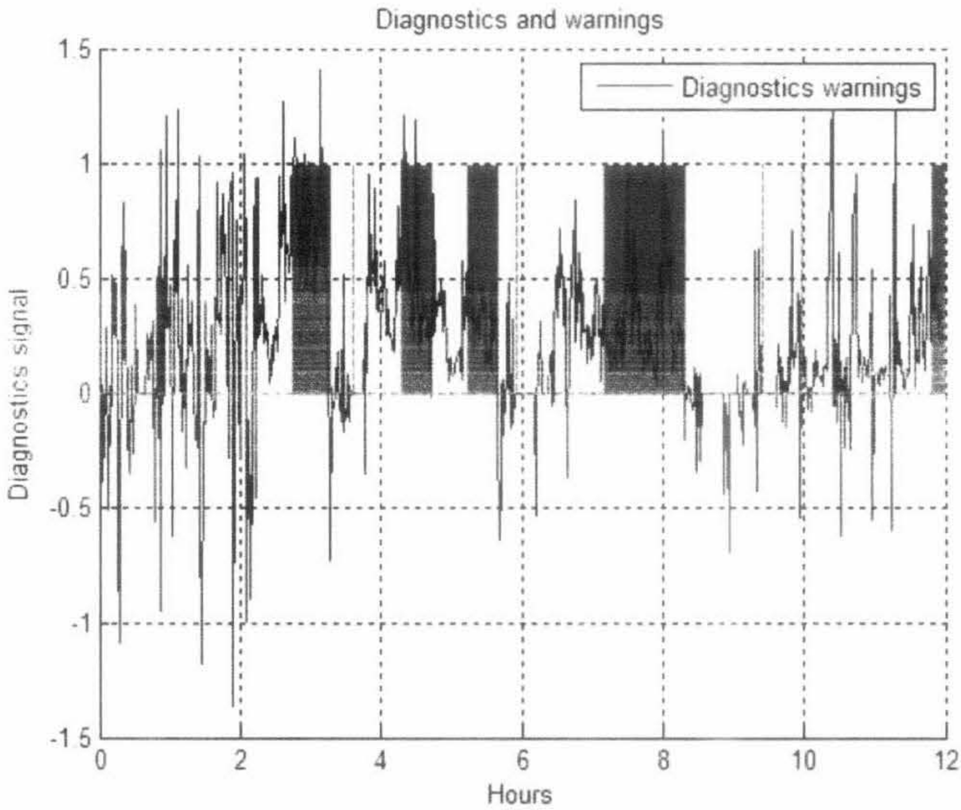

Figure 3: Diagnostics signal and warnings well A (Source: Thor O. Gulsrud, Roar Nybø and Knut S. Bjørkevoll, "Statistical Method for Detection of Poor Hole Cleaning and Stuck Pipe", Society of Petroleum Engineers, SPE 123374)

Figure above shows the diagnostics signal generated by using a segment N of size 12. An average sampling rate of the data from well A is 0.2 Hz, N=12 corresponds to 60 seconds. The warnings from the statistical method (red vertical lines) were generated by detecting the sign of the diagnostics signal samples using a moving time window, W, of size 30. The threshold values R_{th} and A_{th} were set to 1 and 0, respectively.

Well B

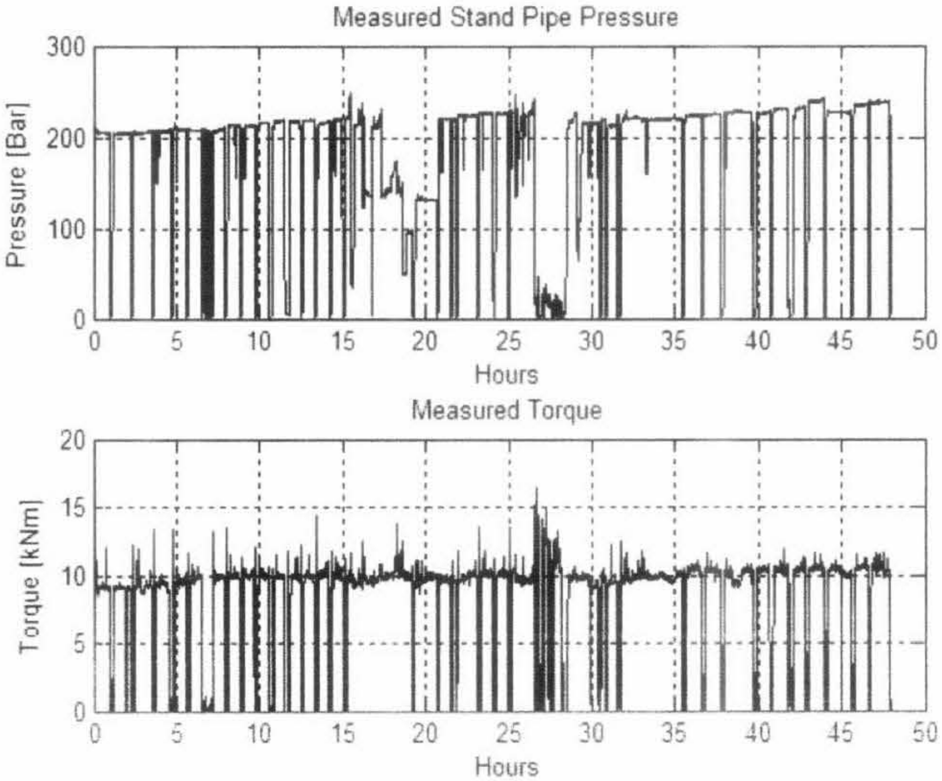

Figure 4: SPP signal and TRQ signal for well B (Source: Thor O. Gulsrud, Roar Nybø and Knut S. Bjørkevoll, "Statistical Method for Detection of Poor Hole Cleaning and Stuck Pipe", Society of Petroleum Engineers, SPE 123374)

As mention before, the borehole pressure signal is the preferred pressure signal as the stand pipe pressure signal may be influenced by wellbore mechanics unrelated to poor hole cleaning. However, the stand pipe pressure signal must be used if the bottom hole pressure signal is not available, which is the case for the present well. Figure above shows the measured stand pipe signal and the measured surface torque signal. The sampling rate of the data is 0.1 Hz. Note that there is a significant peak in the torque signal at 26-27 hours.

As previously mentioned, the sensitivity of the proposed method depends on the size of the parameters N and W. Obviously; N depends on the data sampling rate. In addition, sensitivity can be adjusted by the threshold value R_{th} and A_{th}. For the present case of the sensitivity parameters were found by trial-and-error and knowledge about the approximate position of the poor hole cleaning and stuck pipe incidents.

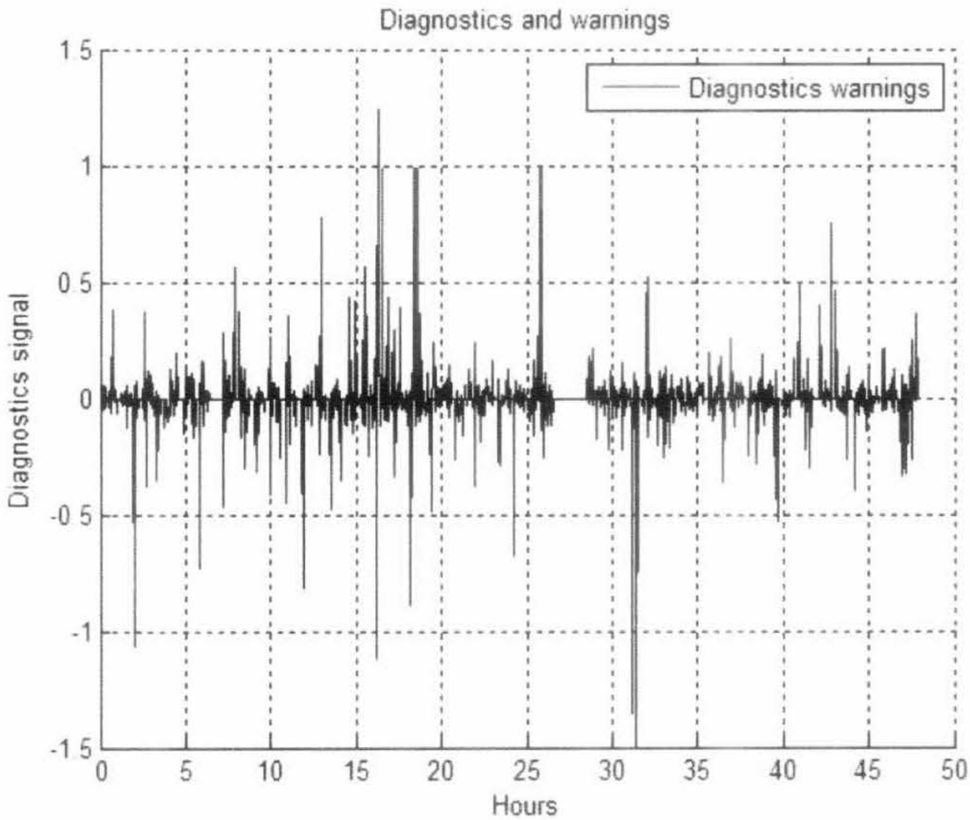

Figure 5: Diagnostic signal and warnings well B (Source: Thor O. Gulsrud, Roar Nybø and Knut S. Bjørkevoll, "Statistical Method for Detection of Poor Hole Cleaning and Stuck Pipe", Society of Petroleum Engineers, SPE 123374)

In figure above, the diagnostics signal and the generated warnings are shown. The size of the time segment N is twelve. The size of the moving time window is W=8. The threshold value R_{th} and A_{th} is 0.85 and 0.2 respectively, i.e. more than 85% of the diagnostics samples within W have to be positive and the maximum value of the samples has to be greater than 0.2 in order to raise a warning.

2.4 Pressure While Drilling System

Pressure while drilling (PWD) is a branch of measurement while drilling which uses more advanced tools. PWD is a better approach to optimize well construction of advanced wells for example, underbalanced drilling, extended wells, high angle wells, to name a few. PWD system is equipped with tools which can read the downhole pressure, Equivalent Circulating Density (ECD) monitoring and the detection of gas influxes which will lead to better drilling efficiency. PWD application has allowed improvement on drilling performance of Statfjord wells.

Statfjord Field

- Pressure depleted field
- Jurassic sandstone reservoir with occasional brittle coal layers (low fracture strength)
- Has a requirement where mud weight must not exceed collapse pressure of shales (figure below)
- Is a high-angle wells where it is critical to maintain ECD under safe operating limit
- An occasion if ECD is above safe operating limit, it will result in expensive lost circulation, differential sticking and pack off incidents
- PWD helps monitor real time downhole pressure instead of relying on pressure derived from predictive models
- This allows improvement on hydraulic information to control pressure related problem
- It also helps in optimizing drilling practices while getting to have a better understanding of the formation pressure constraints

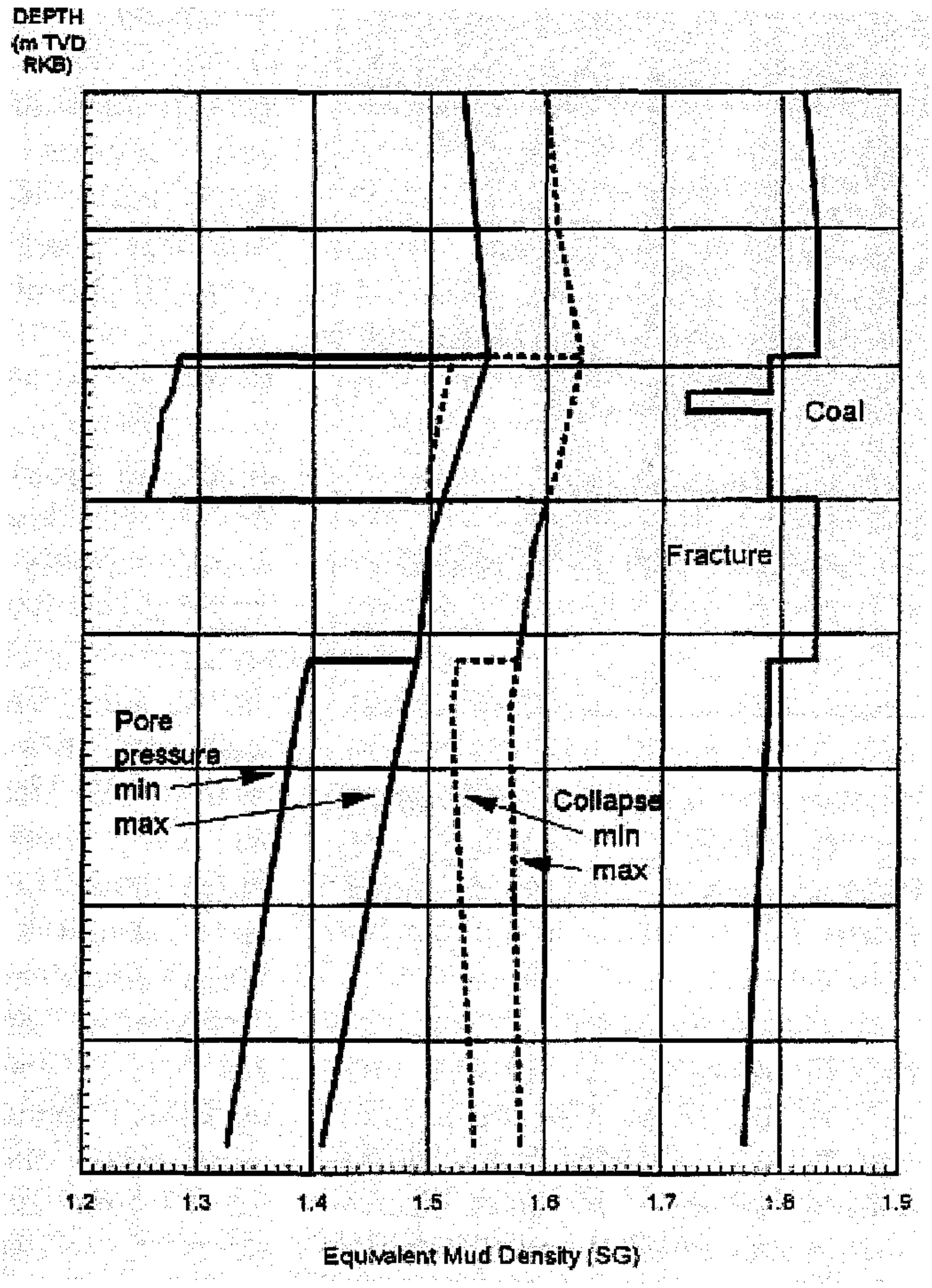

Figure 6: Borehole stability plot Statfjord(1997 Ward, C.D., and E. Andreassen)

2.5 Kumang F9-A1

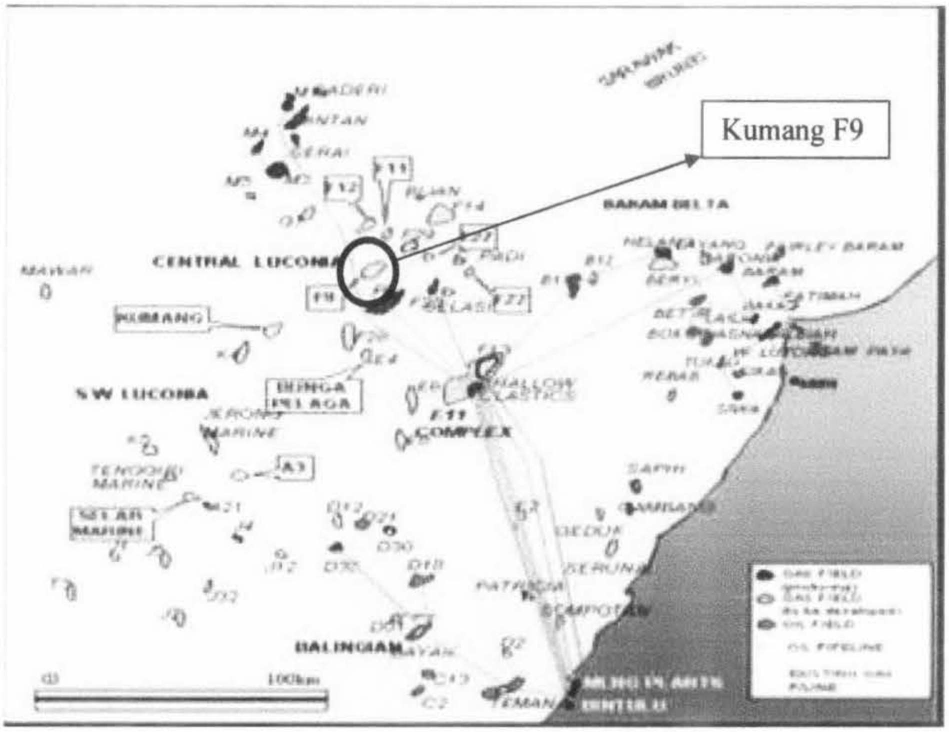

Figure 7: Kumang F9 location

Kumang F9 is a carbonate field. The field was discovered with appraisal well F9-1X in 1969 by then operator Sarawak Shell Berhad. Subsequent appraisal well was drilled in March 2001 to confirm the discovery of the field. Well F9-3 was drilled in October 2006 and the Gas Water Contact was confirmed at 1412m. Further reservoir test and calculation resulted in reservoir pressure at about 2240 psi.

The purpose of well F9-A1 is for appraisal of the carbonate reservoir characteristics while F9-A1ST1purpose is to drain the gas at the gas zones.

CHAPTER 3

METHODOLOGY

3.1 Research Methodology

In order to achieve the aim of the project, studies had been done on several resources from books, technical papers and internet. For the first step, gathering information needs to be done on the Stuck Pipe: Types, Causes and Preventions and also for the available methods of early detection of stuck pipe. Further analysis on PWD tools had also been done in order to come up with comparative analysis of the statistical method and the current method. For example, the theory behind the usage of ECD and drag to predict the occurrence of stuck pipe.

3.2 Project Activities

The project activities are shown in the figure below.

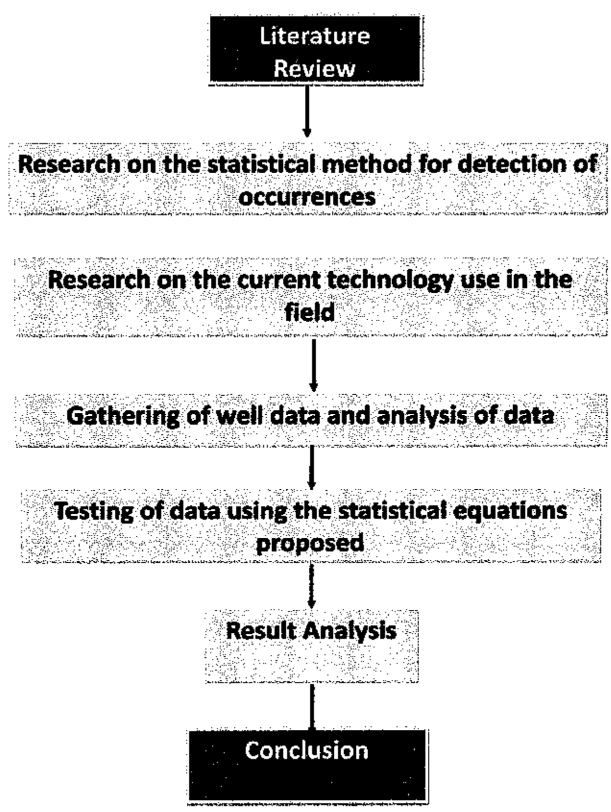

Figure 8: Project activities

3.3 Gantt Chart

The Gantt chart is the timeline for the project. It can be changed from time to time depending on certain circumstances. The Gantt chart is attached in the Appendix as Table 1.

Table 1: Gantt chart

		MAY	JUNE				JULY					AUGUST				SEPTEMBER		
No	**Activities /Week**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17 - 19**
1	Gathering data							MID-SEM BREAK									STUDY WEEK	EXAMINATION WEEK
2	Extraction and analysis of data																	
3	Comparison study																	
4	Progress Report Submission																	
	Pre-EDX																	
5	EDX																	
6	Final Oral Presentation																	
7	Delivery of Final Report to External Examiner																	
8	Submission of Hardbound Copies																	

Activities completed

Incoming activities

3.4 Statistical Method

The diagnostics signal is calculated within a moving time window of a selected size. Within this time window the sign of each diagnostics signal sample is detected and the ration of the number of positive samples to the total number of samples within the window is calculated. If the ration exceeds a given threshold a warning is generated. As a potential sticking problem is characterized by one-sided positive spikes in the diagnostics signal the selected threshold should be close to one. The proposed method can then be summarized as follows:

1. Collect vectors giving the bore hole pressure (or stand pipe pressure) and torque signal over a time segment of N samples.
2. Compute the skew, F_1 of each bore hole pressure (or stand pipe pressure) vector using Equation 2
3. Compute the normalized standard deviation, F_2 of each torque vector using Equation 3
4. Compute the diagnostics signal as the product of F_1 and F_2
5. Define the number, W of diagnostics value, F to be used in a moving time window implementation. The moving time window is to be updated with a new F value once every N samples (see Figure 1)
6. For every update of the moving time window, detect the number, P of positive diagnostics signal values within the window (see Figure 1)
7. For every update of the moving time window, compute the ratio $R=P/W$
8. For every signal update of the moving time window, detect the maximum amplitude, A_{max} of the positive diagnostics signal values within the window
9. For every update of the moving time window, raise a warning if ($R \geq R_{th}$) and ($A_{max} \geq A_{th}$), where R_{th} and A_{th} are predefined threshold values

Steps were taken from paper [Thor O. Gulsrud, Roar Nybø and Knut S. Bjørkevoll, *"Statistical Method for Detection of Poor Hole Cleaning and Stuck Pipe"*]

CHAPTER 4

RESULTS AND DISCUSSION

From the method discussed in the methodology, data was collected from stand pipe pressure and torque signal of 17 ½" section of Kumang F9-A1. For purpose of this experiment, N was set at 4. Using Equation 2 will give us the values for F_1 and Equation 3 will give us the value for F_2. Using Equation 4 below will give us the diagnostic signal, F.

$$F = F1 . F2$$

Equation 4

Once the value of the diagnostic signal for a time segment of N sample, repeat the calculation for the next set of SPP and TRQ data according to the amount of the moving time window, W where in this case, W was set at 6. For every moving time window, the number of positive diagnostic signal were counted and denoted as P. In every moving time window, we calculate the ratio of P over W which was denoted as R and the highest value of the diagnostic signal for every moving time window was taken note and recorded and denoted as Amax.

The method was tested with the data from 17 ½" Section of well Kumang F9-A1 Run 400 and Run 500. Run 400 begins at depth of 640m until 1505m and then Run 500 continues to be drilled until 1690m. For the purpose of this study, it was decided that the calculation will begin with data from Run 500 and then be continued with data from Run 400.

The mean value and the standard deviation value of both SPP and TRQ are at time segment of 4 samples, values below are the mean of each time sample. Actual data extracted will be included in the Appendix.

Calculations.

Run 500

Where N_{th} = 4 sample size

Table 2: Run 500 Stand pipe pressure, psi

Nth	Mean	μ_3	σ^3	F_1
1	2022.60	-19932.22	28126.58	-0.708661
2	1961.27	196.42	914.52	0.214775
3	1981.82	-370.39	508.31	-0.728673
4	1938.19	1123.37	77555.99	0.014485
5	1824.51	-185.15	347.24	-0.533210
6	1959.97	23.62	111.94	0.211047
7	2004.03	-91.53	7622.92	-0.012007
8	2311.76	103528.05	643730.46	0.160825
9	2230.93	0.01	0.16	0.058086
10	2233.81	-1.75	2.95	-0.591286
11	2215.45	-58784.45	51071.11	-1.151031
12	2228.99	-10734.21	9334.23	-1.149984
13	2218.96	-72589.85	66222.84	-1.096145
14	2262.31	-110.93	103.54	-1.071354
15	2625.10	-109978.79	99533.72	-1.104940
16	2621.30	-12764.36	47264.32	-0.270063
17	2657.89	-1.73	42.11	-0.040965
18	2641.89	-18900.71	19194.80	-0.984679
19	2641.23	-6072.55	7703.86	-0.788248
20	2649.25	-4306.27	5043.57	-0.853814
21	2648.18	-17928.28	18279.90	-0.980765
22	2636.71	-17643.68	15825.09	-1.114918
23	2650.31	-9991.13	14324.35	-0.697493
24	2688.14	-7867.56	87220.51	-0.090203
25	2735.77	1871.13	102469.96	0.018260
26	2713.39	4986.55	5160.72	0.966251
27	2726.48	-75.46	460.09	-0.164012
28	2701.12	18735.92	17378.66	1.078099
29	2690.85	95.35	463.86	0.205566
30	2649.20	11.04	1367.05	0.008074
31	2639.45	-37.89	95.11	-0.398375
32	2635.35	5.06	13.41	0.377667
33	2329.56	342683.97	298753.40	1.147046
34	2296.42	0.03	0.24	0.111822
35	2417.93	4016942.35	4136848.40	0.971015
36	2679.78	-229.44	408.29	-0.561943
37	2673.33	-19091.38	16770.62	-1.138382
38	2681.75	2.03	46.97	0.043117
39	2679.03	105.83	122.04	0.867165

40	2679.88	-477.52	4529.08	-0.105433

Using the equation for F_2, calculations were tabulated as below

Table 3: Run 500 Torque, kN.m

Nth	Standard Deviation, σ	Mean, μ	F_2
1	0.209376	7.001	0.029907
2	0.283758	7.331	0.038707
3	0.252659	7.857	0.032156
4	0.218733	7.986	0.027388
5	0.420181	7.723	0.054406
6	0.968963	7.999	0.121139
7	0.820949	8.415	0.097558
8	1.071806	8.699	0.123215
9	0.344164	9.832	0.035006
10	0.402843	9.251	0.043545
11	0.350012	9.738	0.035943
12	0.527649	10.514	0.050183
13	0.297551	10.233	0.029077
14	1.274542	10.132	0.125798
15	1.265111	9.723	0.130112
16	0.090748	10.598	0.008563
17	0.195688	10.549	0.018551
18	0.728412	9.808	0.074267
19	0.476923	9.506	0.050172
20	0.865946	9.562	0.090562
21	0.346909	9.115	0.038057
22	0.139153	8.962	0.015528
23	0.067718	9.070	0.007467
24	0.455158	9.532	0.047748
25	0.154588	9.513	0.016250
26	0.31443	9.745	0.032267
27	0.297286	9.634	0.030859
28	0.189796	9.818	0.019332
29	0.121661	9.543	0.012748
30	0.057591	9.275	0.006209
31	0.142445	9.722	0.014652
32	0.242777	9.731	0.024948
33	0.448556	9.653	0.046470
34	0.30494	10.460	0.029152
35	0.443345	10.366	0.042768
36	0.323444	10.587	0.030551
37	0.272735	10.908	0.025003
38	0.286194	10.027	0.028542
39	0.360356	10.677	0.033752
40	1.168392	12.006	0.097320

Using the equation of diagnostic signal, F was calculated for each N_{th} samples.

Table 4: Run 500 Diagnostic signal, F

N_{th}	F_1	F_2	Diagnostic Signal, F
1	-0.708661	0.029907	-0.021194
2	0.214775	0.038707	0.008313
3	-0.728673	0.032156	-0.023431
4	0.014485	0.027388	0.000397
5	-0.533210	0.054406	-0.029010
6	0.211047	0.121139	0.025566
7	-0.012007	0.097558	-0.001171
8	0.160825	0.123215	0.019816
9	0.058086	0.035006	0.002033
10	-0.591286	0.043545	-0.025748
11	-1.151031	0.035943	-0.041371
12	-1.149984	0.050183	-0.057710
13	-1.096145	0.029077	-0.031873
14	-1.071354	0.125798	-0.134774
15	-1.104940	0.130112	-0.143765
16	-0.270063	0.008563	-0.002312
17	-0.040965	0.018551	-0.000760
18	-0.984679	0.074267	-0.073129
19	-0.788248	0.050172	-0.039548
20	-0.853814	0.090562	-0.077323
21	-0.980765	0.038057	-0.037325
22	-1.114918	0.015528	-0.017312
23	-0.697493	0.007467	-0.005208
24	-0.090203	0.047748	-0.004307
25	0.018260	0.016250	0.000297
26	0.966251	0.032267	0.031178
27	-0.164012	0.030859	-0.005061
28	1.078099	0.019332	0.020842
29	0.205566	0.012748	0.002621
30	0.008074	0.006209	0.000050
31	-0.398375	0.014652	-0.005837
32	0.377667	0.024948	0.009422
33	1.147046	0.046470	0.053303
34	0.111822	0.029152	0.003260
35	0.971015	0.042768	0.041529
36	-0.561943	0.030551	-0.017168
37	-1.138382	0.025003	-0.028463
38	0.043117	0.028542	0.001231
39	0.867165	0.033752	0.029269
40	-0.105433	0.097320	-0.010261

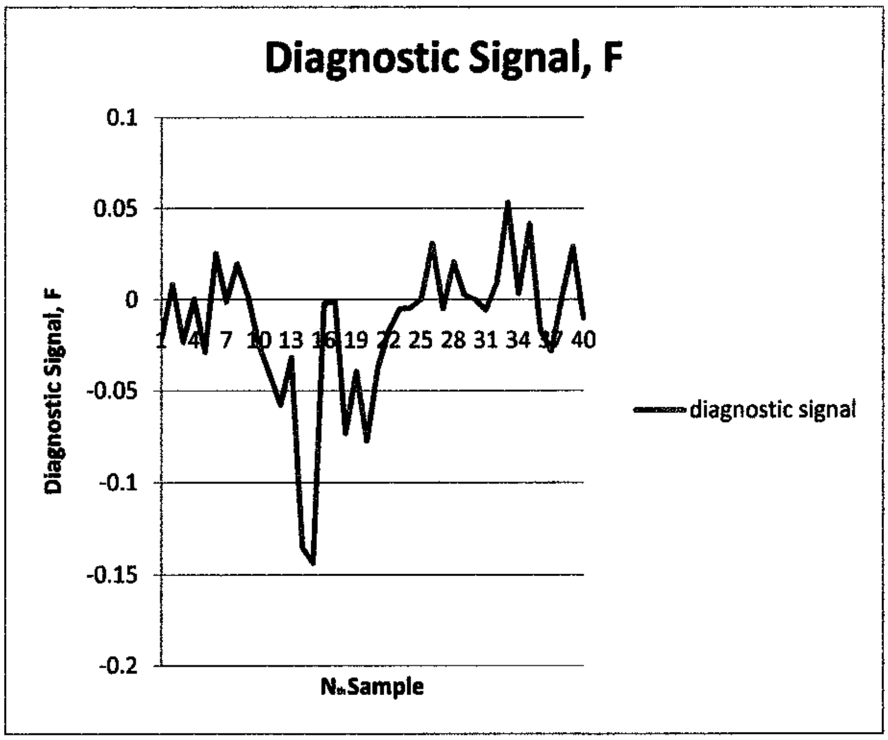

Figure 9: Graph of Diagnostic signal Run 500

The number of positive diagnostic signal in the moving time window was tabulated, along with the ratio where we set W=6, and the value of the highest positive diagnostic signal for each moving time window were tabulated as well.

Table 5: Run 500 P, R and A_{max} value

Window	No. of Positive Diagnostic Signal, P	Ratio of P/W, R	Highest P, A_{max}
1	3	0.500000	0.025566
2	3	0.500000	0.025566
3	3	0.500000	0.025566
4	3	0.500000	0.025566
5	3	0.000000	0.025566
6	3	0.000000	0.025566
7	2	0.083333	0.019816
8	2	0.083333	0.019816
9	1	0.166667	0.002033
10	0	0.000000	-0.025748
11	0	0.000000	-0.031873
12	0	0.000000	-0.000760
13	0	0.000000	-0.000760
14	0	0.000000	-0.000760
15	0	0.000000	-0.000760
16	0	0.000000	-0.000760
17	0	0.000000	-0.000760
18	0	0.000000	-0.005208
19	0	0.000000	-0.004307
20	1	0.166667	0.000297
21	2	0.333333	0.031178
22	2	0.333333	0.031178
23	3	0.500000	0.031178
24	4	0.666667	0.031178
25	5	0.833333	0.031178
26	4	0.666667	0.031178
27	4	0.666667	0.020842
28	4	0.666667	0.053303
29	5	0.833333	0.053303
30	5	0.833333	0.053303
31	4	0.666667	0.053303
32	4	0.666667	0.053303
33	4	0.666667	0.053303
34	4	0.666667	0.041529
35	3	0.500000	0.041529

The threshold values are set at at R_{th}=0.5 and A_{th}=0. In order for an alarm or notification to be raise, the value for $R \geq R_{th}$ and $A_{max} \geq A_{th}$.

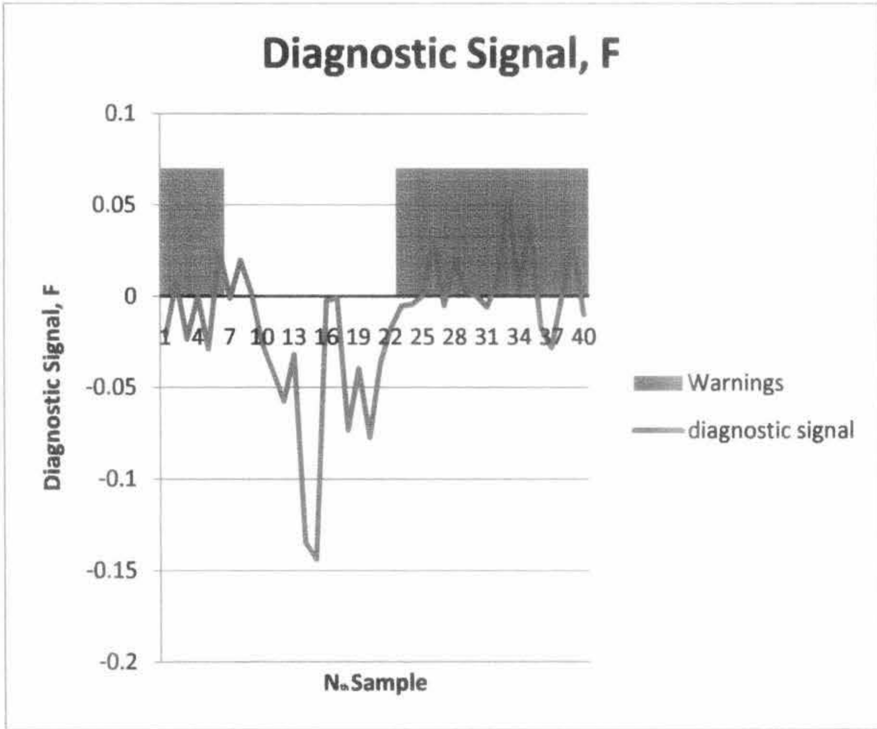

Figure 10: Diagnostic signal & warnings Run 500

Based on the calculations done, warning should be alarmed at the area where it is shaded in red. Comparing it with the results from the current method of detection, it was detected that at depth 1530m which is at the beginning of Window 1 of Run 500 there has already been an increase of ECD. The mud weight at that time was 11.5ppg while the equivalent static density was read at 12.1ppg. That indicates the possibility of cutting loading inside the annulus. At depth 1620m which is the beginning of Window 23, there was also increment of the ECD from the mud weight used. From the report, it was stated that at the end of Run 500, well Kumang F9-A1experienced stuck pipe incident when they tried to pull back the borehole assembly during back reaming. This shows that the statistical method is able to detect an occurrence of stuck pipe before it happen. In this Run 500, the platform personnel neglected the advice from the drilling optimization team onshore about the increment of ECD and continue drilling instead of stop drilling operation and circulate cutting loading down at the borehole. From this case, it could have been possible to avoid it if method such as the statistical method is presence at the platform. It can strengthen the claim of the drilling optimization team from onshore and the losses could have been avoided.

Run 400

N_{th} = 4 sample size, W = 6 time window

Table 6: Run 400 Diagnostic signal, F

N_{th}	F_1	F_2	Diagnostic Signal, F
1	-0.952533	1.189417	-1.132959
2	-0.198546	0.023643	-0.004694
3	-1.092091	0.018082	-0.019747
4	-1.154534	0.045193	-0.052177
5	-0.991455	0.067158	-0.066584
6	0.074433	0.052294	0.003892
7	0.617107	0.054145	0.033413
8	-1.095823	0.149236	-0.163536
9	-0.942482	0.076143	-0.071764
10	0.210092	0.052090	0.010944
11	0.222301	0.021545	0.004789
12	-1.074854	0.052187	-0.056094
13	0.844692	0.074850	0.063225
14	-0.107907	0.045667	-0.004928
15	-1.138933	0.044174	-0.050312
16	-0.091422	0.021588	-0.001974
17	0.272384	0.116645	0.031772
18	-0.987966	0.050765	-0.050154
19	-0.242684	0.091972	-0.022320
20	1.075765	0.068558	0.073752
21	0.034326	0.062740	0.002154
22	0.534792	0.025142	0.013446
23	-0.953006	0.147802	-0.140856
24	-1.013453	0.052648	-0.053356
25	-0.003429	0.007172	-0.000025
26	-1.135389	0.028548	-0.032413
27	-0.218057	0.034966	-0.007625
28	-1.127540	0.015776	-0.017788
29	-0.840415	0.038654	-0.032486
30	0.555528	0.034089	0.018937
31	0.019471	0.021176	0.000412
32	0.408768	0.017294	0.007069
33	-0.146777	0.015169	-0.002227
34	-0.169945	0.031058	-0.005278
35	-1.061995	0.007985	-0.008481
36	-0.839825	0.010299	-0.008649
37	-0.012327	0.069074	-0.000851
38	-0.258164	0.035573	-0.009184
39	-0.963847	0.010074	-0.009710
40	-0.513827	0.015602	-0.008017

N_{th}	F_1	F_2	Diagnostic Signal, F
41	-1.152303	0.010422	-0.012009
42	-0.533767	0.014773	-0.007886
43	0.091815	0.016994	0.001560
44	0.345001	0.068475	0.023624
45	-1.120727	0.016615	-0.018621
46	-0.125491	0.014537	-0.001824
47	-1.046890	0.009047	-0.009471
48	-1.153116	0.021705	-0.025028
49	-0.382883	0.054677	-0.020935
50	-0.133982	0.023619	-0.003164
51	-0.576084	0.053997	-0.031107
52	0.463046	0.139222	0.064466
53	-0.821191	0.044774	-0.036768
54	-1.150087	0.022247	-0.025586
55	-0.229788	0.023391	-0.005375
56	-0.139612	0.008512	-0.001188
57	0.831068	0.011439	0.009507
58	-0.703166	0.011029	-0.007755
59	-0.565300	0.066243	-0.037447
60	-0.000189	0.012240	-0.000002
61	0.812366	0.010868	0.008829
62	-1.014818	0.020736	-0.021043
63	-0.434831	0.006762	-0.002940
64	-1.028571	0.010737	-0.011043
65	-1.093848	0.014341	-0.015687
66	-0.466469	0.035468	-0.016545
67	0.039254	0.009074	0.000356
68	-1.125268	0.021067	-0.023706
69	-1.098795	0.010201	-0.011209
70	-0.049984	0.020575	-0.001028
71	0.363319	0.017546	0.006375
72	0.001319	0.008765	0.000012
73	0.314071	0.021897	0.006877
74	1.046204	0.033929	0.035497
75	-0.641707	0.033412	-0.021440
76	-1.145874	0.008611	-0.009867
77	-0.872181	0.024427	-0.021305
78	-1.146278	0.011709	-0.013422
79	-0.677336	0.030224	-0.020472
80	-1.118763	0.081504	-0.091183
81	0.089675	0.008741	0.000784
82	-1.040862	0.028429	-0.029590
83	-0.014888	0.043645	-0.000650
84	-0.594758	0.018716	-0.011131

N_{th}	F_1	F_2	Diagnostic Signal, F
85	-0.177848	0.005946	-0.001057
86	1.002807	0.012654	0.012690
87	-1.135031	0.064408	-0.073105
88	-0.161612	0.034722	-0.005612
89	0.230302	0.029853	0.006875
90	0.405025	0.015660	0.006343
91	-0.383592	0.020188	-0.007744
92	0.053775	0.030062	0.001617
93	0.045707	0.043951	0.002009
94	0.023109	0.025179	0.000582
95	0.698558	0.024995	0.017461
96	-1.046158	0.030027	-0.031413
97	-1.018783	0.061493	-0.062649
98	-1.112044	0.033945	-0.037748
99	-0.466384	0.036386	-0.016970
100	-0.280400	0.025593	-0.007176
101	0.098307	0.048248	0.004743
102	-0.407005	0.034157	-0.013902
103	0.730692	0.023666	0.017292
104	0.864370	0.035895	0.031027
105	-0.008944	0.050482	-0.000452
106	0.353404	0.047519	0.016793
107	-0.436985	0.004231	-0.001849
108	0.773503	0.014730	0.011394
109	-0.892918	0.034573	-0.030871
110	-1.140308	0.033092	-0.037735
111	0.216018	0.023603	0.005099
112	0.541345	0.012615	0.006829
113	-0.138959	0.109971	-0.015281
114	-1.047333	0.023309	-0.024412
115	-0.064469	0.062918	-0.004056
116	0.184161	0.088213	0.016245
117	-1.028742	0.044839	-0.046128
118	-0.909456	0.021014	-0.019111
119	-1.152211	0.026531	-0.030570
120	-0.377264	0.038904	-0.014677
121	-1.154602	0.048395	-0.055877
122	0.697811	0.013866	0.009676
123	-0.047992	0.007414	-0.000356
124	-0.661908	0.016684	-0.011043
125	0.019108	0.023561	0.000450
126	-0.905762	0.118673	-0.107490
127	0.798029	0.054772	0.043710
128	-1.106013	0.048851	-0.054030

N_{th}	F_1	F_2	Diagnostic Signal, F
129	-1.144788	0.039034	-0.044685
130	-0.711830	0.019553	-0.013918
131	-0.994214	0.077289	-0.076842
132	1.010906	0.045147	0.045639
133	-0.243444	0.052859	-0.012868
134	-0.786308	0.066435	-0.052239
135	0.474883	0.179339	0.085165
136	0.632957	0.035800	0.022660
137	-0.162955	0.036783	-0.005994
138	0.060042	0.100507	0.006035
139	-1.142063	0.024086	-0.027508
140	0.215553	0.025415	0.005478
141	-0.501375	0.020339	-0.010197
142	-0.006035	0.030685	-0.000185
143	-0.010711	0.025010	-0.000268
144	1.106440	0.059763	0.066124
145	-0.613493	0.027767	-0.017035
146	0.629195	0.024591	0.015472
147	-0.843300	0.012764	-0.010764
148	-0.092281	0.001160	-0.000107
149	-0.902705	0.020564	-0.018564
150	0.962973	0.024657	0.023744
151	0.009548	0.023105	0.000221
152	1.038093	0.093355	0.096911
153	-0.090970	0.032336	-0.002942
154	-0.593361	0.086571	-0.051368
155	0.486777	0.052176	0.025398
156	0.792597	0.266433	0.211174
157	-0.570481	0.201337	-0.114859
158	0.401100	0.022371	0.008973
159	-0.148431	0.061546	-0.009135
160	-1.078874	0.104111	-0.112322
161	0.876262	0.125969	0.110382
162	0.353862	0.116792	0.041328
163	-0.006044	0.127144	-0.000768
164	-1.053458	0.122520	-0.129070
165	-0.804359	0.076579	-0.061597
166	0.002796	0.051236	0.000143
167	-0.657225	0.087759	-0.057677
168	-0.492619	0.009430	-0.004645
169	1.095476	0.058069	0.063613
170	-0.375539	0.017286	-0.006492
171	0.295952	0.033285	0.009851
172	-0.119288	0.058065	-0.006926

N_{th}	F_1	F_2	Diagnostic Signal, F
173	0.566280	0.024524	0.013887
174	0.111775	0.192085	0.021470
175	-1.094132	0.035643	-0.038998
176	-1.152136	0.019296	-0.022232
177	-0.832639	0.048570	-0.040441
178	-0.011731	0.007318	-0.000086
179	-0.537250	0.038367	-0.020613
180	-0.885052	0.020158	-0.017841
181	0.342247	0.026848	0.009189
182	-0.669899	0.025062	-0.016789
183	-0.540729	0.012297	-0.006649
184	-0.958983	0.039101	-0.037497
185	-0.059806	0.042928	-0.002567
186	-0.538607	0.017690	-0.009528
187	0.090847	0.063163	0.005738
188	0.069151	0.012755	0.000882
189	0.376557	0.015010	0.005652
190	0.279440	0.063832	0.017837
191	-0.506659	0.040751	-0.020647
192	0.500546	0.014556	0.007286
193	0.035749	0.053059	0.001897
194	-0.664641	0.026365	-0.017523
195	-0.082398	0.028910	-0.002382

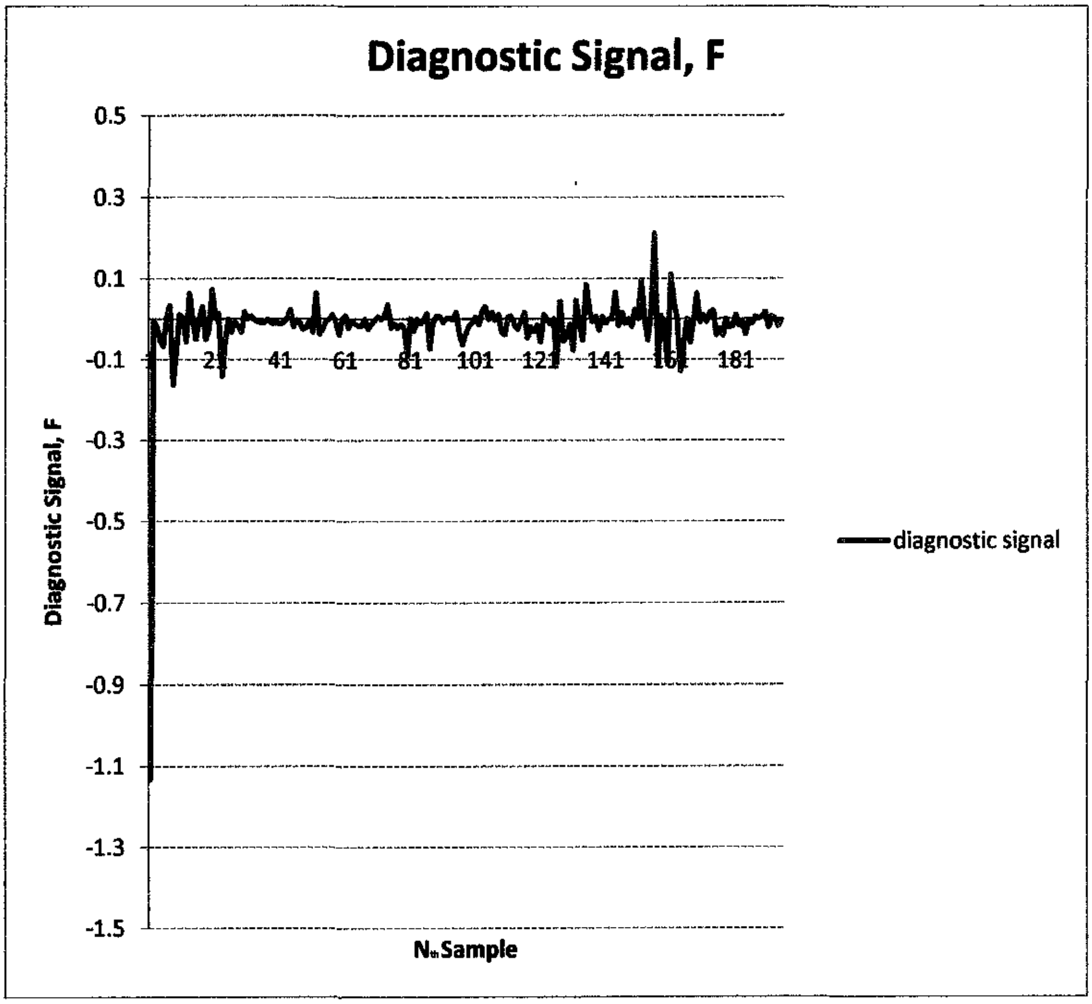

Figure 11: Graph of Diagnostic signal Run 400

Ratio of Positive Spike over time window, Maximum positive spike in time window

Table 7: Run 400 P, R and A_{max} value

Window	No. of Positive Diagnostic Signal, P	Ratio of P/W	Highest P, A_{max}
1	1	0.166667	0.003892438
2	2	0.333333	0.033413182
3	2	0.333333	0.033413182
4	2	0.333333	0.033413182
5	3	0.500000	0.0334132
6	4	0.666667	0.0334132
7	3	0.500000	0.0334132
8	3	0.500000	0.0632251
9	3	0.500000	0.0632251
10	3	0.500000	0.0632251
11	2	0.333333	0.0632251
12	2	0.333333	0.0632251
13	2	0.333333	0.063225
14	1	0.166667	0.031772
15	2	0.333333	0.073752
16	3	0.500000	0.073752
17	4	0.666667	0.073752
18	3	0.500000	0.073752
19	3	0.500000	0.073752
20	3	0.500000	0.073752
21	2	0.333333	0.013446
22	1	0.166667	0.013446
23	0	0.000000	-0.000025
24	0	0.000000	-0.000025
25	1	0.166667	0.018937
26	2	0.333333	0.018937
27	3	0.500000	0.018937
28	3	0.500000	0.018937
29	3	0.500000	0.018937
30	3	0.500000	0.018937
31	2	0.333333	0.007069
32	1	0.166667	0.007069
33	0	0.000000	-0.000851
34	0	0.000000	-0.000851
35	0	0.000000	-0.000851
36	0	0.000000	-0.000851
37	0	0.000000	-0.000851
38	0	0.000000	0.001560
39	0	0.000000	0.023624
40	0	0.000000	0.023624
41	0	0.000000	0.023624

Window	No. of Positive Diagnostic Signal, P	Ratio of P/W	Highest P, A_{max}
42	0	0.000000	0.023624
43	0	0.000000	0.023624
44	0	0.000000	0.023624
45	0	0.000000	-0.001824
46	0	0.000000	-0.001824
47	1	0.166667	0.064466
48	1	0.166667	0.064466
49	1	0.166667	0.064466
50	1	0.166667	0.064466
51	1	0.166667	0.064466
52	2	0.333333	0.064466
53	1	0.166667	0.009507
54	1	0.166667	0.009507
55	1	0.166667	0.009507
56	2	0.333333	0.009507
57	2	0.333333	0.009507
58	1	0.166667	0.008829
59	1	0.166667	0.008829
60	1	0.166667	0.008829
61	1	0.166667	0.008829
62	1	0.166667	0.000356
63	1	0.166667	0.000356
64	1	0.166667	0.000356
65	1	0.166667	0.000356
66	2	0.333333	0.006375
67	3	0.500000	0.006375
68	3	0.500000	0.006877
69	4	0.666667	0.035497
70	4	0.666667	0.035497
71	4	0.666667	0.035497
72	3	0.500000	0.035497
73	2	0.333333	0.035497
74	1	0.166667	0.035497
75	0	0.000000	-0.009867
76	1	0.166667	0.000784
77	1	0.166667	0.000784
78	1	0.166667	0.000784
79	1	0.166667	0.000784
80	1	0.166667	0.000784
81	2	0.333333	0.012690
82	1	0.166667	0.012690
83	1	0.166667	0.012690
84	2	0.333333	0.012690
85	3	0.500000	0.012690

Window	No. of Positive Diagnostic Signal, P	Ratio of P/W	Highest P, A_{max}
86	3	0.500000	0.012690
87	3	0.500000	0.006875
88	4	0.666667	0.006875
89	5	0.833333	0.006875
90	5	0.833333	0.017461
91	4	0.666667	0.017461
92	4	0.666667	0.017461
93	3	0.500000	0.017461
94	2	0.333333	0.017461
95	1	0.166667	0.017461
96	1	0.166667	0.004743
97	1	0.166667	0.004743
98	2	0.333333	0.017292
99	3	0.500000	0.031027
100	3	0.500000	0.031027
101	4	0.666667	0.031027
102	3	0.500000	0.031027
103	4	0.666667	0.031027
104	3	0.500000	0.031027
105	2	0.333333	0.016793
106	3	0.500000	0.016793
107	3	0.500000	0.011394
108	3	0.500000	0.011394
109	2	0.333333	0.006829
110	2	0.333333	0.006829
111	3	0.500000	0.016245
112	2	0.333333	0.016245
113	1	0.166667	0.016245
114	1	0.166667	0.016245
115	1	0.166667	0.016245
116	1	0.166667	0.016245
117	1	0.166667	0.009676
118	1	0.166667	0.009676
119	1	0.166667	0.009676
120	2	0.333333	0.009676
121	2	0.333333	0.009676
122	3	0.500000	0.043710
123	2	0.333333	0.043710
124	2	0.333333	0.043710
125	2	0.333333	0.043710
126	1	0.166667	0.043710
127	2	0.333333	0.045639
128	1	0.166667	0.045639
129	1	0.166667	0.045639

Window	No. of Positive Diagnostic Signal, P	Ratio of P/W	Highest P, A_{max}
130	2	0.333333	0.085165
131	3	0.500000	0.085165
132	3	0.500000	0.085165
133	3	0.500000	0.085165
134	3	0.500000	0.085165
135	4	0.666667	0.085165
136	3	0.500000	0.022660
137	2	0.333333	0.006035
138	2	0.333333	0.006035
139	2	0.333333	0.066124
140	2	0.333333	0.066124
141	2	0.333333	0.066124
142	2	0.333333	0.066124
143	2	0.333333	0.066124
144	2	0.333333	0.066124
145	2	0.333333	0.023744
146	3	0.500000	0.023744
147	3	0.500000	0.096911
148	3	0.500000	0.096911
149	3	0.500000	0.096911
150	4	0.666667	0.096911
151	4	0.666667	0.211174
152	3	0.500000	0.211174
153	3	0.500000	0.211174
154	3	0.500000	0.211174
155	3	0.500000	0.211174
156	3	0.500000	0.211174
157	3	0.500000	0.110382
158	3	0.500000	0.110382
159	2	0.333333	0.110382
160	2	0.333333	0.110382
161	3	0.500000	0.110382
162	2	0.333333	0.041328
163	1	0.166667	0.000143
164	2	0.333333	0.063613
165	2	0.333333	0.063613
166	3	0.500000	0.063613
167	2	0.333333	0.063613
168	3	0.500000	0.063613
169	4	0.666667	0.063613
170	3	0.500000	0.021470
171	3	0.500000	0.021470
172	2	0.333333	0.021470
173	2	0.333333	0.021470

Window	No. of Positive Diagnostic Signal, P	Ratio of P/W	Highest P, A_{max}
174	1	0.166667	0.021470
175	0	0.000000	-0.000086
176	1	0.166667	0.009189
177	1	0.166667	0.009189
178	1	0.166667	0.009189
179	1	0.166667	0.009189
180	1	0.166667	0.009189
181	1	0.166667	0.009189
182	1	0.166667	0.005738
183	2	0.333333	0.005738
184	3	0.500000	0.005738
185	4	0.666667	0.017837
186	4	0.666667	0.017837
187	5	0.833333	0.017837
188	5	0.833333	0.017837
189	4	0.666667	0.017837
190	3	0.500000	0.017837

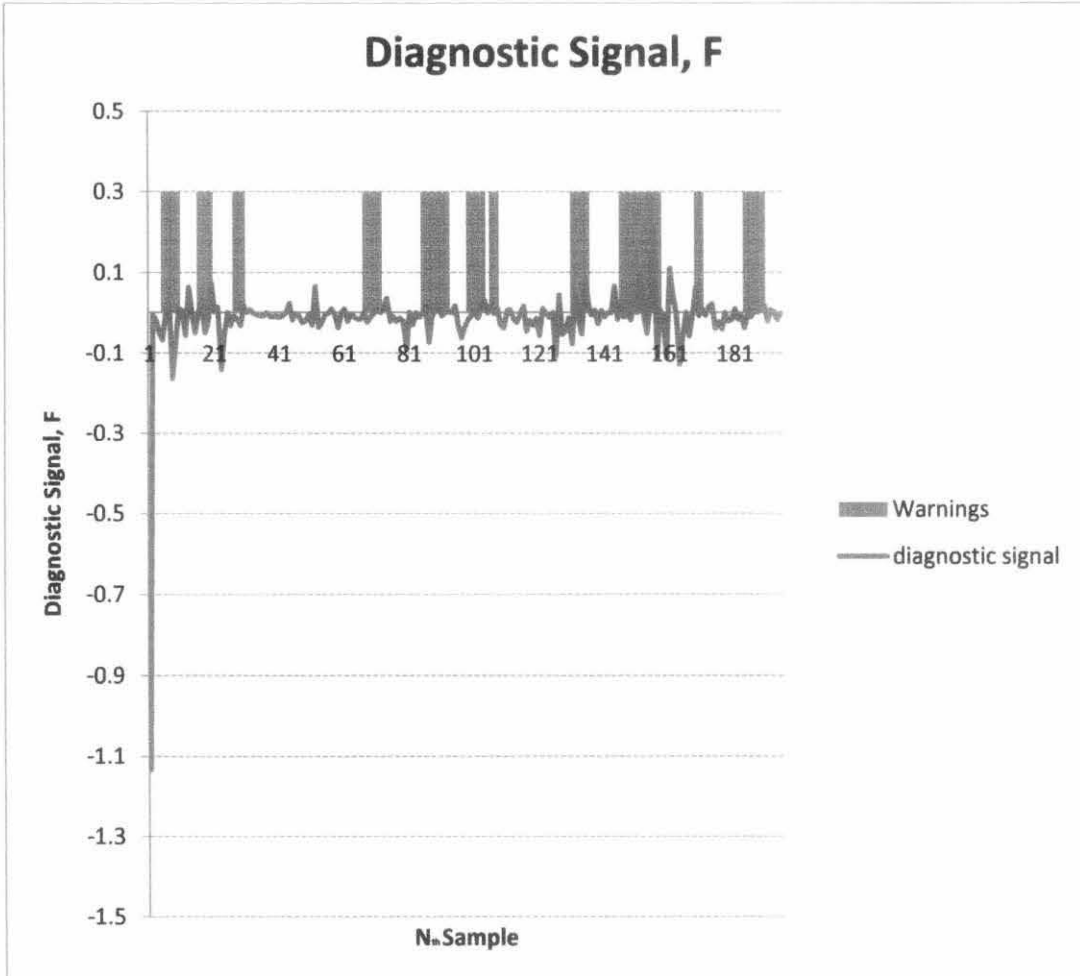

Figure 12: Diagnostic signal & warnings Run 400

Graph above are the diagnostic signal and warnings to be alarmed for Run 400. Run 400 were drilled before Run 500 where it begins at depth 667m of the 17 1/2 " section. As for this study, the calculation began at depth 734m in the same hole section. Comparing the result gotten through the statistical method with PWD ECD data, most of the warnings are correct because the statistical method does not take mud weight (increment in density) into consideration. Furthermore, the downside of using stand pipe pressure instead of measured bottom hole pressure is that SPP might be influenced by wellbore mechanics unrelated to stuck pipe and poor hole cleaning. However, if we look at near the end of the graph at 184th sample, the warnings indicate that there is a probability that stuck pipe is oncoming based on SPP and TRQ reading and the trend line for ECD

1500m beginning to slightly increase deviating from the predicted value when drilling at ROP 30m/hr and RPM of 120.

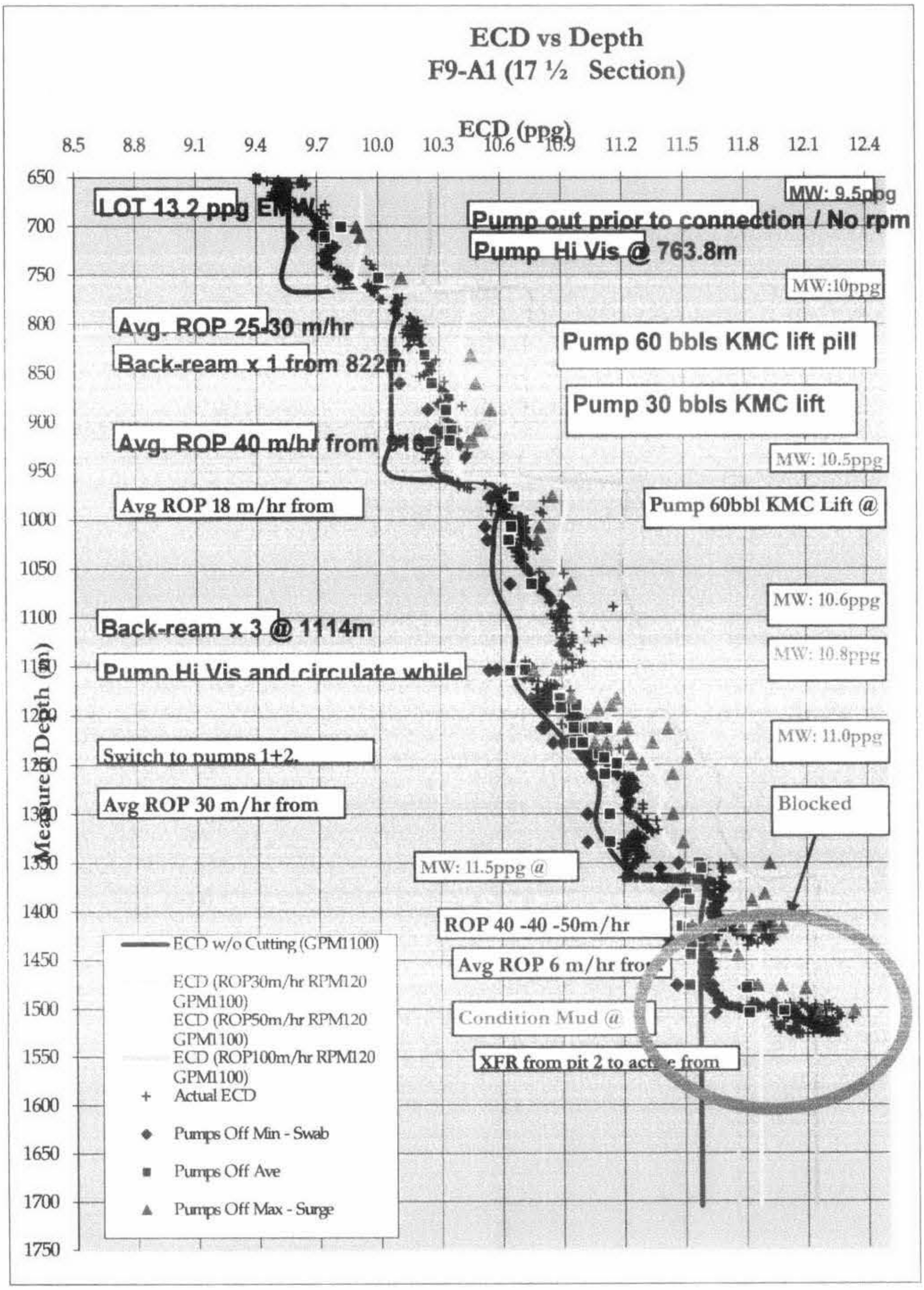

Figure 13: ECD vs Depth roadmaps (Source: Roadmap DOMC 17 1/2" Section F9-A1)

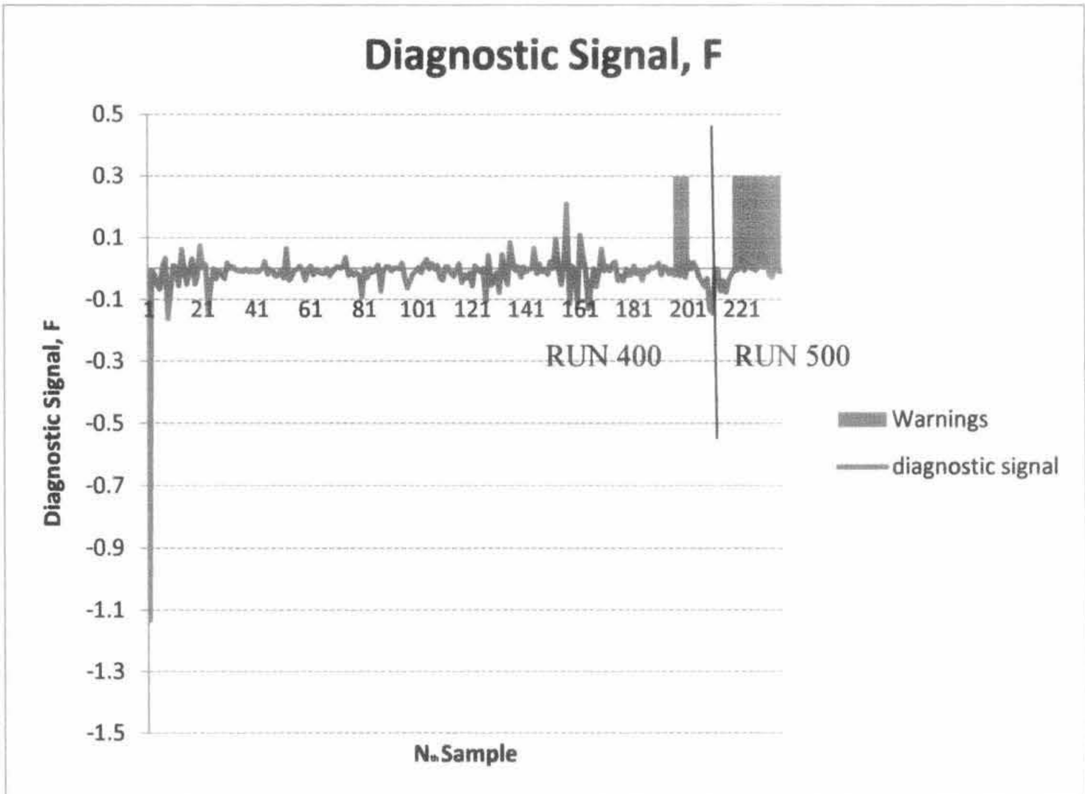

Figure 14: Diagnostic signal & warnings, Run 400 & Run 500

If we look at the graph above, it is the combination of both runs, highlighting the warnings at near the end of Run 400 and the beginning of Run 500 is the most correct prediction of this statistical method as there are also increment in ECD and Drag during drilling. Finally, the last warning at the end is actually the situation of the pipe downhole gets worst and worst until it finally got stuck. It is also shown in the Drag Roadmap below.

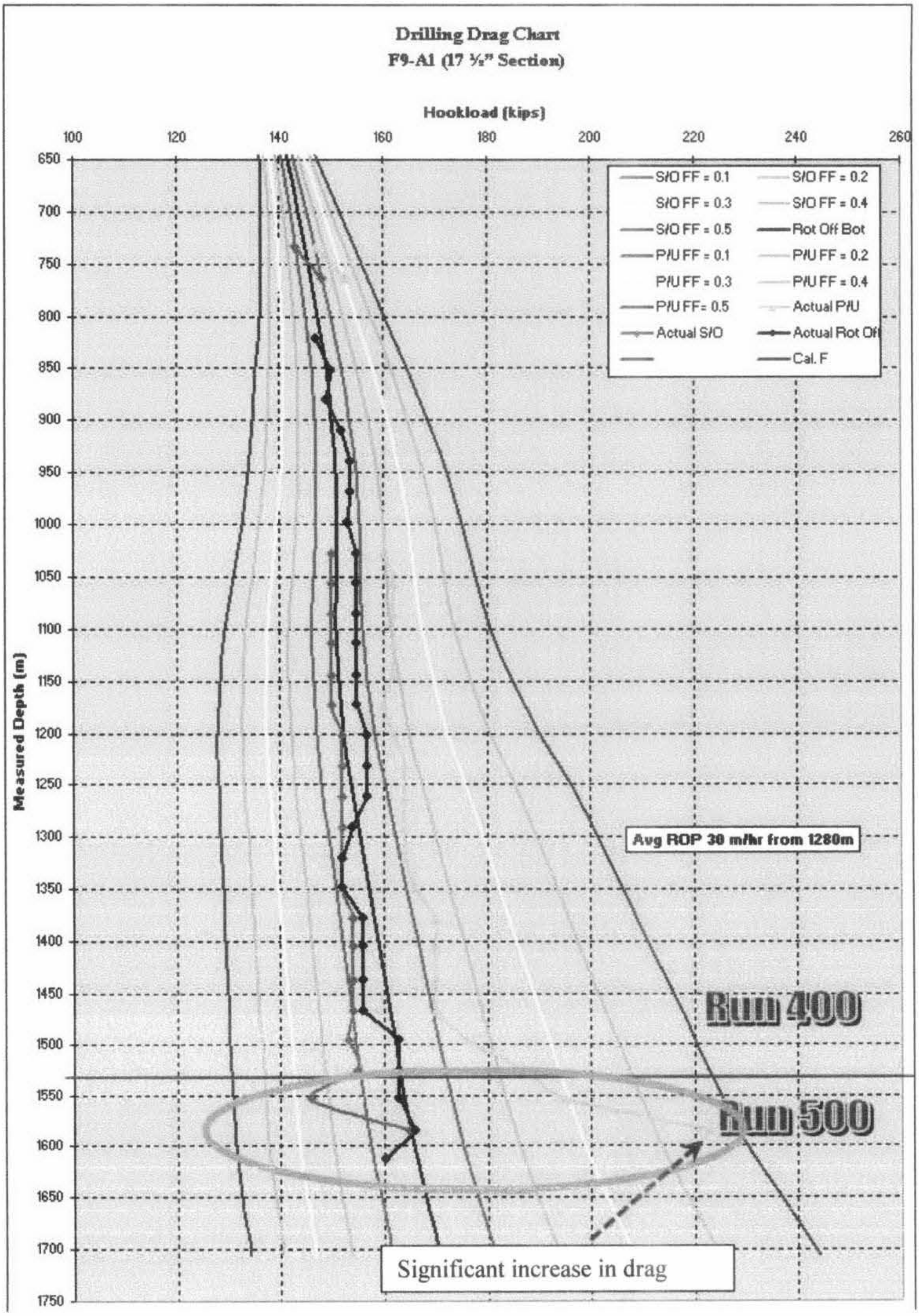

Figure 15: Drilling drag roadmap (Source: Roadmap DOMC 17 1/2" Section F9-A1)

CHAPTER 5

CONCLUSION

Pipe sticking and poor hole cleaning affects the cost of drilling operation badly, millions of dollars were wasted in order to recover after such loss. These occurrences should be avoided instead of recovered from. Prevention methods which takes advantage of statistical method and also multivariate analysis to not only detect when the stuck pipe will occur but also reads the type of stuck pipe which will occur will be helpful in saving more cost. The current method available uses PWD data and the flow patterns of those data are analyzed by experienced engineers from the drilling optimization team. It allows early detection based on the engineer's knowledge and experience on the subject to detect a possible occurrence. However, cases like Run 500 still happen when the drilling platform personnel fail to adhere to their advice and continue operation like usual. This statistical method can be developed even further so that it will be able to strengthen the claim of the drilling optimization team. In conclusion, it is believe that the statistical method is a viable option in order not to replace but to strengthen the current method available for the detection of stuck pipe.

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DOMC-PCSB Insite Reports on Kumang F9-A1

APPENDIX

The tables below are the data which was use for the calculation of the statistical method. The data was divided according to their respective runs.

Run 400

Depth,m	SPP, psi	TRQ, ft-lbs
734.00	1088.46	757.58
735.00	1216.01	85.60
736.00	1256.64	591.00
737.00	1261.30	3134.04
738.00	1250.47	2701.73
739.00	1253.37	2803.83
740.00	1255.77	2782.96
741.00	1257.77	2860.89
742.00	1254.84	2702.54
743.00	1256.30	2774.56
744.00	1222.03	2767.46
745.00	1260.43	2673.73
746.00	1263.62	2720.83
747.00	1263.75	2694.65
748.00	1265.44	2713.32
749.00	1024.87	2959.18
750.00	1269.08	2817.62
751.00	1275.18	2820.43
752.00	1276.25	2899.93
753.00	1274.58	3233.84
754.00	1277.33	2927.53
755.00	1280.24	3063.61
756.00	1279.64	2763.25
757.00	1277.28	3107.54
758.00	1252.71	2744.49
759.00	1235.37	2612.22
760.00	1231.81	2518.39
761.00	1241.06	2417.12
762.00	1257.57	2402.64
764.00	922.77	2003.74
765.00	1316.69	2894.16
766.00	1290.86	2480.59
767.00	1315.80	2912.44
768.00	1315.80	2544.47
769.00	1287.26	3023.84
770.00	1324.13	2709.91
771.00	1317.69	3283.34
772.00	1320.65	2974.71
773.00	1305.91	2930.28
774.00	1335.46	3013.88

Depth,m	SPP, psi	TRQ, ft-lbs
775.00	1333.25	3021.23
776.00	1322.91	3081.38
777.00	1319.74	3030.51
778.00	1328.03	2925.72
779.00	1337.94	2925.97
780.00	1357.26	3149.67
781.00	1361.32	3150.20
782.00	1359.79	3325.64
783.00	1360.16	3153.48
784.00	1360.12	3155.68
785.00	1364.80	3293.21
786.00	1361.62	3680.40
787.00	1360.48	3479.12
788.00	1361.46	3318.73
789.00	1363.00	3168.07
790.00	1363.69	3162.79
791.00	1364.29	3281.82
792.00	1364.36	3342.77
793.00	1366.31	3324.70
794.00	1337.06	3034.25
795.00	1313.51	3329.25
796.00	1294.90	3340.15
797.00	1306.92	3365.97
798.00	1324.10	3487.81
799.00	1331.39	3485.30
800.00	1330.09	3310.66
801.00	1328.52	4296.30
802.00	1329.38	3842.53
803.00	1327.22	3258.69
804.00	1324.14	3101.36
805.00	1319.07	2971.65
806.00	1294.20	2907.09
807.00	1306.97	2717.06
808.00	1297.25	2841.40
809.00	1324.77	2912.31
810.00	1321.76	3342.30
811.00	1301.14	3419.43
812.00	1291.87	3232.84
813.00	1329.04	2990.10
814.00	1510.39	2962.87

Depth,m	SPP, psi	TRQ, ft-lbs
815.00	1591.22	3837.64
816.00	1591.62	3593.84
817.00	1592.92	3698.46
818.00	1592.47	3303.63
819.00	1593.13	3204.98
820.00	1596.14	3227.64
821.00	1598.99	3205.11
822.00	1605.88	3374.76
823.00	1276.46	2566.61
824.00	1538.68	3686.11
825.00	1611.37	3282.42
826.00	1635.45	3423.09
827.00	1891.54	3675.00
828.00	1914.88	4156.95
829.00	1915.23	4046.59
830.00	1920.50	4033.19
831.00	1924.48	4302.65
832.00	1924.02	4241.45
833.00	1929.88	4242.56
834.00	1929.50	4240.82
835.00	1931.89	4326.11
836.00	1933.70	4206.17
837.00	1937.27	4272.66
838.00	1874.41	4048.66
839.00	1937.47	3959.06
840.00	1943.70	4306.53
841.00	1943.05	4159.75
842.00	1939.57	4094.06
843.00	1939.89	4286.19
844.00	1871.07	4141.83
845.00	1937.12	4206.44
846.00	1932.78	4273.47
847.00	1926.60	4140.50
848.00	1925.21	4505.59
849.00	1926.84	4230.98
850.00	1927.24	4181.44
851.00	1930.14	4141.52
853.00	1845.83	4091.33
854.00	1803.07	4245.14
855.00	1772.41	4417.24

Depth,m	SPP, psi	TRQ, ft-lbs
856.00	1780.41	4368.33
857.00	1828.07	4395.77
858.00	1836.27	4324.15
859.00	1775.13	4189.59
860.00	1844.48	4390.42
861.00	1847.82	4459.68
862.00	1865.98	4315.97
863.00	1883.24	4293.71
864.00	1903.13	4301.88
865.00	1915.02	4451.00
866.00	1924.44	4321.79
867.00	1933.64	4361.15
868.00	1944.57	4320.59
869.00	1947.60	4248.65
870.00	1952.66	4556.16
871.00	1954.14	4449.26
872.00	1955.62	4437.33
873.00	1959.21	4379.06
874.00	1959.02	4372.81
875.00	1958.55	4436.10
876.00	1962.49	4288.30
877.00	1965.77	4389.84
878.00	1967.16	4307.10
879.00	1967.42	4341.80
880.00	1973.55	4712.84
881.00	1970.70	4334.69
882.00	1808.07	4009.69
883.00	1822.61	4194.97
884.00	1828.23	4477.32
885.00	1829.67	4770.54
886.00	1829.67	4831.35
887.00	1827.40	4825.38
888.00	1752.77	4757.45
889.00	1806.69	4721.85
890.00	1822.60	4644.51
891.00	1825.40	4718.78
892.00	1827.28	4663.76
893.00	1825.33	4840.06
894.00	1822.02	4790.68
895.00	1816.53	4758.92

Depth,m	SPP, psi	TRQ, ft-lbs
896.00	1810.36	4676.29
897.00	1811.56	4592.21
898.00	1723.90	4696.79
900.00	1808.79	4620.59
901.00	1805.80	4631.39
902.00	1805.71	4684.75
903.00	1788.04	4754.88
904.00	1768.77	4786.12
905.00	1760.82	4824.22
906.00	1757.58	4629.60
907.00	1757.10	4752.63
908.00	1754.15	4728.46
909.00	1753.62	4703.31
910.00	1761.58	4730.15
911.00	1896.46	4145.32
912.00	1996.97	4854.23
913.00	1995.90	4779.08
914.00	1997.00	4658.45
915.00	1900.46	4827.79
916.00	1986.58	4687.84
917.00	1997.95	4726.99
918.00	1983.29	4742.38
919.00	1962.62	4598.68
920.00	1943.33	4734.94
921.00	1934.17	4863.53
922.00	1935.01	4861.21
923.00	1929.24	4888.66
924.00	1935.40	4956.09
925.00	1933.85	4876.94
926.00	1938.54	4801.92
927.00	1938.45	5056.03
928.00	1732.78	4917.12
929.00	1669.82	4401.62
930.00	1758.19	4927.42
931.00	1858.67	4881.63
932.00	1874.61	4956.84
933.00	1870.11	4827.96
934.00	1837.38	4926.00
935.00	1852.90	4699.75
936.00	1881.55	4688.39

Depth,m	SPP, psi	TRQ, ft-lbs
937.00	1912.78	4745.36
938.00	1904.40	4994.32
939.00	1694.04	4400.52
940.00	1439.14	4578.13
941.00	1436.48	5258.08
942.00	1397.90	4054.22
943.00	1427.55	4027.41
944.00	1486.84	4059.97
945.00	1694.12	4341.55
946.00	1708.43	4035.05
947.00	1711.53	4429.04
948.00	1715.57	4456.14
949.00	1721.22	4303.70
950.00	1720.20	4481.40
951.00	1723.17	4526.13
952.00	1653.85	4484.76
953.00	1747.25	4511.85
954.00	1756.89	4635.67
955.00	1775.57	4380.40
956.00	1774.49	4479.29
957.00	1774.25	4359.22
958.00	1760.96	4341.98
959.00	1756.67	4342.55
960.00	1741.10	4420.50
961.00	1727.96	4528.82
962.00	1680.33	4535.88
963.00	1685.09	4508.05
964.00	1696.67	4424.06
965.00	1672.34	4458.83
966.00	1656.34	4448.81
967.00	1668.04	4373.29
968.00	1666.62	4366.65
969.00	1657.90	4349.81
970.00	1824.40	3733.97
971.00	1968.15	3966.69
972.00	1967.68	4194.72
973.00	1968.71	4189.03
974.00	1971.25	4181.52
975.00	1790.39	4293.27
976.00	1787.14	4238.48

Depth,m	SPP, psi	TRQ, ft-lbs
977.00	1788.87	4089.73
978.00	1777.27	4153.68
979.00	1831.15	4138.16
980.00	1930.44	4056.40
981.00	1929.78	4004.07
982.00	1891.06	3948.45
983.00	1937.32	4041.46
984.00	1941.15	4146.87
985.00	1946.99	4044.38
986.00	1949.91	4020.42
987.00	1951.58	4060.40
988.00	1952.95	4085.60
989.00	1954.48	4087.73
990.00	1951.53	4186.68
991.00	1954.29	4149.63
992.00	1940.01	4106.56
993.00	1912.80	4110.78
994.00	1955.56	4145.57
995.00	1957.29	4235.01
996.00	1962.68	4222.19
997.00	1982.54	4159.37
998.00	1993.89	4141.92
999.00	1911.77	3858.05
1000.00	1837.35	4138.12
1001.00	1838.79	4094.24
1002.00	1823.67	4141.72
1003.00	1738.54	4134.90
1004.00	1738.82	4185.95
1005.00	1775.54	4102.55
1006.00	1897.54	3919.01
1007.00	1912.24	3945.41
1008.00	1905.08	3946.08
1009.00	2055.16	4000.74
1010.00	2138.77	3974.08
1011.00	2146.26	4054.44
1012.00	2153.09	4057.33
1013.00	2161.63	4058.86
1014.00	2160.10	4040.86
1015.00	2103.51	3982.35
1016.00	2091.72	4181.39

Depth,m	SPP, psi	TRQ, ft-lbs
1017.00	2099.48	4162.11
1018.00	2104.68	4310.81
1019.00	2113.86	4329.31
1020.00	2125.36	4273.66
1021.00	2134.10	4274.60
1022.00	2110.56	4285.95
1023.00	2089.22	4202.88
1024.00	2112.74	4242.47
1025.00	2131.45	4350.81
1026.00	2145.96	4274.59
1027.00	2158.71	4253.54
1030.00	2139.45	4126.61
1031.00	2108.94	4132.32
1032.00	2111.81	4199.12
1033.00	2115.71	4097.50
1034.00	2142.63	3879.48
1035.00	2146.22	3946.01
1036.00	2151.91	4164.98
1037.00	2153.60	4275.34
1038.00	2155.85	4098.57
1039.00	2098.11	4226.67
1040.00	2162.15	4199.44
1041.00	2165.92	4211.98
1042.00	2165.50	4143.96
1043.00	2171.78	4165.73
1044.00	2194.88	4169.82
1045.00	2176.78	4248.88
1046.00	2113.70	4387.46
1047.00	1889.12	4512.95
1048.00	2159.80	4636.26
1049.00	2166.88	4611.20
1050.00	2176.57	4572.92
1051.00	2181.95	4450.82
1052.00	2191.87	4576.37
1053.00	2196.15	4516.93
1054.00	2198.91	4771.79
1055.00	2203.56	4656.13
1056.00	2205.47	4780.21
1057.00	2165.15	4009.58
1058.00	2200.70	4232.15

Depth,m	SPP, psi	TRQ, ft-lbs
1060.00	2161.14	4346.25
1061.00	2152.02	4401.72
1062.00	2151.09	4384.19
1063.00	2158.82	4316.79
1064.00	2172.52	4566.68
1065.00	2182.37	4773.13
1066.00	2187.86	4796.56
1067.00	2113.25	4886.60
1068.00	2198.84	4601.75
1069.00	2208.05	4968.05
1070.00	2214.60	4563.75
1071.00	2223.60	4910.67
1072.00	2228.27	4765.58
1073.00	2233.62	4892.44
1074.00	2236.15	4936.69
1075.00	2237.97	4976.75
1076.00	2237.29	4972.57
1077.00	2234.52	4986.92
1078.00	2234.39	5000.13
1079.00	2231.09	5041.58
1080.00	2231.63	4980.43
1082.00	2231.41	4925.24
1083.00	2232.21	4846.83
1084.00	2234.80	4859.37
1085.00	2234.89	4878.92
1086.00	1517.13	4302.83
1087.00	2174.91	4952.58
1088.00	2188.80	4907.65
1089.00	2205.60	4817.68
1090.00	2215.76	4883.98
1091.00	2224.75	5212.31
1092.00	2232.20	4989.08
1093.00	2237.36	4889.31
1094.00	2182.04	4954.93
1095.00	2118.42	5005.19
1096.00	2089.02	5234.17
1097.00	2272.68	5454.20
1098.00	2273.24	5625.05
1099.00	2274.44	5602.26
1100.00	2275.92	5647.79

Depth,m	SPP, psi	TRQ, ft-lbs
1101.00	2284.53	5396.90
1102.00	2284.05	5275.54
1103.00	2282.70	5350.15
1104.00	2281.26	5534.14
1105.00	2277.73	5679.62
1106.00	2278.67	5656.39
1107.00	2280.27	5592.04
1108.00	2276.24	5316.63
1109.00	2276.87	5198.11
1110.00	2279.54	5447.21
1111.00	2281.29	5686.99
1112.00	2284.14	5718.83
1113.00	2288.19	5583.67
1114.00	2288.16	5620.66
1115.00	2299.71	5381.67
1116.00	2298.35	5349.41
1117.00	2162.01	5321.24
1118.00	2294.63	5153.62
1119.00	2140.10	5162.62
1120.00	2203.20	5426.02
1121.00	2101.79	5520.76
1122.00	2219.69	5527.53
1123.00	2234.82	5179.79
1124.00	2249.15	5403.18
1125.00	2123.55	5459.25
1126.00	2216.69	4752.61
1127.00	2214.72	4991.22
1128.00	2196.75	5297.28
1129.00	2293.86	5313.14
1130.00	2304.25	4993.75
1131.00	2311.92	5410.06
1132.00	2171.59	5245.59
1133.00	2243.26	5166.03
1134.00	2221.75	5211.49
1135.00	2191.70	5283.54
1136.00	2140.65	5594.76
1137.00	2252.96	5784.93
1138.00	2263.09	5765.62
1139.00	2272.70	5999.92
1140.00	2277.95	6065.14

Depth,m	SPP, psi	TRQ, ft-lbs
1141.00	2288.29	5674.94
1142.00	2294.75	5999.47
1143.00	2301.53	5781.99
1144.00	2309.25	5339.74
1145.00	2307.06	5399.63
1146.00	2258.51	5080.58
1147.00	2365.40	5120.58
1148.00	2348.08	4992.58
1149.00	2298.91	5132.42
1150.00	1705.10	5237.49
1151.00	1497.30	4967.24
1152.00	1776.59	5020.01
1153.00	1848.89	4987.64
1154.00	1818.35	5207.56
1155.00	1819.24	5143.78
1156.00	1916.97	5436.88
1157.00	2122.02	5426.55
1158.00	2138.36	5424.37
1159.00	2259.14	5125.16
1160.00	2245.88	4881.51
1161.00	2302.58	4865.00
1162.00	2216.93	5071.65
1163.00	2239.28	5219.92
1164.00	2262.57	5445.73
1165.00	2283.81	5424.17
1166.00	2298.86	5369.57
1167.00	2296.44	5393.08
1168.00	2270.99	5404.90
1169.00	2242.19	5655.26
1170.00	2225.42	5456.80
1171.00	2215.44	5575.35
1172.00	2217.78	5580.02
1173.00	1801.65	4476.73
1174.00	2233.93	4667.70
1175.00	2107.21	4724.00
1176.00	2230.10	4867.98
1177.00	2210.40	4794.11
1178.00	2087.19	5067.85
1179.00	2219.75	4931.93
1180.00	2218.83	4698.77

Depth,m	SPP, psi	TRQ, ft-lbs
1181.00	2220.02	5021.97
1182.00	2219.96	5020.69
1183.00	2224.53	5150.90
1184.00	2226.81	5272.88
1185.00	2229.16	5621.33
1186.00	2232.41	5569.46
1187.00	2233.02	5737.23
1188.00	2238.92	5667.94
1189.00	2238.22	4275.05
1190.00	2267.95	3717.14
1191.00	2348.09	3566.49
1192.00	2342.38	4491.05
1193.00	2345.83	4697.73
1194.00	2348.18	4950.39
1195.00	1889.82	4919.69
1196.00	2263.19	4834.77
1197.00	2276.98	4195.26
1198.00	2278.30	4368.18
1199.00	2263.78	4745.87
1200.00	2260.21	4136.78
1201.00	2277.41	3675.46
1202.00	2306.57	3835.13
1203.00	2245.03	4328.54
1204.00	2226.41	4397.80
1205.00	2251.38	4444.49
1206.00	2232.26	4282.30
1207.00	2156.07	4283.99
1208.00	2237.24	4703.79
1209.00	2180.33	4645.45
1210.00	2256.18	4826.76
1211.00	2270.54	4782.98
1212.00	2287.24	4880.39
1213.00	2292.52	5039.42
1214.00	1591.44	4991.75
1215.00	2271.72	5079.73
1216.00	2274.59	5297.98
1217.00	2277.99	5620.34
1218.00	2283.93	5719.57
1219.00	2284.39	5377.56
1220.00	2288.42	5256.04

Depth,m	SPP, psi	TRQ, ft-lbs
1221.00	2295.19	5284.77
1222.00	2296.17	5350.10
1223.00	2299.22	5497.52
1224.00	1653.50	4900.64
1225.00	2287.62	5309.68
1226.00	2265.78	5301.82
1227.00	2256.12	5410.04
1228.00	2266.55	5452.12
1229.00	2275.88	5410.57
1230.00	2283.77	5480.92
1231.00	2290.81	5438.80
1232.00	2298.06	5387.40
1233.00	2289.09	4633.19
1234.00	2289.97	4779.04
1235.00	2248.98	4685.00
1236.00	2191.55	4800.44
1237.00	2291.30	4851.15
1238.00	2212.76	4929.29
1239.00	2245.49	4668.36
1240.00	2325.56	4758.18
1241.00	2330.66	4797.68
1242.00	2331.43	4465.72
1243.00	2327.17	3847.57
1244.00	2317.06	3752.85
1245.00	2279.25	3912.08
1246.00	2049.67	4427.42
1247.00	2005.24	4377.40
1248.00	1932.59	4272.06
1249.00	1782.85	4802.98
1250.00	1929.07	5250.66
1251.00	1921.34	5230.63
1252.00	1909.05	5385.18
1253.00	1841.42	5487.56
1254.00	1902.59	5349.64
1255.00	1899.04	5303.54
1256.00	1899.54	4998.45
1257.00	1904.17	4840.16
1258.00	1912.43	5019.99
1259.00	1917.95	5019.21
1260.00	1917.21	5056.54

Depth,m	SPP, psi	TRQ, ft-lbs
1261.00	1914.34	5133.28
1262.00	1818.07	4780.30
1263.00	1944.03	5719.15
1264.00	1939.72	5466.10
1265.00	1943.19	5731.39
1266.00	1944.72	5309.37
1267.00	1952.20	5403.63
1268.00	1942.49	5830.72
1269.00	1933.76	5826.37
1270.00	1885.61	6157.59
1271.00	1859.73	6223.25
1272.00	1930.75	5546.16
1273.00	1953.15	4959.68
1274.00	1959.94	5738.84
1275.00	1961.61	5306.96
1276.00	1958.65	5047.50
1277.00	1934.82	4338.25
1278.00	1948.81	4078.62
1279.00	1927.37	5807.57
1280.00	1936.29	5671.43
1281.00	1956.94	5786.74
1282.00	1959.76	5704.66
1283.00	1960.18	5708.72
1284.00	1965.92	5337.10
1285.00	1968.35	4990.65
1286.00	1972.33	5409.30
1287.00	1980.37	5290.09
1288.00	1981.74	5392.10
1289.00	1981.31	5485.16
1290.00	1883.56	5468.06
1291.00	1900.86	5401.99
1292.00	1957.56	6603.25
1293.00	1911.58	6237.61
1294.00	1977.06	6430.66
1295.00	1974.67	6245.93
1296.00	1979.53	6062.41
1297.00	1981.28	6394.66
1298.00	1988.18	6052.60
1299.00	1985.14	6075.33
1300.00	1993.50	6147.23

Depth,m	SPP, psi	TRQ, ft-lbs
1301.00	1900.94	6229.74
1302.00	1939.25	6160.17
1303.00	1977.88	6274.32
1304.00	1975.62	6459.00
1305.00	1974.83	6268.00
1306.00	1975.23	6357.64
1307.00	1979.63	6173.19
1308.00	1979.35	6626.10
1309.00	1978.93	6556.48
1310.00	1981.52	6649.21
1311.00	1991.33	6666.35
1312.00	1993.69	6945.17
1313.00	1993.52	6774.92
1314.00	1991.50	6931.73
1316.00	1995.33	7371.42
1317.00	2019.79	7722.93
1318.00	2020.65	7603.01
1319.00	2042.79	7677.98
1320.00	2049.16	7369.66
1321.00	1986.15	7229.06
1322.00	1986.51	7440.16
1323.00	1987.50	7177.07
1324.00	1992.65	7422.67
1325.00	2000.35	7621.03
1326.00	2006.70	7355.85
1327.00	2001.40	7431.97
1328.00	1990.96	7439.70
1330.00	2005.14	7583.72
1331.00	2012.86	7723.47
1332.00	2021.10	7715.00
1333.00	2029.70	7724.85
1334.00	2036.51	7736.76
1335.00	2033.80	8080.88
1336.00	2033.72	8197.98
1337.00	2030.41	8350.81
1338.00	2021.99	8468.67
1339.00	2020.49	8381.72
1340.00	2013.03	8349.39
1341.00	2010.51	8710.22
1342.00	2010.67	8747.58

Depth,m	SPP, psi	TRQ, ft-lbs
1343.00	2006.65	8254.88
1344.00	2006.28	8645.65
1345.00	2011.90	8342.73
1346.00	2011.35	8616.73
1347.00	2009.49	9149.42
1348.00	2012.44	9013.80
1349.00	2010.51	8996.28
1350.00	2023.66	7443.78
1351.00	2031.51	7245.17
1352.00	2028.36	7023.26
1353.00	1958.27	6781.15
1354.00	1937.29	6774.18
1355.00	2030.05	6736.52
1356.00	2022.79	6903.17
1357.00	2028.33	7661.06
1358.00	2026.92	8085.35
1359.00	2028.77	8833.55
1360.00	2024.37	9036.84
1361.00	2026.52	8109.44
1362.00	2025.32	8254.97
1363.00	2028.73	7749.17
1364.00	2021.88	5239.05
1365.00	2035.22	4903.16
1366.00	2059.80	4419.85
1367.00	2087.44	4111.04
1368.00	2102.15	4181.50
1369.00	2112.13	5743.59
1370.00	2115.35	6022.70
1371.00	2111.37	6057.69
1372.00	2117.47	6032.05
1373.00	2133.91	5863.01
1374.00	2152.21	5782.63
1375.00	2146.21	5786.19
1376.00	2150.13	5758.68
1377.00	2154.66	5382.55
1378.00	2157.39	5074.32
1379.00	2157.33	4746.91
1380.00	2166.01	5589.74
1381.00	2164.59	5930.96
1382.00	2165.09	6018.62

Depth,m	SPP, psi	TRQ, ft-lbs
1383.00	2169.61	6901.20
1384.00	2172.95	8549.84
1385.00	2171.34	6852.55
1386.00	2180.39	6534.66
1387.00	2179.32	6472.13
1388.00	2177.85	6388.50
1389.00	2176.73	4999.51
1390.00	2181.48	6376.07
1391.00	2174.29	6851.76
1392.00	2171.47	6827.56
1393.00	2161.83	7794.45
1394.00	2158.90	8863.42
1395.00	2167.26	7753.59
1396.00	2171.40	6931.80
1397.00	2170.61	5937.59
1398.00	2170.99	6174.52
1399.00	2166.58	5642.71
1400.00	2181.37	6190.23
1401.00	2184.11	6401.59
1402.00	2188.78	6791.74
1403.00	2180.62	7114.16
1404.00	2176.33	6934.63
1405.00	2181.56	6472.95
1406.00	2177.26	6411.31
1407.00	2177.37	6426.55
1408.00	2174.97	6611.18
1409.00	2172.86	6652.09
1410.00	2166.34	7751.28
1411.00	2166.64	8733.08
1412.00	2173.11	8793.02
1413.00	2173.28	8670.26
1414.00	2177.19	8602.23
1415.00	2182.07	7464.21
1416.00	2180.42	6556.45
1417.00	2181.08	6949.66
1418.00	2191.39	7340.92
1419.00	2185.78	7751.21
1420.00	2194.94	7593.10
1421.00	2200.10	7712.43
1422.00	2205.06	7917.02

Depth,m	SPP, psi	TRQ, ft-lbs
1424.00	2198.35	7884.20
1425.00	2203.04	7992.23
1426.00	2198.55	8504.25
1427.00	2205.97	8149.88
1428.00	2206.18	7932.65
1429.00	2209.45	7211.89
1430.00	2216.34	8057.27
1431.00	2214.02	8262.17
1432.00	2216.96	8226.63
1433.00	2216.56	8217.47
1434.00	2221.58	7816.87
1435.00	2227.23	7985.22
1436.00	2225.09	8319.00
1437.00	2229.91	8746.18
1438.00	2423.93	6353.23
1439.00	2488.39	5911.07
1440.00	2488.91	6112.89
1441.00	2487.21	5860.10
1442.00	2329.54	6006.54
1443.00	2466.28	5627.07
1444.00	2509.55	5532.52
1445.00	2511.53	5646.63
1446.00	2287.72	5711.07
1447.00	2504.38	5791.59
1448.00	2507.92	6125.12
1449.00	2426.49	5449.42
1450.00	2484.21	5691.85
1451.00	2487.43	5785.92
1452.00	2484.91	6078.09
1453.00	2487.74	6138.97
1454.00	2474.27	6150.97
1455.00	2471.18	6060.08
1456.00	2397.16	6273.55
1457.00	2405.10	5890.71
1458.00	2480.72	6379.34
1459.00	2263.28	5969.31
1460.00	2207.67	6307.24
1461.00	2206.76	6404.65
1462.00	2182.91	6103.91
1463.00	2200.11	6240.45

Depth,m	SPP, psi	TRQ, ft-lbs
1464.00	2220.88	6150.43
1465.00	2238.57	5923.38
1466.00	2229.26	6321.16
1467.00	2216.84	6088.85
1468.00	2221.54	6240.61
1469.00	2219.08	5962.60
1470.00	2214.13	6019.78
1471.00	2204.02	5890.41
1472.00	2198.44	6039.10
1473.00	2210.13	6027.47
1474.00	2185.13	6018.38
1475.00	2210.79	6176.52
1476.00	2205.19	6926.83
1477.00	2201.13	6579.48
1478.00	2182.60	6371.02
1479.00	2207.87	6877.51
1480.00	2212.06	6832.77
1481.00	2209.12	6316.40
1482.00	2206.19	6585.16
1483.00	2202.91	6966.17
1484.00	2201.05	6662.01
1485.00	2212.13	6649.48
1486.00	2222.70	6464.44
1487.00	2221.12	6741.58
1488.00	2213.90	7162.53
1489.00	2215.38	7657.42
1490.00	2222.57	7223.35
1491.00	2225.39	6559.26
1492.00	2226.46	6465.35
1493.00	2225.04	6621.17
1494.00	2221.66	6636.59
1495.00	2222.81	6640.25
1496.00	2204.07	6575.41
1497.00	2222.55	6389.04
1498.00	2234.86	6385.84
1499.00	2265.80	6373.56
1500.00	2268.98	6088.68
1501.00	2301.30	6159.28
1503.00	2530.32	6272.46
1504.00	2685.43	6972.91

Depth,m	SPP, psi	TRQ, ft-lbs
1505.00	2730.37	6940.87
1506.00	2731.83	6909.77
1507.00	2612.52	6677.55
1508.00	2672.65	6348.09
1509.00	2691.06	6084.15
1510.00	2694.53	6133.70
1511.00	2691.49	6290.68
1512.00	2692.82	6135.33
1513.00	2698.29	6053.40
1514.00	2697.87	6135.60
1515.00	2696.84	6565.46
1516.00	2699.36	6757.88
1517.00	2704.67	7348.14
1518.00	2709.16	7240.06
1519.00	2707.32	7057.33
1520.00	2709.20	6924.95
1521.00	2706.08	6987.17
1522.00	2707.45	7284.05
1523.00	2710.48	7246.08
1524.00	2711.38	6858.37
1525.00	2714.57	6934.86
1526.00	2711.72	6929.18
1527.00	2658.63	6687.88

Run 500

Depth,m	SPP, psi	TRQ, ft-lbs
1530.00	2056.38	5072.01
1531.00	2032.81	5084.14
1532.00	2027.86	5103.87
1533.00	1973.34	5394.41
1534.00	1948.60	5691.13
1535.00	1957.89	5407.61
1536.00	1963.15	5335.99
1537.00	1975.46	5193.38
1538.00	1969.01	5908.79
1539.00	1981.27	5551.00
1540.00	1987.73	5753.37
1541.00	1989.26	5968.10
1542.00	1985.82	5674.91
1543.00	1975.41	5859.09
1544.00	1898.83	6005.24
1545.00	1892.68	6022.60
1546.00	1830.21	6131.92
1547.00	1822.72	5686.39
1548.00	1831.34	5544.40
1549.00	1813.77	5422.08
1550.00	1959.99	5324.61
1551.00	1967.10	5382.86
1552.00	1953.53	6033.83
1553.00	1959.27	6856.99
1554.00	1996.00	7112.57
1555.00	1977.32	5908.03
1556.00	2030.56	5850.71
1557.00	2012.25	5955.00
1558.00	2424.38	5866.65
1559.00	2367.00	5619.83
1560.00	2227.01	7220.47
1561.00	2228.66	6956.31
1562.00	2231.61	7007.41
1563.00	2230.52	7188.83
1564.00	2231.29	7608.26
1565.00	2230.29	7201.32
1566.00	2231.55	6965.33
1567.00	2234.54	7025.30
1568.00	2235.42	6920.32
1569.00	2233.73	6382.33
1570.00	2235.44	7251.18

Depth,m	SPP, psi	TRQ, ft-lbs
1571.00	2236.39	6804.83
1572.00	2238.75	7287.04
1573.00	2151.22	7386.58
1574.00	2192.55	7553.59
1575.00	2240.86	7675.38
1576.00	2240.21	8324.51
1578.00	2242.35	7466.68
1579.00	2245.40	7234.23
1580.00	2247.50	7556.80
1581.00	2149.50	7700.45
1582.00	2233.46	7698.74
1583.00	2254.28	8349.64
1584.00	2263.79	8221.18
1585.00	2265.44	6684.84
1586.00	2265.74	6635.37
1587.00	2545.42	6342.83
1588.00	2643.13	6420.57
1589.00	2653.06	7722.94
1590.00	2658.80	8199.77
1591.00	2655.55	7827.66
1592.00	2602.62	7894.21
1593.00	2571.17	7813.78
1594.00	2655.85	7731.24
1595.00	2653.55	7832.76
1596.00	2655.48	7948.73
1597.00	2660.49	7610.69
1598.00	2662.02	7729.23
1599.00	2662.99	8031.39
1600.00	2660.85	6858.39
1601.00	2646.96	7016.59
1602.00	2596.75	7029.70
1603.00	2641.09	6843.25
1604.00	2655.24	6776.39
1605.00	2659.47	6890.67
1606.00	2609.12	7534.01
1607.00	2621.02	7993.99
1608.00	2650.08	6749.81
1609.00	2661.68	6877.56
1610.00	2664.23	6588.67
1611.00	2664.75	6389.13
1612.00	2670.52	6732.33

Depth,m	SPP, psi	TRQ, ft-lbs
1614.00	2653.68	7011.99
1615.00	2603.77	6759.46
1616.00	2653.33	6746.82
1617.00	2653.38	6625.35
1618.00	2593.49	6554.04
1619.00	2646.66	6512.46
1620.00	2647.70	6740.51
1621.00	2611.63	6704.80
1622.00	2669.38	6690.76
1623.00	2672.51	6621.33
1624.00	2749.38	6602.94
1625.00	2624.22	6967.26
1626.00	2685.84	7399.50
1627.00	2693.13	7153.52
1628.00	2700.32	7009.10
1629.00	2680.13	7007.79
1630.00	2792.68	6885.05
1631.00	2769.94	7163.44
1632.00	2742.43	7480.99
1634.00	2701.59	7260.42
1635.00	2699.15	7037.97
1636.00	2710.38	6969.47
1637.00	2727.72	6825.41
1638.00	2736.92	7064.74
1639.00	2726.10	7345.68
1640.00	2715.18	7185.74
1641.00	2692.57	7191.26
1642.00	2681.93	7449.46
1643.00	2684.53	7149.86
1644.00	2745.47	7173.54
1645.00	2701.82	7142.29
1646.00	2686.51	7051.36
1647.00	2693.81	7037.62
1648.00	2681.27	6923.53
1649.00	2657.56	6884.35
1650.00	2662.51	6793.69
1651.00	2636.03	6867.94
1652.00	2640.70	6817.13
1653.00	2643.84	7237.56
1654.00	2643.49	7021.19
1655.00	2637.68	7174.22

Depth,m	SPP, psi	TRQ, ft-lbs
1656.00	2632.77	7249.94
1657.00	2632.67	7373.05
1658.00	2638.85	7260.56
1659.00	2636.11	6960.17
1661.00	2633.76	7115.68
1662.00	2445.22	7063.16
1663.00	2286.78	6676.59
1664.00	2290.59	7320.67
1665.00	2295.66	7417.08
1666.00	2295.91	7706.76
1667.00	2297.22	8031.19
1668.00	2295.72	7609.09
1669.00	2296.83	7513.76
1670.00	2296.01	7785.67
1671.00	2297.02	7976.12
1672.00	2390.83	7612.31
1673.00	2687.86	7208.78
1674.00	2687.72	7463.84
1675.00	2668.26	7967.61
1676.00	2678.56	7833.48
1677.00	2684.57	7969.76
1678.00	2685.19	7845.17
1679.00	2629.10	7916.80
1680.00	2689.73	8283.21
1681.00	2689.30	8136.01
1682.00	2686.44	7452.10
1683.00	2677.23	7581.47
1684.00	2679.48	7457.12
1685.00	2683.86	7092.05
1686.00	2675.01	8245.89
1687.00	2675.13	7615.05
1688.00	2678.77	7833.81
1689.00	2687.21	7803.62
1690.00	2679.46	8042.65
1691.00	2681.47	9908.65
1692.00	2655.94	8271.26
1693.00	2702.66	9197.16
1694.00	2705.45	9190.29