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Logging while drilling operation

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A R T I C L E I N F O

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A B S T R A C T

This research presents detailed notes on the penetrating geological formations of the wellbore. Logs can be presented in two forms of good geological logs, means visual inspection of surface-carrying samples, and geophysical logs, means physical measurements by instruments that are lowered into holes. Logs that are created during drilling are called real-time logs. LWD tool is produced from real-time data transmitted to the surface computer from downhole. Three common services are Natural Gamma Ray, Resistivity, and Porosity and Bulk Density. The output of an LWD service is a log. A log is a graphical representation of the properties of the formation. Some factors that affect data quality are Depth Calculation, Sensor Malfunction and LWD Tools Measurements Fault. During drilling, borehole path monitoring is the important thing to be maintained because the quality of LWD data is critical for the success of any LWD job. Therefore, the field engineer has to understand the factors that affect data quality. Quality Control Process is the key to ensure that the tools are working properly.

1. Introduction

Logging while drilling means taking measurements of the petrophysical properties of the formation (e.g., hydrocarbon saturation, lithology) around the borehole as the well is drilled. The client uses LWD measurements to evaluate the production value of the reservoir during drilling and after drilling is complete. Therefore, it is important that LWD data be accurate. Three common services are Natural Gamma Ray, Resistivity, and Porosity and Bulk Density. The output of an LWD service is a log (see Fig.1). A log is a graphical representation of the properties of the formation. Logs are critical documents. Analysis of all the log services together is called log interpretation. From this interpretation, the client can derive accurate values for such properties as hydrocarbon saturation (Pike, 2002). The logs for each service are shown to the right.

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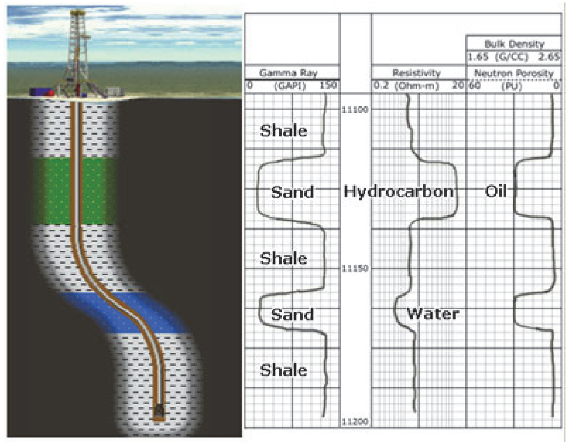

Fig. 1. LWD Log Services

Fig. 1 describes the log from each LWD services which describe the formation evaluation. From the graphic, We can know Natural Gamma Ray measures the naturally occurring gamma rays in the formation. It indicates the composition or type of rock. The log is used to locate sands, which generally are areas of production, or reservoirs. Resistivity measures the degree to which the formation opposes the flow of an electric current. The log indicates whether the fluid in the sand is hydrocarbon or water. This service is also an indicator of formation pressure in shales. Porosity and Bulk Density commonly uses a radioactive source to measure the percentage of the formation occupied by pore spaces (Melissinos & Napolitano, 2003). The log indicates if the hydrocarbon in an area is oil or gas. Almost all oil and gas produced today comes from pore spaces. The production value of a reservoir is dependent on the percentage of hydrocarbon saturation in those pore spaces, i.e., the percentage of the pore space that is occupied by hydrocarbon rather than water (Collett et al., 2012).

During drilling, the client uses LWD data to make quick and accurate decisions about Directional Drilling and Hazards Prevention. Using log information and directional drilling technology, it is possible to steer the well path to Stay within shallow (thin) payzones, Drill multiple entry points to cut through a reservoir at a better angle and increase the drainage area, and Steer the well path to include more than one target reservoir. Besides that, by using log information, the rig can monitor and maintain borehole pressure. Borehole pressure must be kept at a level that is higher than formation pressure (Bittar et al., 2017). The pressure difference prevents hazardous situations such as a kick, where higher pressure formation fluid enters the borehole.

When drilling is complete, the client uses LWD data to evaluate the formation and make accurate financial decisions, such as whether to produce the well. It means that by using log information, the client may decide to extract the fluids depending on the analysed profitability of the reservoir. Another decision is abandon the well. The client may decide the well will not be profitable and will abandon the well. The last one is drill more wells in the same area. The well can be side-tracked to reach additional payzones (Qleibo et al., 2014).

2. History of Logging While Drilling

Well logging was first used by Conrad and Marcel Schlumberger who was the founder of the Schlumberger company in 1926. At that time, they adopted a Geoelectric Sonde commonly used in searching for mineral subsidized seed prospects for subsurface applications in the oil and gas world. They use the recording to determine the resistance of the formation that lies beneath the surface. So the log that was first used in industrial history is log resistivity. The Sonde is discharged in the borehole at certain periodic intervals and its resistivity is directly recorded on the graph paper. In 1929 electrical resistivity logs were introduced on a commercial scale in Venezuela, the United States and Russia. In subsequent developments well logging is used for the correlation and identification of hydrocarbons. The film data recorder was later developed in 1936. For depth determination in well logging geophysics developed in

1930. Then gamma ray logs and neutron logs began to be used in 1941 (Schlumberger, 1985). Since the first log runs, geophysical well logging has grown to a billion dollars in a global industry serving a variety of industry and research activities. Well logging geophysics is a key technology in the petroleum industry. In the minerals industry, it is a widely used method for both exploration activities and for monitoring work in enforcement. In the geophysical well logging, many different physical properties can be identified for the geological characteristics surrounding the well. The ability to identify different traits is the best ability in well logging geophysics. Different types of information obtained reflect different aspects of geology and often complement each other in nature (Schlumberger, 1989).

Based on the above explanation, it is very clear that Well logging is a very appropriate method for determining the source of oil in the soil, as well logging provides the necessary data to evaluate the quantity of petroleum quantities in actual situations and conditions. Furthermore, it will provide assurance on the results of resource and reserve estimates. (Hearst & Nelson, 1985). Therefore, the use of well logging in petroleum exploration is important and necessary, especially in the determination of sources and estimates of resources or reserves (Chemali & Dirksen, 2017).

Since 1926 until now, well logging technology has undergone many recent developments and innovations to accommodate the needs of oil and gas industry in finding and knowing the prospect of petroleum in a reservoir. from start to conventional tools like GR log, SP log, Density log etc. up to unconventional tools like NMR, dipmeter. even the data retrieval technique has now developed into LWD (Logging While Drilling) where between log and drilling recording is done simultaneously, so hopefully this condition can reflect the most "real time" condition of the formation (Schlumberger, 1985).

2.1. Logging While Drilling Method

To take measurements of the formation while drilling, Many company have developed LWD tools. These tools are designed to provide one or more logging services. Each tool is installed inside a drill collar at the shop before being sent to the rig. The rig crew adds the LWD drill collar to the drillstring, close to the drill bit, before drilling begins. Sensors inside the LWD tool take the formation measurements. The sensors can be powered either by the MWD tool or by lithium batteries in the LWD tool (Ellis & Singer, 2007).

Logs that are created during drilling are called real-time logs (see Fig 2). In Figure 2 explain how LWD tool produced from real-time data transmitted to the surface computer from downhole. To transmit data, the LWD tool sends its measurements to the MWD tool. The MWD tool sends the data uphole by producing pressure waves in the mud inside the drillstring. The signal wave is detected by a surface sensor and sent to the surface computer for processing into logs. Due to constraints imposed by drilling and the method of telemetry, real-time data is typically low-density, and it includes only one or two variables per datapoint. Real-time logs provide enough information for the client to make quick decisions during drilling (Youmans, 1986; Herrmann, 1997).

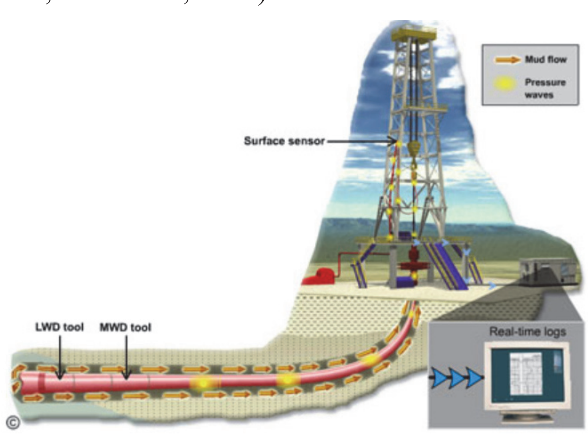

Fig. 2. Logging While Drilling Produce Real Time Log

In addition to producing real-time data, the LWD tool also records data in its internal computer memory. There is no limit to the amount of data that can be recorded other than the size of the tool's memory. Therefore, recorded data typically has a higher density and includes more variables per datapoint than real-time data. This gives a higher resolution image of the formation (Darling, 2005). Recorded mode data is retrieved from the LWD tool when drilling stops and the tool is brought to the surface. The field engineer dumps the data from the tool into the surface computer to produce recorded mode logs. Recorded mode logs are given to the client at the end of each bit run and at the end of the job.

2.2. Logging While Drilling Operation

The field engineer runs the LWD bit run after the tools are made up in the BHA, and the BHA goes in the borehole. To run the job, the field engineer performs specific tasks during each bit run and at the end of the job. In this section, you will learn what the field engineer does before, during, and after the completion of an LWD bit run and after the completion of an LWD job. Tasks: (1) Tripping In, (2) Drilling, (3) Tripping Out, (4) Tools at Surface, (5) Post-Job Tasks (Li, 2003).

2.2.1. Tripping In

At the beginning of each job, the field engineer starts a new tally book that is used for the duration of the job. Before the start of each bit run, the field engineer makes a list in the tally book of the stands or joints to be used in the run. Next, the field engineer calculates Pipe + BHA length and Driller's Depth for each stand or joint and enters the values into the tally book (Baaziz & Quoniam, 2015).

At the start of each bit run, when the BHA is in the shallow part of the borehole, the field engineer tests the downhole tools. The LWD tools are tested to make sure they are communicating with each other and with the MWD tool and surface computer. To perform the test, the field engineer asks the driller to start the pumps. When the flow rate rises above a set threshold, the MWD tool turns on and begins data transmission. All the LWD tools should be taking readings and sending data to the MWD tool. To verify this, the field engineer looks at the tool readings and the status word from each tool in the surface computer. If the surface computer does not receive any data it could indicate a problem with the SPT (surface sensor for MWD signal), computer demodulation setup, or downhole tools. If the problem cannot be corrected with the tools still in the borehole, the tools will need to be pulled out of hole and either fixed or replaced (Pardo et al., 2013).

If any of the LWD tool readings show maximum values, there is a communication problem in the extenders between the LWD tools and the MWD tool. The maximum value is dependent on the number of bits in the binary word. When the MWD tool turns on, it takes a survey and transmits the data uphole. To determine if the tool is operating correctly, the field engineer checks G, H and Dip in the Survey Control Panel. G, H and Dip are the primary reference criteria for evaluating a downhole survey (Herrman, 1997). The field engineer knows the tool is working properly when G, H and Dip are within the tolerances defined by the reference and deviation values coming from Geomag.

When the bit is 2 to 4 stands, or joints, off bottom, the field engineer sets Block Position, Bit Depth, and Hole Depth in the surface computer. To do this, the field engineer has the driller place the top of the tool joint at the rotary table. After setting Bit Depth, the engineer compares it to Driller's Depth as the last 2 to 4 stands are tripped into the hole. The surface computer depth can be off from Driller's Depth. This is not a problem as long as the difference does not exceed 3 feet approximately when tripping in. The goal is to make sure that the depth tracking procedure is accurate enough to be used during drilling with only minor adjustments required. In this example, the bit will be on bottom at stand 27. Therefore, the field engineer should monitor Bit Depth when stands 26 and 27 are tripped in (Herron et al., 2014). If Bit Depth is close to Driller's Depth at each stand, it means the depth sensor is calibrated correctly and working properly, and that block position is set correctly.

2.2.2. Drilling

When drilling begins, the field engineer starts comparing Hole Depth in the surface computer to Driller's Depth after each stand or joint is drilled. When the difference between Hole Depth and Driller's Depth is less than 2 feet, the field engineer should adjust Block Position in the surface computer rather than reset Hole Depth. A decrease in Block Position reduces the number of pulses coming from the depth encoder. An increase in Block Position increases the number of pulses. By changing Block Position, the computer calculates the depth correction (Sun et al., 2010).

The field engineer monitors operational conditions of the tools during drilling. It is important to be on guard for tool problems caused by downhole conditions. The field engineer should keep a watchful eye on the following tool measurements in the surface computer. When the MWD tool transmits survey data, the field engineer checks dogleg severity (DLS) on the Survey Control Panel. DLS should be compared to the tool ratings. If DLS is too high for a tool, the field engineer should inform the Company Man or directional driller that the tool joints may fail if DLS is not reduced. If the tool joints fail, the tools will disconnect from the drillstring. A note should be made in the field engineer's tally book regarding this situation (Alford et al., 2012).

If there is an IWOB (Integrated Weight-On-Bit) sensor on the MWD tool, the field engineer can monitor downhole torque on the drillstring. The torque should be compared to the tool ratings. If torque on the drillstring approaches a tool rating, it can cause the tool connection to break. The field engineer should inform the Company Man or driller of any large increase in downhole torque. All the LWD and MWD tools provide real-time shock data. If there are high shock levels on the surface computer screen, the Company Man or driller should be notified. The field engineer can offer suggestions on how to handle high shocks, such as the following (Annaiyappa et al., 2012): Decrease weight-on-bit, Change RPM, come off-bottom and work the pipe to release torque in the drillstring.

A reduction in pump pressure is a problem when it is caused by a washout, which is a hole in the drillstring. The washout allows mud to flow out of the drillstring and into the annulus, causing pump pressure to drop. The drop in pump pressure reduces the flow to the turbine that powers the MWD tool, lowering turbine RPM. A decrease in pump pressure does NOT automatically mean a washout. To determine if there is a washout, the field engineer should find out if the driller has changed the pump strokes or the flow rate. If nothing has been changed, the field engineer should check the MWD turbine RPM to see if it has decreased. If it has, it means there is a washout above the MWD tool. If turbine RPM has not decreased, there may be a washout below the MWD tool. If a washout is detected, the field engineer should advise the Company Man of the findings (Abimbola et al. 2016). Lowering the flow rate caused the decrease in pump pressure and turbine RPM. This does NOT indicate a washout.

2.2.3. Tripping Out

At the end of a bit run, while the drillstring is being tripped out of hole, the field engineer makes the following decisions about the next run. To decide can the same batteries go back in the hole in the next run, the hours remaining on the batteries is calculated and compared to the expected length of the next run. If the same batteries cannot be used again, the field engineer should select, depassivate and test new batteries in preparation for loading into the LWD tool (Seydoux et al., 2014).

To decide can the same tools go back in the hole in the next run. This decision is affected by whether or not the tool failed in the current run. Also, if the client has requested a different combination of tools for the next run, then the same tools may or may not be used (Qleibo et al., 2014). If the field engineer needs to add or change LWD tools, the tools should be tested and prepared for the next bit run at this time.

During the trip out, the field engineer should verify that the time-depth file is complete and in good order, correcting for any depth changes that were made during the run. When the LWD tools are brought to the surface, the field engineer will dump recorded mode data from the tools into the surface computer. The data will be merged with the time-depth file to produce the recorded mode logs (Pike, 2012). By preparing the time-depth file before the tools arrive at the surface, recorded mode logs can be produced quickly and with less inconvenience to the client.

When the LWD tools reach the surface, they will need to be programmed with different configuration files and profiles before the next run. The field engineer should evaluate what the tools will be logging in the next run. For example, sometimes the client may want to log some sections again to get a second look at a payzone or an anomaly. The field engineer should plan for this ahead of time (Alford et al., 2012). The field engineer completes the current bit run summary, prepares a new bit run summary for the next run, and gathers any notes taken during the run and files them in the job folder.

2.2.4. Tool at Surface

The field engineer should be on the drill floor when the tools are lifted above the rotary table. When the rig crew disconnects the tool from the BHA, the tool collar and connections should be inspected for damage or scarring (Schlumberger, 1989). Then, the field engineer should run water from a hose through the tool before it is picked up and placed in the pipe deck.

If the tool will be rerun in the hole, the field engineer must dump data from the tool while it is still connected to the drillstring. The field engineer runs a cable from the logging unit to the drill floor to dump data. The cable is connected to the Readout Port on the tool. To dump the data, the Readout port cover must be pulled out of the tool. In some districts, opening the Readout Port in Zone 0 is considered hot work. Hot work is any activity that can provide an ignition source in a hazardous atmosphere. The field engineer should check with the rig safety manager before doing any hot work. Stand away from the Readout Port when pulling out the cover. There may be trapped pressure inside. Water should not be allowed to get into the opening (Asquith & Krygowski, 2004). The cable is then attached to the port and to the computer and recorded data is dumped.

After the recorded data is dumped from the tool, the field engineer makes a Techlog. The Techlog will provide clues if something went wrong in the previous run. If the tool worked properly, it can be reprogrammed for the next run. If not, further investigation is needed prior to re-running the tool. Next, the field engineer processes the Time-Data file from the tool with the Time-Depth file to produce a recorded mode log. The log should be checked for errors or unusual data. The recorded mode log should be compared to the real-time log. If the two logs don't agree, an investigation should be made into the cause of the problem (Melissinos & Napolitano, 2003). If the logs agree, they can be given to the client (Collett et al., 2012).

2.2.5. Post Job Task

When the LWD job is done, the field engineer performs the following tasks: During a rig down, all sensors are uninstalled and equipment is packed for shipping. Prepare the logs for the FSM debriefing by annotating, editing and combining data to turn them into a deliverable product for the client. The field engineer hands the finalized logs to the FSM. The FSM gives final approval on the logs. The logs are then given to the client. No job is complete until the client is happy with the job and has accepted the logs. Re-inventory the logging unit in preparation for the next job (Hearst and Nelson, 1985).

3. Measurement While Drilling

The purpose of the MWD signal is to transmit measurement data from downhole to the surface for processing. This overview introduces the signal and the flow of data. In the remaining sections of this module, you will study the signal in more detail - how it is generated, encoded with data, and demodulated. Telemetry is the process of transmitting data from one place to another. In the case of the MWD signal, transmission is from the downhole MWD tool to the surface computer. This overview introduces you to the following steps in the MWD telemetry process: (1) Downhole measurements, (2) Data conversion, (3) Signal generation, (4) Signal propagation, (5) Surface sensor acquisition, (6) Signal demodulation (Schlumberger, 1985).

Drilling uses MWD and LWD tools to make real-time downhole measurements during drilling. These measurements are an important part of the service provided to customers. They allow for formation evaluation, wellbore positioning, and steering the well. Before sending data uphole, the LWD and MWD tools convert each downhole measurement to a binary data word. Then, the MWD tool combines the words into frames. Sync words and error checking information are also added to each frame. During drilling, mud is pumped down the drillpipe, through the MWD tool, and out the bit. To send data uphole, the MWD tool generates a signal by creating pressure pulses in the mud. The tool encodes the binary data within the signal. Signal pulses from the MWD tool propagate back up the mud column inside the drillpipe. At the surface, sensors detect the mud pulses and convert them to an electrical signal. Then, the signal is sent to the surface system computer where the data is decoded and processed. Signal demodulation consists of two processes: receiving and frame decoding. The surface system computer receives binary data from the signal. The receiver sends the binary data to a frame decoder. The frame decoder extracts data words from each frame. These words are stored in a database. The surface system software uses the database to generate output, for example, logs and wellbore coordinates (Schlumberger, 1989). The PowerPulse uses a modulator to generate a continuous wave of positive pulses. The modulator consists of a rotor and stator with four lobes each. The rotor is driven by the modulator motor, which is powered by the turbine alternator in the tool. The flow of mud through the tool powers the turbine. As it turns, the rotor opens and partially closes the space between the lobes of the stator. When the spaces are open, mud pressure is at its minimum. When blocked, mud pressure is at its maximum. Doing this continuously creates the continuous wave (Ellis and Singer, 2007).

4. Problem During Drilling

The quality of LWD data is critical to the success of any LWD job. Therefore, it is important that the field engineer understand the factors that affect data quality. They are Depth Calculation, Sensor Malfunction and LWD Tools Measurements Fault. The major factor is the depth calculation in the surface computer. Because it is calculated, it is prone to error. In this section, we will examine how depth is calculated, and the problems that can produce depth errors. Then, we will address the other factors affecting data quality.

4.1. Sensor Problem

The depth sensor or the hook load sensor can produce erroneous measurements, or no measurements, due to Sensor Malfunction. The main factors that cause sensor malfunction are Improper Sensor Installation and Incorrect Sensor Calibration. Logging While Drilling uses two types of sensors, Analog and Digital. The analog and digital sensors connect to the analog and digital channels, respectively. The signal pressure transducers (SPT) that detect the MWD signal are a special case of analog sensor. They connect to the pressure channels. The drawworks and geolograph encoders are a special case of digital sensor (Melissinos & Napolitano, 2003). They connect to the encoder channels.

Analog and pressure sensors produce a continuous current or continuous voltage signal. The signal varies in direct proportion to the property being measured. For example, the hook load sensor produces an analog signal. The greater the tension on the deadline, the greater the current produced by the sensor. Two types of digital sensors are encoders and counters. They all transmit a fixed voltage signal. The depth encoders generate 5 VDC. The counter generates 12 VDC. The power supply to both types is 12 VDC (Bittar et al, 2017). The two types of digital sensors are wired differently from one another.

In a typical 12 hour tour, you may be required to install one or more sensors. For example, the Clamp-Line Tensiometer (CLT) has to be removed and reinstalled every time the drilling line is slipped and cut. This happens every 500 feet of drilling, approximately. Sensors also have to be replaced when they malfunction. Fig. 3 shows some of the sensors you may be asked to install while drilling. There six kinds of sensor that uses while drilling, such as; Drawworks Encoder, Clamp-Line Tensiometer, Pump Pressure, Pump Stroke Counter, Rotary Torque and Singla Pressure Transducer (see Fig 3). Sometimes sensor malfunction happens when the crew do not install the sensor properly (Herron et al., 2014). In the next topic we will explain how to install and calibrate the sensor properly.

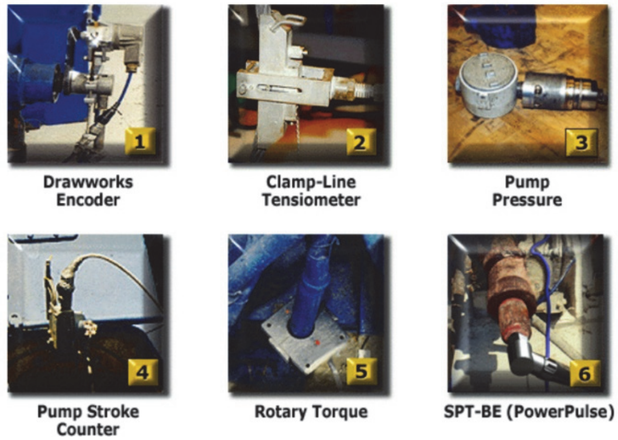

Fig. 3. Logging While Drilling Sensor

4.1.1. Drawwork Encoder

Fig. 4 explains how to install drawwork encoder properly. The Location of this sensor is attached at Drawworks Shaft.

Drawwork Encoder installation steps:

1. Install the timing belt around the encoder pulley and split-ring pulley.
2. Install the encoder's split-ring pulley around the shaft between the rotorseal air coupler and the drawworks.
3. Install the encoder using the mounting bracket.

Some Considerations Drawwork Encoder installation:

1. Talk to the driller before installation. You may need the rig mechanic to help you.
2. Use a proper size split-ring pulley to prevent slippage on the shaft.
3. You will have to remove the rotorseal air coupler or its air line to install the timing belt.
4. Hang a spare timing belt between the rotorseal and drawworks for future replacement (Schlumberger, 1985).

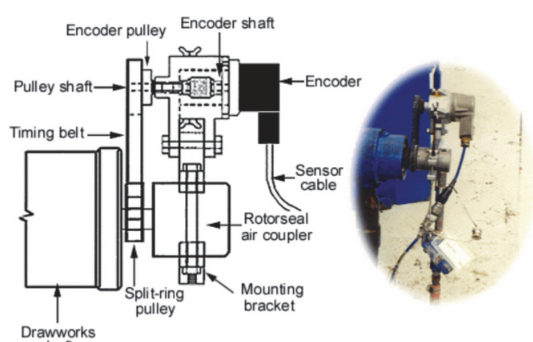

Fig. 4. Drawwork Encoder Installation

4.1.2 Clamp-Line Tension Meter

Fig. 5 explains how to install clamp-line tension meter properly. The Location of this sensor is attached at Deadline.

Clamp-Line Tension Meter installation steps:

1. Unscrew the bolts that connect the front and back pieces.
2. Place the front and back pieces around the deadline 3 or 4 feet above the deadline anchor.
3. Tighten the bolts.
4. Push in the indicator button.
5. Using a wrench, tighten the installation screw until the proper torque is reached, or the indicator button pops out.

Some considerations during Clamp-Line Tension Meter installation:

1. The CLT is heavy. Installation may require two people.
2. Choose an accessible spot on the deadline. The CLT must be reinstalled every time the drilling line is slipped and cut (Schlumberger, 1989).

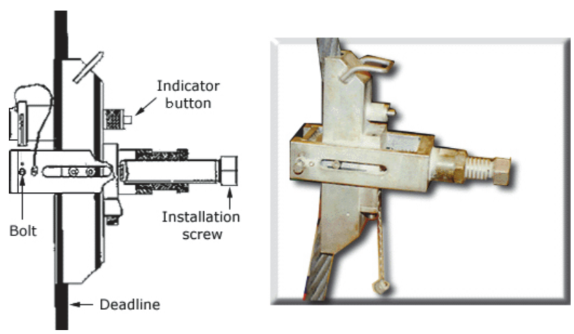

Fig 5. Clamp-Line Tension Meter Installation

4.1.3 Pump Pressure

Fig. 6 shows how to install pump pressure properly. The Location of this sensor is attached at Standpipe Manifold.

Pump Pressure installation steps:

1. Make sure the mud pumps are turned off.
2. Make sure there's no pressure in the standpipe.
3. Make sure the hydraulic line is full of fluid.
4. Place the transducer in an out-of-the-way place

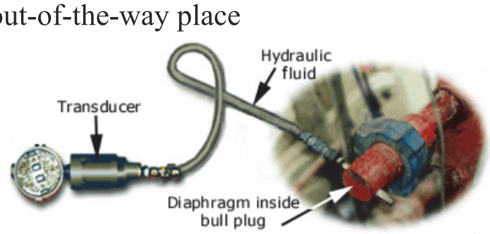

Fig. 6. Pump Pressure Installation

Some considerations during Clamp-Line Tension Meter installation:

1. Make sure the hydraulic line is positioned so stress won't be put on it.
2. You may have to install the bull plug. If so, connect the bull plug containing the diaphragm to a t-fitting or hammer union on the standpipe manifold.
3. Install the bull plug on topside of manifold to prevent mud debris from clogging the diaphragm (Hearst and Nelson, 1985).

4.1.4 Pump Stroke Counter

In the Fig. 8 explain how to install pump stroke counter properly. The Location of this sensor is attached at Pump Frame.

Pump Stroke Counter installation steps:

1. Clamp the sensor to the pump frame.
2. Position the sensor so that the arm drops down close to the pump piston. The arm and switch must be activated by the piston's movement.

Some considerations during Clamp-Line Tension Meter installation:
1. If the pump is on when you install the sensor, avoid getting your clothing or hands caught in moving parts (Youmans, 1968).

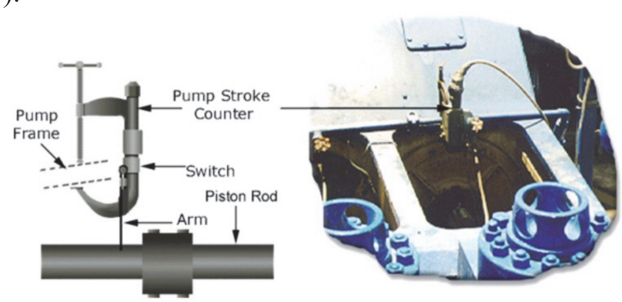

Fig. 7. Pump Stroke Counter Installation

4.1.5 Rotary Torque

Fig. 8 explains how to install rotary torque properly. The Location of this sensor is attached at Top Drive Power Cable.

Pump Stroke Counter installation steps:
1. Unfasten clamping lugs on sides of sensor.
2. The red dots should both be on the same side. With both red dots facing the flow of current, clamp the two parts around the power cable.
3. Fasten the clamping lugs.

Some considerations during Clamp-Line Tension Meter installation:
1. Current should flow toward the red dots. The sensor is directional. It only works if current flows through it in the correct direction (Ellis & Singer, 2008).

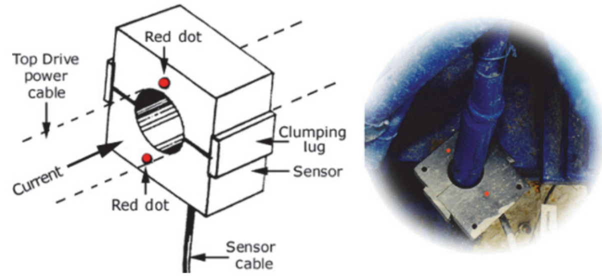

Fig. 8. Rotary Torque Installation

4.1.6 Signal Pressure Transducer (SPT)

Fig. 9 explains how to install SPT properly. SPT1 is typically installed at the top of the standpipe. SPT2 is typically installed at the bottom of the standpipe, close to or on the manifold.

Pump Stroke Counter installation steps:

1. Wrap the SPT threads with Teflon tape.
2. Screw the SPT into the threaded hole in the standpipe.
3. Torque the 3/4" hex to 50 ft/lbs.

Some considerations during Clamp-Line Tension Meter installation:

1. Use the torque wrench on the 3/4" hex only and nowhere else, otherwise you may damage the sensor's crystal (Darling, 2005).

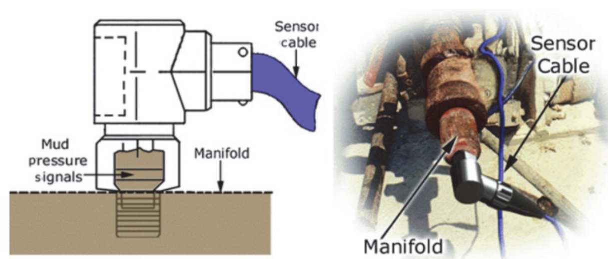

Fig. 9. Rotary Torque Installation.

4.2. Signal Problem

There are 3 major types of signal problems, as follows: Low signal strength, Noise, Signal distortion. Drilling conditions can cause low signal strength at the surface. The following are the most common causes of low signal strength: Depth of the well, High mud viscosity, Mud flow rate, Mud condition, Signal frequency, Pipe ID, Radiation loss (Youmans, 1986).

The MWD signal always loses some energy as it propagates uphole to the surface. As the MWD tool goes deeper, the signal must travel over longer distances. The longer the distance, the more signal energy that is lost. High mud viscosity produces more friction between the mud molecules. Friction weakens the signal as it propagates uphole through the mud. Viscosity is the biggest destroyer of the MWD signal. In colder climates, the mud cools and gels in the mud pits. This increases mud viscosity (Li, 2003).

The mud flow rate is the major consideration when setting the MWD tool modulator gap. When the gap is too large for the flow rate, the tool produces a weak signal. Gas or air in the mud has the effect of weakening the signal. For example, malfunctioning pumps can pump air into the mud, thereby reducing signal strength as the signal propagates uphole. Low frequency waves propagate through the mud better than higher frequency waves because the mud acts as a lowpass filter. Low frequency energy passes through the mud while the energy at higher frequencies is filtered out (Herrman, 1997). This filtering effect is more pronounced with increasing depth. The severity of the filtering effect varies depending on mud type.

The drillstring can be made up from several different sizes of drillpipe. The smaller the internal diameter of the pipe, the greater the loss of signal energy (attenuation) due to friction as the signal propagates uphole inside the drillstring. As the signal propagates uphole inside the drillstring, it loses energy horizontally out through the walls of the drillpipe. The amount of radiation loss is affected by pipe size, wall strength and conditions in the annulus. When signal strength is low, signal power within the telemetry bandwidth will be below expected levels. It is not possible to simply view the signal in the time domain trace, power density spectrum or spectrogram and see low signal strength. Instead, it requires an evaluation of current drilling conditions, which is beyond the scope of this section (Darling, 2005).

After drilling begins, there is little the field engineer can do to increase signal strength. Nothing can be done in the surface software because the energy loss (attenuation) occurs before the signal reaches the surface. Also, in most cases, field engineer can not change mud viscosity or flow rate to increase signal strength. Therefore, to ensure adequate signal strength, the MWD tool modulator configuration must be set for the expected flow rate before drilling begins. As explained in another section, the size of the gap for a given flow rate controls the size of the pressure drop across the modulator or pulser in the MWD tool. The larger the pressure drop, the stronger the signal (Herron et al., 2014).

4.3. Pump Noise

There are three main sources of noise, as follows: Mud pumps, Downhole equipment, Electrical equipment (Sun et al., 2010). Pump noise is stable and repetitive, producing constant, steady frequencies. Consequently, the noise can appear as distinct peaks on the power density spectrum and as horizontal lines on the spectrogram. Normally, the biggest problem you will face is interference from the mud pumps because they are close to the SPTs. A typical rig uses two triplex (3 cylinders) positive displacement pumps to move drilling fluid through the circulation system (Bittar et al, 2017).

Because pump noise is stable and repetitive, the frequencies can be predicted. When pump noise is predicted to fall within the telemetry bandwidth, the basic solution is to change the pump stroke rate. The stroke rate is changed so that the frequency of the pump noise falls outside the telemetry bandwidth. Another solution is to make sure that the pulsation dampener is operating correctly. The pulsation dampener is located on the pump. Its purpose is to extend the life of the hoses and pipes by dampening the pressure fluctuations produced by the pumps. When it is operating correctly, it has the effect of weakening pump noise. Differential filtering is a software option for canceling out pump noise. To use it, two SPTs must be rigged up. In the case shown here, SPT1 is at the top of the standpipe, closest to downhole and SPT2 is at the bottom of the standpipe, closest to the mud pumps. The software combines the signals from both SPTs to cancel out the pump noise (Schlumberger, 1985).

If the pump stroke rate is constant, a notch filter can be used to filter out the pump noise frequency that falls within the telemetry bandwidth. The filter will screen out a narrow range of frequencies around the notch. When the pump noise can NOT be moved away from the telemetry band, or filtered or cancelled out, the MWD signal carrier frequency can be changed to move the bandwidth away from the noise (Hearst and Nelson, 1985).

4.4.Signal Distortion

As the MWD signal propagates to the surface, it can be distorted when it encounters a change in the cross-sectional area of a pipe, a valve, or any other component of the circulating system. The distortion is due to some of the wave being transmitted forward and some being transmitted back. This is called a reflection. Reflections interfere with subsequent waves. When a reflection is also reflected, it is called an echo. Echoes and reflections reduce signal strength. At some points in the circulating system, signal distortion may be so severe that the signal disappears. These locations are called null points. Null points are frequency dependent. If an SPT is installed at one of these null points, it will not detect the signal at that frequency. For example, if the SPT is installed at a 10 Hz null point, you would see a lack of signal at 10 Hz on the power density spectrum, as shown here (Herron et al., 2014).

It is difficult to avoid the occurrence of echoes and reflections because pipe diameters often change between lengths of pipe and equipment. The following is a list of possible solutions: Large changes in pipe diameter in the drillstring should be avoided. The equalizer receiver, a type of receiver, can be used to counteract signal distortion. The carrier frequency can be moved so that the null point does not fall within the telemetry bandwidth. The SPT can be re-installed so that it is no longer at the null point. This is a demodulation technique similar to differential filtering. It attempts to correct for the effects of echoes and reflections by strengthening the MWD signal (Pilkington & Tudoeschuck, 1991).

4.5. Sensor Calibration

We will go through the same basic steps to calibrate the hook load sensor as you did to calibrate the pump pressure sensor. You will use the driller's hook load gauge as the outside measurement source.
Steps to Calibrate Sensor:

1. With the equipment at a low point, take a measurement with an outside source and record it.
2. Record the counts for the low measurement in the computer.
3. With the equipment at a high point, take a measurement with an outside source and record it.
4. Record the counts for the high measurement in the computer.
5. Have the computer calculate the linear relationship (Sun et al., 2010).

4.6. Programming Logging While Drilling Tool

The purpose of program the tools so they will take the necessary measurements correctly. Connect the tool's Readout Port to the surface computer in the logging unit. Programming involves the following steps (Hearst & Nelson, 1985):

1. Check the OST sheet
2. Load a configuration file into the tool
3. Set up a profile
4. Initialize the LWD clock and surface computer clock to the same time
5. Monitor tool operation at the surface

Technicians at the shop in town perform a system test on each tool before it is sent to the rig. They also calibrate the tool. They fill out an Outgoing System Test (OST) sheet. The sheet contains coefficients from the calibration. You will enter these coefficients into the configuration file of the tool. The serial number of the tool is also on the sheet. Check it against the serial number in your tally book. Make sure they match. If they don't, you may have the wrong OST sheet or tool (Pardo et al., 2013). In any case, you don't want to enter the wrong coefficients into the configuration file.

The field engineer sets up a configuration file and loads it into the tool. The file tells the tool the type of measurements to take, and the scan and record rates for each type. The field engineer loads a profile into the tool. The profile tells the tool how long to use the configuration file. For example, if multiple configuration files are set up for a run, the profile indicates how long to use each one. When the field engineer initializes the tool, the tool clock is set to the same time as the surface computer clock, expressed in seconds. The clocks are typically set to the current time of day. For example, if current time of day is 12:10:40, the time in both clocks would equal 43,840 seconds. With the LWD tool connected to the surface computer, the field engineer monitors voltage, temperature, and various other parameters depending on tool type, to make sure the tool is working properly. Also, the field engineer checks the status word coming from the tool (Annaiyappa et al., 2012). The status word should indicate if the tool is working properly or not.

5 . Conclusions

Logging while drilling means taking measurements of the petrophysical properties of the formation (e.g., hydrocarbon saturation, lithology) around the borehole as the well is drilled. The client uses LWD measurements to evaluate the production value of the reservoir during drilling and after drilling is complete. Therefore, it is important that LWD data be accurate. Three common services are Natural Gamma Ray, Resistivity, and Porosity and Bulk Density. The output of an LWD service is a log (see fig.1). A log is a graphical representation of the properties of the formation. Logs are critical documents. Some problem that may occur during drilling are below:

- Sensor Problem

The depth sensor or the hook load sensor can produce erroneous measurements, or no measurements, due to Sensor Malfunction. The main factors that cause sensor malfunction are Improper Sensor Installation and Incorrect Sensor Calibration. Logging While Drilling uses two types of sensors, Analog and Digital. The analog and digital sensors connect to the analog and digital channels, respectively. The signal pressure transducers (SPT) that detect the MWD signal are a special case of analog sensor. They connect to the pressure channels. The drawworks and geolograph encoders are a special case of digital sensor. They connect to the encoder channels.

- Signal Problem

There are 3 major types of signal problems, as follows: Low signal strength, Noise, Signal distortion. Drilling conditions can cause low signal strength at the surface. The following are the most common causes of low signal strength: Depth of the well, High mud viscosity, Mud flow rate, Mud condition, Signal frequency, Pipe ID, Radiation loss.

- Pump Noise

There are three main sources of noise, as follows: Mud pumps, Downhole equipment, Electrical

- Signal Distotrion

As the MWD signal propagates to the surface, it can be distorted when it encounters a change in the cross-sectional area of a pipe, a valve, or any other component of the circulating system. The distortion is due to some of the wave being transmitted forward and some being transmitted back

- Programming Logging While Drilling Tool

The purpose of program the tools so they will take the necessary measurements correctly. Connect the tool's Readout Port to the surface computer in the logging unit. Programming involves the following steps: (1) Check the OST sheet. (2) Load a configuration file into the tool. (3) Set up a profile. (4) Initialize the LWD clock and surface computer clock to the same time. (5) Monitor tool operation at the surface.

- Tech Log and Quality Control Log

To verify the quality of LWD data, the field engineer can generate Techlogs (time raw data) and Quality Control logs (depth raw data) during recorded mode processing. A Techlog is a time-based plot of the raw measurements taken by the LWD tool. The Quality Control log is a depth-based log of raw and calculated measurements with environmental corrections applied. Together, the Techlog and Quality Control log allow the field engineer to carry out a Quality Control process and ensure that the tools were working properly.

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