NOVEL APPROACHES FOR COST-EFFICIENT WIRELINE WELL INTERVENTION

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CERTIFICATION OF ORIGINALITY

This is to 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 that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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(AZRI BIN KHAIRUDIN)

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ABSTRACT

The slickline technology goes beyond pass decades in ensuring proper well intervention operation to operate successfully. Plenty of operations that works and operate by using the slickline technology which referring to the light load intervention that require less manpower, minimum load usage and less data requirement. . Its portability has allowed it to be cost efficient for performing these services in remote locations and on satellite platforms. In order to perform a much complicated operations via the well intervention, the option of using the slickline technology is off the hook which bring to much more manpower involvements, higher load usage and details data requirements which leads to more than one unit of wireline crew needed on board. By using more than one crew on board and others additional requirements, it will lead to the increment of cost of the operation.

Therefore, slickline service capabilities and completion equipment have continually been improved over the last decade; a significant increase in the usage of slick line to replace other more costly service options has only recently been noted. By explaning details of the new technology, it show on the capability that new technology of slickline purpose can covers much complicated operations via slickline and thus decrease the cost for each of intervention. Comparison between old classic technology and newly develop technology in term of cost per operation proves that the slickline technology has been improved significantly in helping oil and gas company to carry out operations more effectively and efficiently.

As to backup this thesis, few cases histories based on existence of slickline intervention whom use the newly develop technology being brought up and explain and been compare to determine the success and level of efficiently newly develop slickline technology in term of few aspects and characteristic. The newly develop slickline works wonder and just could be the key milestone of improvement of slickline technology for future reference.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

In oil and gas industry, slickline servicing has provided an effective means for performing well maintenance by high-speed mechanical deployment, manipulation, and retrieval of downhole service tools in all types of wells, including those with high pressure and flowing well conditions. Its portability has allowed it to be cost efficient for performing these services in remote locations and on satellite platforms.

In addition, slickline service capabilities and completion equipment have continually been improved over the last decade, a significant increase in the usage of slick line to replace other more costly service options has only recently been noted. This has been due to several factors. The strained economic climate in the oilfield has continually required conceptual changes in operational strategies and equipment, but until the declining economic conditions forced a resurgence of investigation into enhanced efficiency strategies, very little attention had been paid to slickline depth measurement capabilities and the technical merit of surface measurement accuracy during normal operations

Precise measurements have become more critical for production strings with multiple profiles closely spaced in a tubing string,(especially if a locating profile had become fouled with scale or other well debris) or in tubing strings without locating profiles such as in the new nipple less, monobore completions.

1.2 Problem Statement

Although slickline-related technologies have been improved throughout the last 50 years, a significant increase in use of slickline to replace the other traditional service options has only recently been noted. Several factors have been instrumental in effecting this change:

1. Economic decline in oil production
2. Problem of gathering and obtain precise measurement regarding the measured depth (MD) and also the total vertical depth (TVD).
3. The combination of two alternatives, the slick line and the wire line itself.

1.3 .Objectives

The objective of this research will discuss on the slickline technology that helps in providing alternatives that helps in term of economically that were traditionally reserved for more costly options. Case study helps in enlarged the innovative low cost service options that the industry has been looking for.

Other than that, I would like to give a detail analysis on the solution regarding this few factors that cause the wireline to be able to produce more newly technology.

1. Economic decline in oil production
2. Problem of gathering and obtain precise measurement regarding the measured depth (MD) and also the total vertical depth (TVD).
3. The combination of two alternatives, the slick line and the wire line itself.

1.4 Scope of Study

The comparison of today’s slickline capabilities with its early usage for routine remedial workovers and maintenance best illustrates the significant advances that have occurred within slickline technology.

Today, for example, slickline can be used to set and retrieve retrievable safety valves or plugs; open and close downhole circulating devices; retrieve accurate depth/time data for correlation with memory production surveys for well diagnostics (problem identification), reservoir description, or flow analysis; provide accurate correlation of tubing casing collars; and pull and run multiple flow controls, set packers, and other downhole equipment without explosives, set monobore tools, and perform other well interventions that are dependent on measurement accuracy.

This expansion is overwhelming when considering that less than decade ago slickline was considered only for mechanical well workovers. This paper discusses the newly developed technology that allows slickline to economically provide alternatives economically to services that were traditionally reserved for more costly options. Case histories illustrate the enlarged scope of services and how the equipment combines to provide the innovative low cost service options that the industry has been seeking.

CHAPTER 2

LITERATURE REVIEW

2.1 Wireline –Intervention:

Intervention by using wireline method is well known as a light intervention in oil & gas industry. This method does not require the usage of Blow Out Preventer (BOP) or any other heavy duty equipment plus with this method mobilization and assembly is much easier and thus help in improving the frequency of interventions being carry out by time to time. Wireline intervention also can be take place in either offshore or onshore platform regardless of situation and condition. Within offshore condition, either platform or subsea the wireline intervention can be applied to both with no major problems. In addition, if using in subsea environment, heavy intervention equipment is needed in order to match the condition of the surrounding.

Normaly, underbalnced condition is needed in order to perform such operation which means the reservoir pressure is relatively higher then the well pressure exerted and thus fluid production is expected. The problem that always rise regarding this type of intervention is, how we can keep it maintain the pressure in a state of underbalance conditions and at the same time proceed with the operation with evading the blow-out effect   to encounter such problem, wirelines has been divided into 5 different class that carry different function and withstand certain types of condition downhole. Below are 5 types of wireline that are currently being used in oil and gas industry.

Type	Size of line (inch)
Slick line wireline	41/500”, 23/250”, 21/20”, 27/250”, 1/8”
Braided line Wireline	3/16”, 7/32”, ¼” and 5/16”
Heavy duty die-formed slick fishing line	7/32”, 5/16”
Mono-conductor wireline	3/16”, 7/32”, 5/16”, 3/8”, 7/16”
Multi-conductor logging wireline	15/32”

Table 2.1 Type of slickline and size of the line

Slickline

Out of all the type of wireline method, slick line has the smallest diameter compared all other alternatives. Slickline is capable of only pulling or pushing by jarring and jamming action. Thus, slick line is use mainly for fishing out tools downhole, gauge cutting, setting up plug and also memory logging. Other task that can be carried out by slick line unit are :

1. Running and pulling plugs, chokes, check valves.
2. Opening and closing circulation devices on the side pocket mandrel and also the circulation valves.
3. Checking debris inside tubing and inspection of waxe scale and corrosion.
4. Tubing perforations.
5. Depth measurement up until Measure Depth (MD) and fishing lost object downhole.

The downside of the slick line is that it has farely lower breaking strength between 7800N and 12 380N which is low in comparison to other slick line alternatives. In addition, the slick line should not be worked one its plastic limit of deformation has been exceed or reached. Such limitation usually is the 50% of its breaking point.

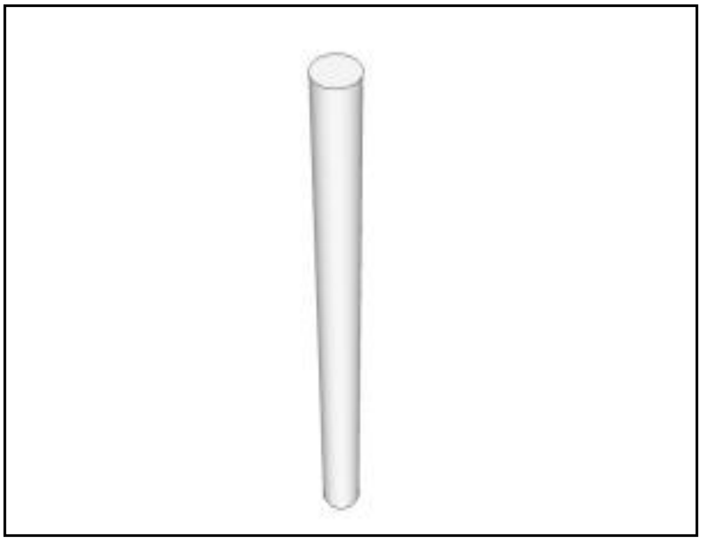


Figure 2.1 Illustration of slick line unit.
[14]

A much more complex and multi-function alternatives rather than slick line is the braided line. For the braided line it is used to pulls of heavy duty work which has two layers of spirally coiled armour wire. It is also called as “sand line” and primarily for heavy duty slick-line. This is because the working capacity is greater than the slick line and braided line is widely choose as an alternative to replace slick line because of its ability to sustain heavy load. Braided line typically used for :

1. Fishing for lost objects (heavy duty fishing)
2. Running simultaneously both temperature and pressure gauges.
3. Do all the slick line job but differ only capability of sustaining load.

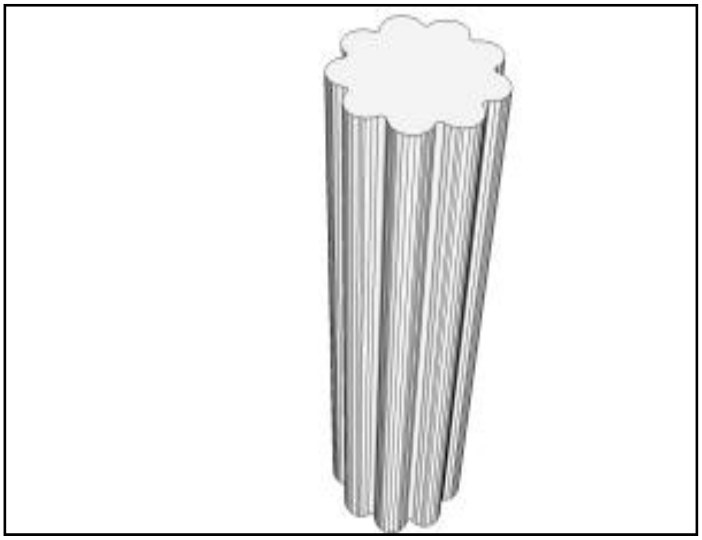


Figure 2.2 Illustration of braided line. [14]

One of the most popular slick line in the market is the Electrical line commercially known as E-Line. Its is a modification from the braided line with one or more electrics conductors in the middle of the line where its need the requirement of the source of electrical power or signal. However, it experienced a decrease in tension capacity compared to the braided line because of the present of the conductor within the braided line itself.in addition, some conductor line or E-Line consist up to 7 conductors and use exclusively for open hole logging. These logging unit often use on drilling rigs which control via a column of mud down hole.

As for the wireline intervention using these slick line type, the most important or precaution steps that need to be done is that the wells should be properly shut in and secured from any operation on the rig itself. An extra drilling team or unit called Drilling Intervention Tower (DIT) must be installed on board via any operation on the deck. The wireline equipment must be properly connected to the riser and a wireline blow-out preventer (BOP).a tool string that being connected with the slick line will carry out the process via gravity force down wards inside the borehole itself.

The important features within the wireline intervention system are:

1. Wireline
2. Stuffing box
3. Lubricator
4. Blow out preventer
5. Hydraulics power pack
6. Weight indicator
7. Measuring device
8. Control system

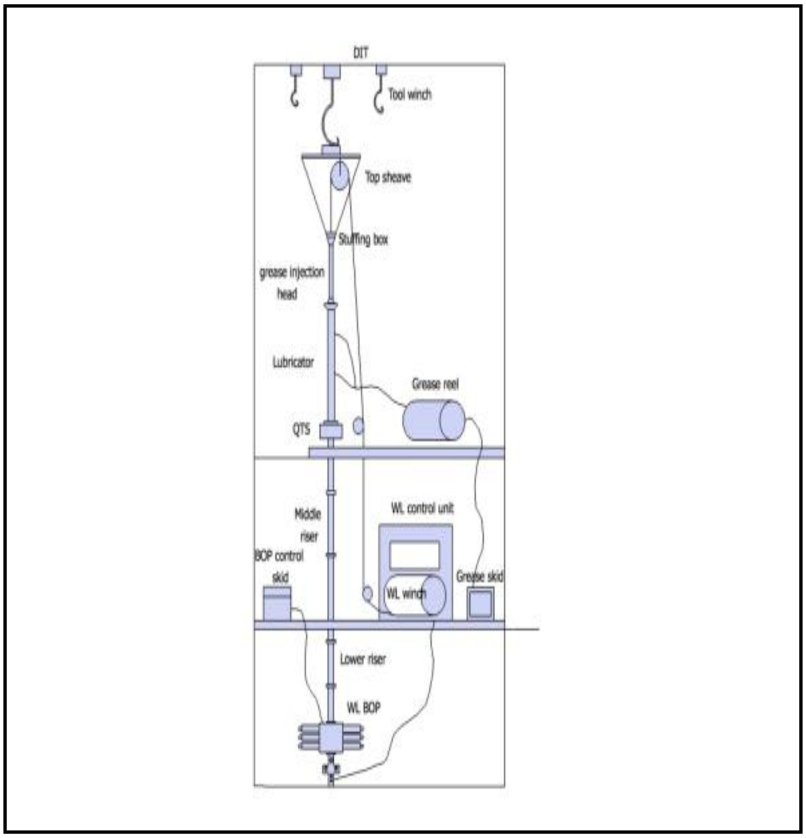


Figure 2.3 Sketch with 2-D view on the arrangement of wireline system.[14]

In addition, the most common production enhancement by using wireline is the cleaning of a well. Wells itself can be cleaned by pumping special fluids inside wellbore in order to avoid debris accumulation. Other than that, the usage of gauge cutter is one of the alternative methods for well cleaning. Gauge cutter consists of various types as illustrate below:

Figure 2.4 Type of gauge cutter*[15]*

When using the gauge cutter, several run should be conducted in order for precision and quality cleaning inside the wells. Furthermore, do not try running the gauge under the same size of casing ID because it will affect the cleaning process within the wellbore.
Other usages of the gauge cutter are:

1. Replacement of gas lifts valves.
2. Down hole cleaning
3. Replacement of DHSV.
4. Well logging

After connection to the WLBOP thus to the X-mas tree, the leak test for the system is being tested in order to verify the barriers that the system provide along the operation.

Prior to the operation, the opening and closing of the valves play an important role in determine a successful test or not. Firstly, valves that are located inside the X-mas tree need to be pressurized equally prior to opening. As the down hole safety valve (DHSV) could not work with bottom hole assembly but only if it is necessary that is during pumping of diesel using Bottom hole assembly.

Prior to the pull out of hole, pumping or injection of diesel need to be stop at once when the BHA is operated above the swab valve. Then the safety valve and hydraulic master valve need to be closed in order to do the inflow test. Diesel needed to be pumped regularly in order to prevent the debris to be accumulated in the side pocket mandrel in the bottom hole assembly. (Note: riser needed to be purge with N_2).

To get a clear picture here is the 3D overview of the wire line intervention system on DIT:

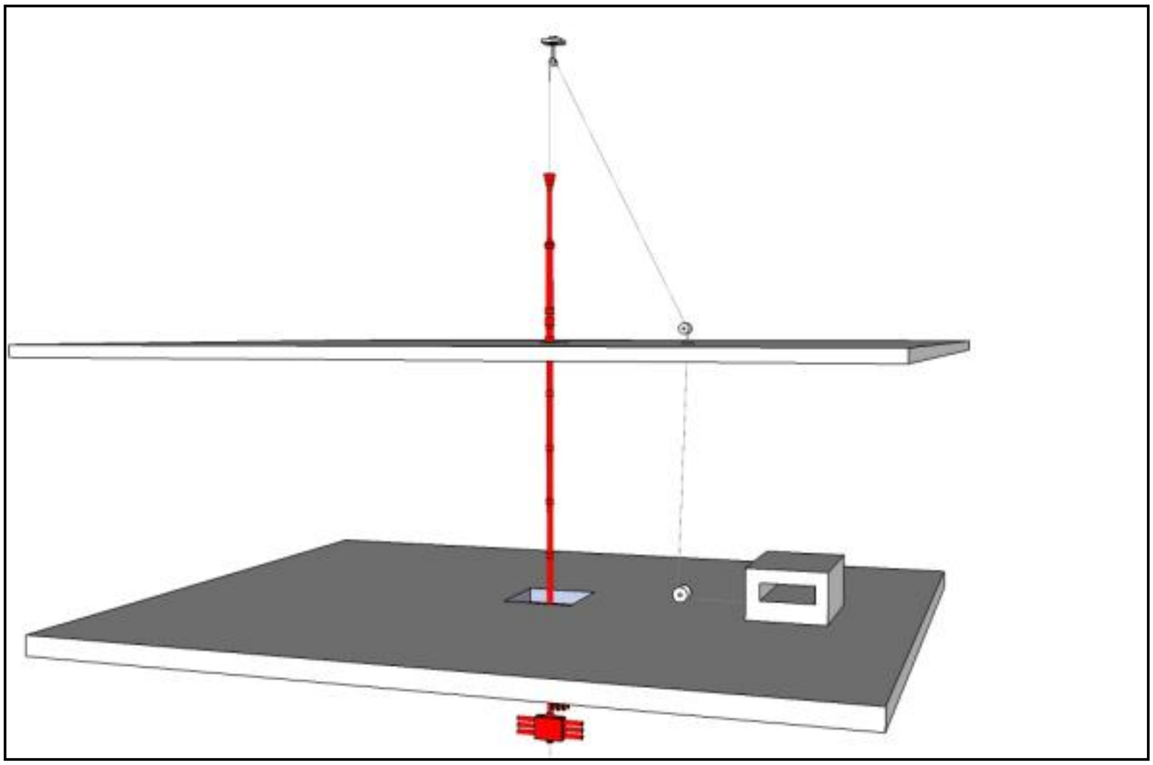


Figure 2.5: 3D view on the wireline intervention system on DIT [15]

2.2 Types of well intervention:

Economic initiatives usually drive new technologies. There has been a significant decline in the oilfield climate during the last decade, and no era has been as momentous in providing stimuli for operational change. Unfortunately, operators who seek new methods usually look to new technologies as potential problem solvers and, in so doing, overlook enhancements to the older, proven technologies that can provide the alternatives they want. This has been the case with slickline. Until the resurgence of investigation of new strategies to meet the oilfield cost constraints of the last decade, slickline service was considered only for routine mechanical workovers.

The capabilities that have changed the profile of slickline service from one of routine mechanical well workovers to a multifaceted service technology are derived from the new slickline tools that can be used independently or combined to further enhance the scope of services. The new equipment is discussed later. There are several types of well intervention that consist of wireline or slickline unit. Based on case histories, few wireline intervention methods will be explained as proof of newly improved technology help in providing a better future for the oil and gas industry. These wireline intervention methods are:

1. Plugback and tubing cut
2. Set packers
3. Fishing
4. Activating perforating gun
5. Memory gauge logging
6. Tubig cleanout and many more.

Each of the wireline intervention method need different criteria or parameters in order to ensure the wireline intervention is a successful intervention. These parameters give a huge impact to the success of the wireline intervention process. These parameters are materials used for each intervention, the limitation of the total depth either total vertical depth or measured depth, the well conditions itself regarding the pressure, temperature, shut-in or flowing does give a huge impact on intervention process. Therefore details analysis and details information need to be provided to the wireline unit so that a much clearer picture can be achieved thus lead to a much more successful intervention.

2.3 Component of Slickline Technology

These wireline methods have different operational structure that mainly required neither wireline nor slickline unit. However, particular interest will be the methodology that allowed a series of interdependent developments to be combined into a suite of new slickline well servicing tools and related equipment upgrades in order to provide more service efficiency for petroleum operators. New technology and methods have facilitated the use of slickline well servicing methods for jobs traditionally performed by electric line methods. The following sections will provide a comprehensive review of the component equipment and the specific contributions each makes in the scope of the advanced slickline service capabilities. The components that involve in the advanced slickline service capabilities are:

1. Electronic Triggering Device (ETD)
2. Electronice Setting Device (ESD)/ Downhole Power Unit (DPU)
3. The Aforementioned Slickline Tools/ Advance Measurement System (AMS)
4. Slickline Collar Locator (SLCL)
5. Slickline Inspection Device
6. Data/Job Logger

Electronic Triggering Devices (ETD):

The electronic trigger device (ETD) brings perforating capabilities to slickline services (Fig. 2.1). By coupling a battery pack, control circuit, firing head and the proper electric detonator, the electronic trigger device becomes a self contained system to fire perforating charges, tubing cutters and other explosive devices. Electric wireline and special electronic surface equipment is not required. In order to ensure safe operation, a proprietary control circuit monitors pressure, time and movement, and when the proper conditions are met, the detonator is fired. The tool is capable of operation in temperatures of up to 300°F and pressures to up to 10,000 psi and is available in l-11116-inch OD for thru-tubing applications

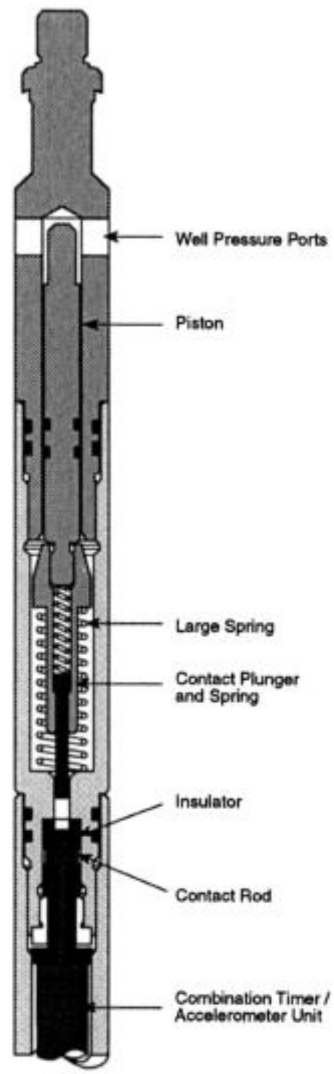


Figure 2.6: Electronic Triggering Device [3]

Operational principle:

The electronic trigger device incorporates two independent pressure switches, an accelerometer (or motion detector) and several timing circuits to control its operation. The tool is inactive when first assembled to ensure safety. Following proper explosive safety and handling procedures, the electronic trigger device is assembled into the tool string. When the tool string has been placed in the lubricator, and well pressure is applied, the first pressure switch engages and applies power to the tool. Once power is applied, the timing circuits and motion detector circuitry become active. A second pressure switch is activated at a higher pressure than the control pressure switch and completes the connection to the detonator. Three timer circuits control the firing sequence. The first timer activated inhibits the operation of the firing timer for a minimum of ten minutes.

Once the cycle of the inhibit timer is completed, the fire timer begins its operation. During operation of the fire timer operation, any motion sensed by the accelerometer resets the fire timer to the beginning of its cycle. Thus motion of the tool as it is lowered to the desired depth prevents the timer from firing as the tool string must be motionless for a period of twelve minutes before the detonator is triggered. A safety time-o
\ut timer is started simultaneously with the inhibit timer. If the firing sequence does not reach completion, the safety time-out timer blows a safety fuse so that all power is removed from the tool, allowing it to be brought back to the surface in an inactive state

Electronic Setting Device:

An electromechanical downhole power unit (DPU) has been developed for setting and retrieving downhole tools on slickline equipment without the use of explosive charges. Traditionally, the method of choice for setting wireline packers, bridge plugs, and similar wellbore tools has consisted of running an electrically activated explosive charge-setting tool to the required depth on electric line and activating the tool with electric charge.

Recently, however, new completion technologies such as monobore lock/plugging systems with wellbore configurations in which the explosive-type setting method is not desirable have been introduced to the oil field. In these configurations, the rapid setting motion provided by explosive charge-actuated tools may not allow the slips and sealing elements to fully conform to the tubing wall. The DPU produces a bidirectional, linear force for setting or retrieving downhole tools, thus solving the problem mentioned above with the new monobore systems. A gear motor operates a linear drive to generate a gradual, controlled, axial compressive or tensile force to optimize the setting of downhole completion equipment. A specially developed circuitry is used for the DPU to ensure that it will be activated at the proper depth.

The electronic setting device available in two sizes: 3.766 and 2.50 in. (diameter). The 3.66-in. tool is capable of generating more than 60,000 lbf over an 8.75-in. stroke in temperatures up to 250°F and pressures of up to 10,000 psi. The 2.50-in. tool can generate 30,000 lbf over a 9.5-in. stroke in temperatures of up to 300°F and pressures of up to 15,000 psi. As shown in, the DPU consists of three sections. The top section of the tool encloses the pressure sending actuator, the middle section is the control and power source, and the lower section contains the linear drive mechanism. The tool stroke direction can be selected at the surface depending on the job to be performed. Typically, the DPU is used in the tension mode for most setting operations such as packers or bridge plugs. Tool stroke is reversed (extension mode) for specialized operations such as retrieving a nippleless lock. Unlike explosive-type setting tools, the DPU is aided by wellbore pressure when in the tension mode. A proprietary control circuit controls the setting operation. The control circuit senses pressure, time, and movement. When the Proper conditions are met, the setting operation is activated. With no explosives device used, the safety is increased and maintenance for the tool itself is decreased. The reduced maintenance requirements allow it to be prepared for each operation within 30 minutes.

Operational Principle:

The device to be set in the well is made up to the DPU with a setting adapter(s). A timer within the DPU is preset before assembling the tool. The assembly is placed in the lubricator and installed on the wellhead. When the wellhead is opened and the tool string is exposed to wellbore pressure, a pressure switch in the DPU activates the control circuit. The timer circuit starts counting through the preset time period to the start of the setting sequence. Any movement of the tool string is sensed by the accelerometer circuit, which sets the timer back to the beginning of its cycle. When the time has lapsed, the setting sequence begins. The motor and gearbox start drawing the center power rod into the tool, which pulls the adapter against the outer part of the tool. This action continues until the proper compressive forces are generated and the device shears free. The motor continues to run until the power rod reaches its free rotation point and the run-time timer turns the tool off. The DPU has two operational modes: the tension (or pull) mode and the extension (or push) mode. In the tension mode, which is the mode used to set packer-type devices, the power rod is drawn into the DPU, and as it nears the end of its stroke, the shear pins connecting it to the downhole device are sheared. This mode requires that the motor polarity be set to normal, and the tension guide sleeve is installed into the DPU. The wellbore device is then attached to the DPU by means of the appropriate adapter kit. The power rod extends outward from the DPU and is used to unlock and extend wellbore devices before they are removed from the well. This mode requires reversal of the motor polarity and replacement of the tension guide sleeve with the extension guide sleeve. The appropriate adapter kit is then installed. In the case of a nippleless lock, this adapter is a pulling prong assembly. The DPU is landed on the lock, and the pulling prong engages the lock. Ten minutes after landing, the DPU starts extending the nippleless lock’s sealing elements and release mechanism.

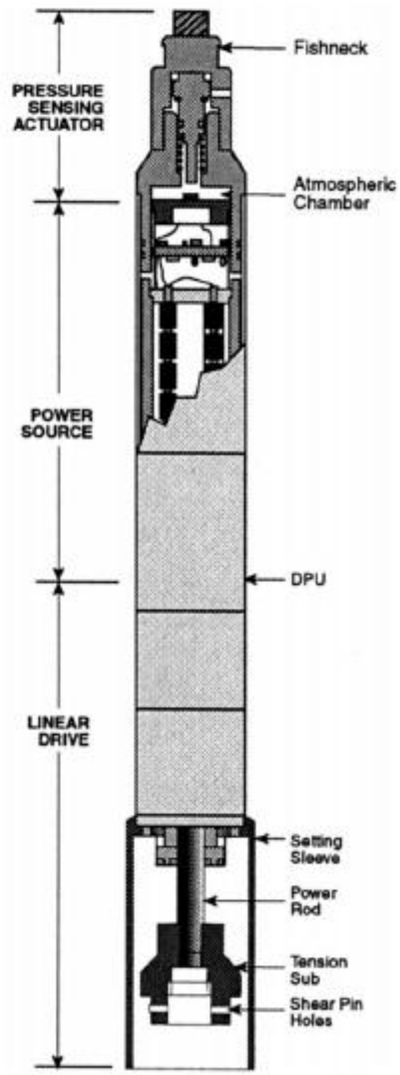


Figure 2.7: Electronic Setting Device- assembled to DPU[2]

The Aforementioned System/ Advance Measurement System (AMS):

The aforementioned slickline service tools have a common need for job success, i.e., measurement accuracy to reliably place the service tool at a selected depth in the wellbore. An AMS that automatically corrects measurement inaccuracies resulting from line stretch and environmental stress factors has been developed to satisfy this need. The system uses high-speed micro processing compatible with slickline speeds to deliver measurement accuracy that is comparable to electric line units. The AMS is an operator-interface portable tool that provides accurate depth and line tension measurements for slickline operations. The system consists of three primary components: the depth panel, the encoder, and the slickline tension-measuring load sensor. Digital displays include depth, line tension, and line speed. Analog line tension dial indicators for gross tension and incremental tension (65 lbf) provide the clarity and response sensitivity needed during slickline operations. To facilitate operational safety, several features have been incorporated. These are a 100-ft/m surface alarm that warns the operator of approaching the surface depth; an excessive tension override, which can be tied into the hydraulic drive and will stall the hydraulic drive of the wireline drum if line tension exceeds the operator's setting; and continuous recording of depth data in flash memory, which will allow the wireline operator to recover true depth information regardless of power failure or inadvertent operator switch interference.

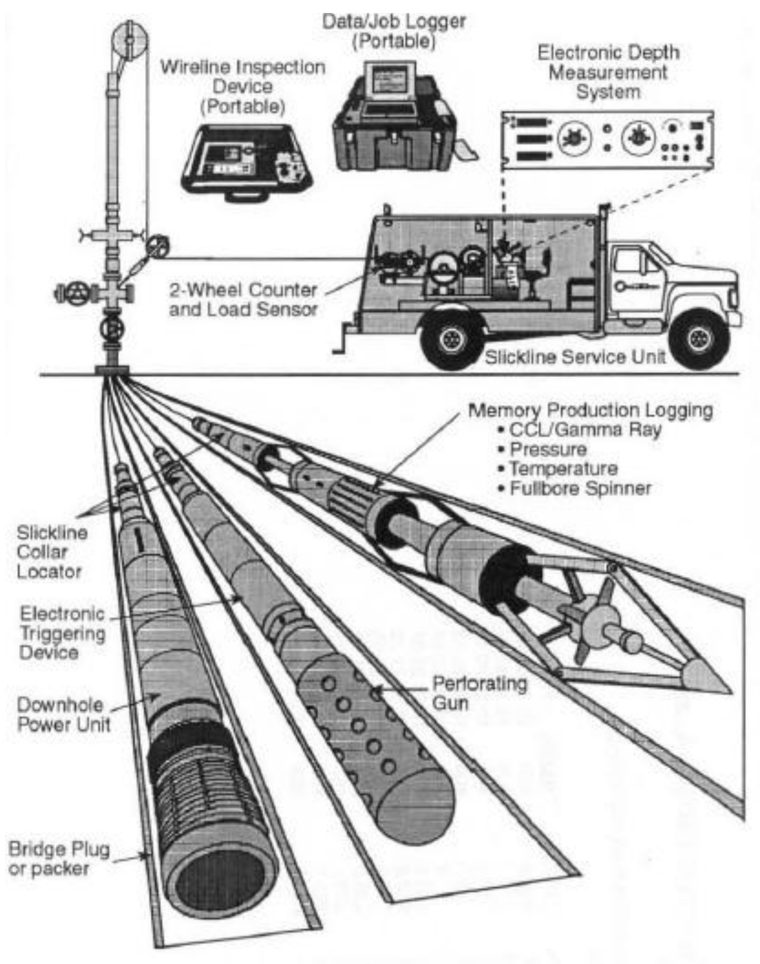


Figure 2.8: Advanced Slickline System[2]

Operational Principle:

Depth measurement with the electronic measurement system is more accurate than when conventional mechanical wheel devices are used, because the electronic system compensates for elastic stretch resulting from line tension and the effects of ambient temperature on the diameter of the mechanical measuring wheels. Elastic stretch is the most critical correction performed by the depth system. Because certain environmental stress factors cannot be measured during slickline operations, the system is conservative at accuracy of 65 ft in 10,000 ft. Some of these factors are buoyancy and drag or lift, which are functions of fluid viscosity, wellbore geometry, flowing conditions of the well, line speed, etc. For all practical purposes, these factors are inherently measured as tension on the surface. Controlled system testing proved the system to be accurate within 0.04% of the actual pipe depth and between surveys was repeatable within 0.005%. The depth panel receives two real-time data signals: one from the optical encoder for depth and one from the load sensor providing raw line tension data. Because of the high speed inherent with slickline operations, the system uses two microprocessors. The main processor performs the depth correction calculations for ambient temperature, elastic stretch, and actual line tension by means of total load from the load sensor and included rig-up angle. The secondary processor controls all the routine tasks of interfacing to the displays and transmitting current depth, tension, line speed, etc. through the serial ports. The encoder, which is driven by the mechanical measuring wheel, sends raw encoder pulses to the depth panel for processing into corrected depth. The electronic load sensor provides the means for determining actual line tension. The load sensor measures the total load and is either attached to one of the sheaves at the wellhead or is integrated into the slickline counter assembly. The load cell is calibrated at the beginning of each operation. Wireline tool weight is measured at the wellhead before the tool string is run into the wellbore.

Slickline Collar Locator:

The slickline collar locator is an electromechanical device that provides slickline operators with indications of collar locations in the wellbore. It is used in conjunction with the slickline electronic measurement system, a personal computer, and a printer or data/job logger that prints a log of collar locations as a tool string is raised through the wellbore. The battery-powered slick line collar locator employs a standard casing collar locator, signal conditioning assembly and drag mechanism to sense collars, and when a collar is passed, increases and decreases line tension. These tension changes are plotted against depth by the surface equipment, and thus, the operator is provided with an accurate indication of collar location. Slickline collar locators are presently able to operate in tubing sizes that range from ID' s of 2 .125-inch to 7.5- inch. The SLCL is shown in Fig. 2.4.

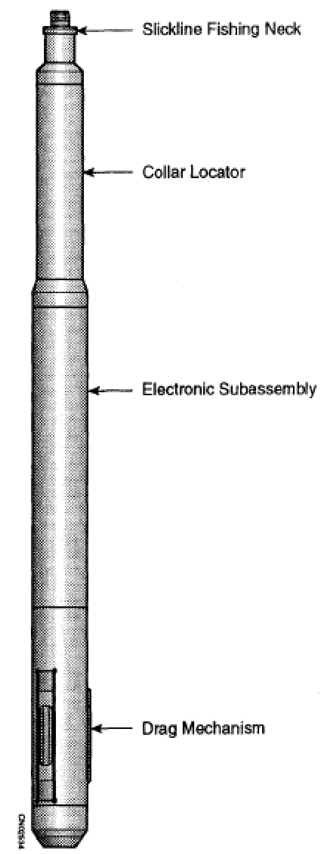


Figure 2.9: Slickline Collar Locator[2]

Operational Principle:

The slickline collar locator is powered by standard alkaline batteries and can be used in conjunction with the downhole power unit or the electronic triggering device. As the tool string is lowered into the wellbore, the slickline collar locator is inactive. After the tool string has reached the proper depth, and a preset time period has lapsed, the drag assembly is activated. The tool string is raised at a steady rate of fifty to one hundred feet per minute. As the tool string passes the collars, the drag mechanism is momentarily energized, which causes a brief increase in line tension. The line tension increase is sensed at the surface by the electronic measurement system and plotted by the data/job logging system. The operator can then compare the plot with an actual electric wireline casing collar locator log and correlate his depth setting accordingly. The tool string can be lowered, and the device can be set at the proper depth.

Data/Job Logger:

The data/job logger provides a means for recording the electronic depth measurement data via the RS-232 or RS-422 serial ports. This data includes tool direction, depth, line tension, line speed, time, and units of measurement. A printout of information typically retrieved by the data/job logger is shown in Table 1. By utilizing real time logging software, the data/job logger can generate historical job summaries, real time slickline collar locator logs, and/or can be used to produce memory production logs. Examples are shown in Figs. 9, 10, and 11. Fig. 9 represents a gauge run in the hole and flowing surveys at different depths for specified periods of time. Fig. 10 compares a slickline collar locator survey with an E-Iine collar locator survey in the same well. Fig. **11** shows a computed printout of a memory production survey. The historical job summary logs will be represented on a time base, whereas the slickline collar log and memory production will be plotted on a depth base.

Operational Principle:

The system consists of three primary components: 1) a laptop computer with hard drive; 2) a thermal graphic printer; and 3) a universal power supply (12- 30 VDC or 110-240 V AC). These components are packaged into a carrying case for portability. Once the laptop computer is connected via the RS-232 to the electronic depth measurement system, the laptop is ready to receive data. The electronic depth measurement system is set up to communicate with 8 data bits and one start/stop bit. Sending an upper case "D" to the system will return data. This data is converted to standard LAS format for plotting by the printer. All hard copy output logs or records are in standard API format.

Table 2.2: Data retrieved from the data/job logger through RS-232

UD	DEPTH	SPEED	TENSION	TIME
EU +	6833.6	155.9	206	10:36:15.46
EU +	6830.4	160.0	418	10:36:16.13
EU +	6827.7	164.1	404	10:36:20.68
EU +	6826.5	48.0	385	10:36:20.85
EU +	6826.1	51.9	379	10:36:21.01
EU +	6826.2	160.0	323	10:36:21.23
EU +	6825.6	232.0	305	10:36:21.56
EU +	6826.1	208.0	298	10:36:21.78
EU +	6826.6	300.0	187	10:36:22.61
EU +	6826.8	295.9	139	10:36:22.99
EU +	6831.7	288.0	166	10:36:23.65

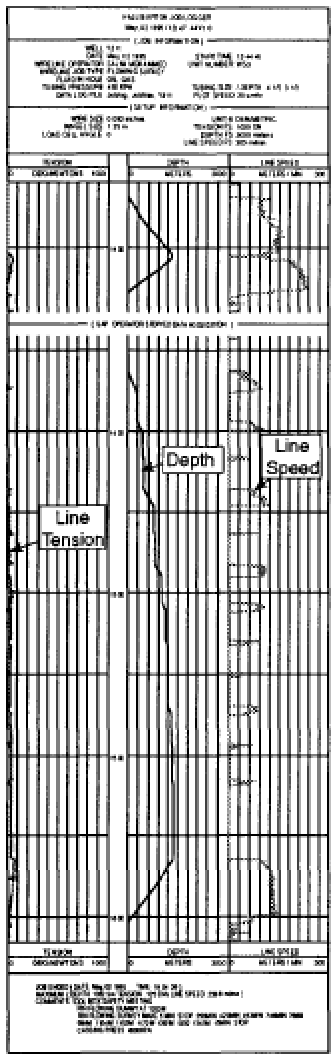


Figure 2.10: Data Job Log of Flowing Survey[2]

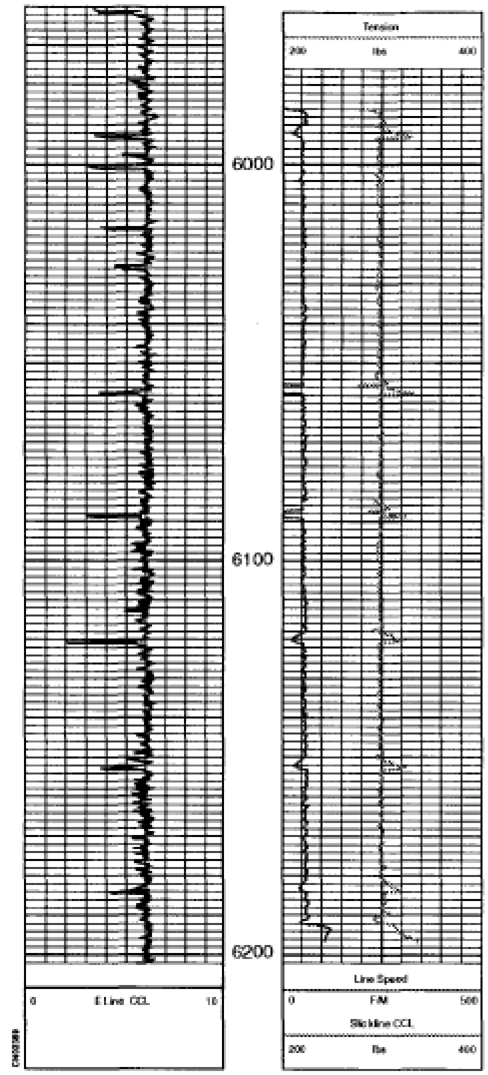


Figure 2.11.: Collar Locator Comparison[2]

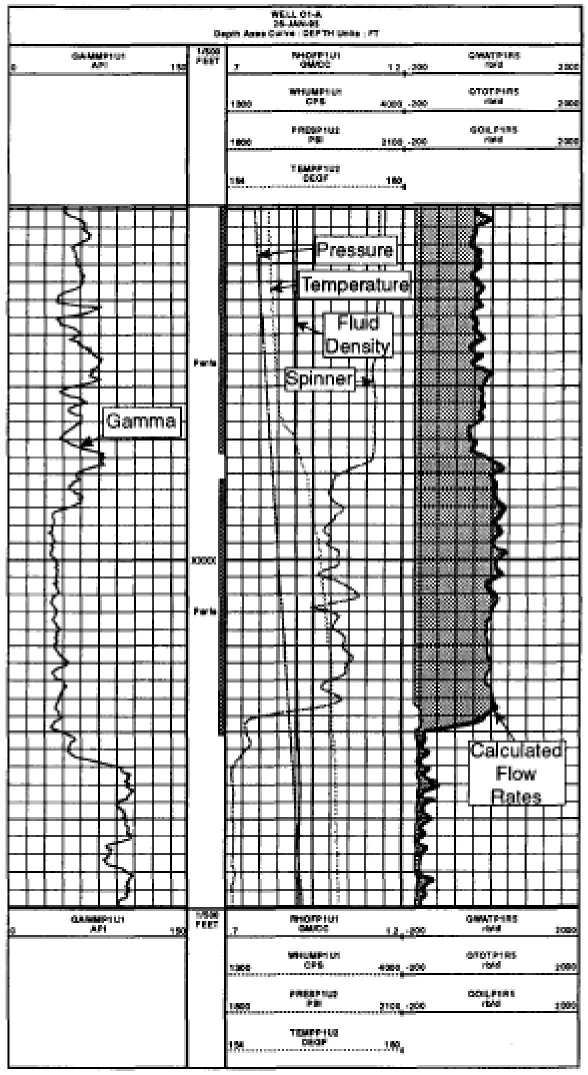


Figure 2.12: Computed Memory Production Survey[2]

Slickline Inspection Device:

The slickline inspection device employs eddycurrent inspection technology for wire inspection. When considering costly premature wire failures during slickline operations, the significance of wire inspection is obvious. The nondestructive eddy current inspection technology is used for slickline inspection to 1) ensure integrity of new wire as it is being spooled, 2) avoid costly replacement of still-useable wire, 3) facilitate general wire-life assessment, and 4) inspect wire during critical service operations where well conditions can cause rapid degradation of the wire.

Operational Principle:

The device consists of an inspection instrument and inspection coil sized specifically for the wire diameter to be inspected. During operation, the coil will have high-frequency, low-power alternating currents passing through it. The alternating current produces an alternating magnetic field around the coil. When a conductive test object (such as wire) is positioned within the alternating magnetic field, an electrical current or "eddy current" is generated inside the test object. The eddy current and impedance of the inspection coil is dependent on the test object's conductivity within the magnetic field. Any changes or discontinuities in the electrical conductivity of the test object changes the eddy current, and thus, the impedance of the coil. Any changes in the inspection coil's impedance are recognized on the inspection instrument. The test objects electrical conductivity at a particular point is a function of material permeability, material composition, and geometric shape. The slickline inspection device can be used to highlight discontinuities such as cracks, pits, laps, and other flaws on the wire's surface. This system uses a self-comparison differential coil arrangement (Fig. 13) which will locate sudden, localized imperfections in the wire.

Testing involves threading the slick line through the appropriately sized inspection coil, which can be mounted directly to the wireline unit's level wind/counter. The device can then inspect for flaws while spooling wire or during an actual service job. The actual detection of flaws relies on 1) establishing base values for the inspection coil's impedance and phase relationship when proximate to sound material using reference wires, 2) adjusting the instrument so that it notes surface imperfections, 3) balancing the instrument on these settings and values, and 4) detecting and analyzing the resulting changes of the coil when unsound material; i.e., material with a change in the shape of its surface, replaces the sound material. When a flaw or discontinuity that exceeds a preset level on the instrument is detected, an alarm sounds. The extent of the discontinuity can be judged relative to the base value established by the sample defects placed on the reference wires or to other flaws.

Although the slickline inspection system cannot provide an absolute measurement of the flaws detected, it can help to establish a basis for wire disposition. For example, the sample defects or notches placed on the reference wires can be used to establish pass/fail criteria for a specific wire type and diameter. After initial discovery by the slickline inspection device, visual and metallurgical evaluation may be required to determine the extent of the discontinuity. Field and laboratory testing with the slickline inspection device has proved beneficial in locating service-related defects resulting from fatigue, pitting, and gradual thinning due to mechanical wear and/or effects of corrosion for used wire and can locate defects in new wire.

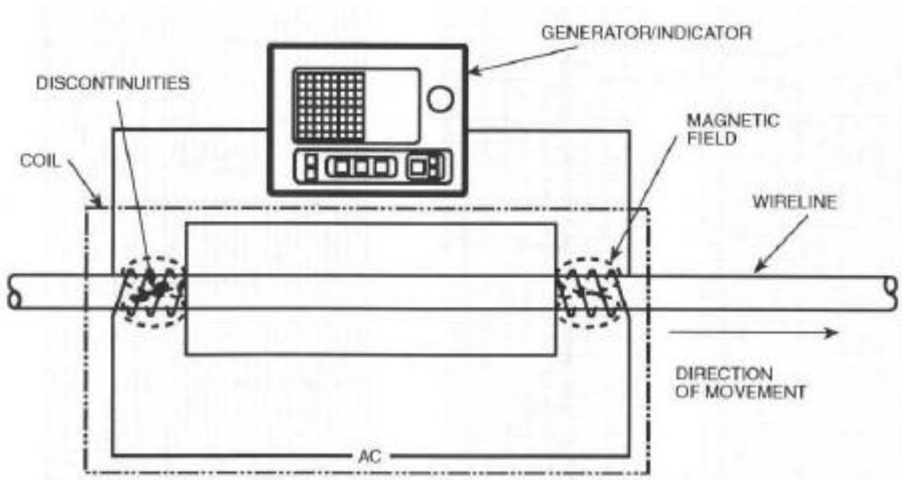


Figure 3.3: Inspection System Using Self Comparison Differential Coils[3]

CHAPTER 3

WIRELINE INTERVENTION DESIGN

Based on the previous chapter, the improvement of slickline and wireline technology has been clearly shown especially on interventions method. Due to all of the improvement, variety of method and combinations of technology can be established to overcome well issue regardless of location whether offshore or onshore. In addition, newly found technology via slickline and wireline intervention help the oil and gas industry especially the operators to greatly reduce the capital cost (capex and opex) regarding the well intervention work. The exploration and production team (E&P) evaluates additional advantages profited by the operators through the use of the slickline and wireline newly found technology such as reduced the cost for the logistic, accommodation, security requirements, footprints needed for the intervention operation and reduced the rigging time for each of the operation. Furthermore, we can classify the newly proposed technology of the wireline slickline intervention as an economically attractive solution which greatly helped to reduce well intervention cost without the needs of sacrificing the operation and safety of all the personnel. On top of that the conventional slickline unit is a fast, low risk and relatively inexpensive method which is use for well intervention operations such as for checking tubing clearance check, fishing, tubing cleanout, setting plug, and many more. However, the slickline application itself has its own downside of the operation which it is limited by the weight of tools which it can be run and limited type of tools which it can mechanically operates. Plus, the slickline unit cannot obtain the real-time data logging application. Therefore, the introduction of wireline unit helps in solving most of the disadvantages that slickline unit has. The combinations of these two units are critical in ensuring the effectiveness of the wireline intervention operation. The capability of the new technology which known as the advanced slickline service proof to be a system that can provide low cost solution for well interventions. The system capabilities include;

- Setting production packer
- Setting tubing and casing bridge plugs for workover
- Perforating tubing or casing
- Performing high quality memory logging
- Changing the gas lift
- Verify the slickline integrity.

3.1 Combined System Capabilities:

The equipment designed with purposed to provide enhanced capabilities when used in combination. For example, usage of the electronic depth measurement system in conjunction with the slickline collar locator can provide depth correlation equivalent in accuracy to electric line. The electronic depth measurement system provides the operator interface and sensitive line tension measurements for precise control of downhole tool assemblies. The slickline collar locator provides the method for determining the position of the casing or tubing collars via line tension fluctuations measured by the electronic depth measurement system. A hard copy of the data produced by the Data/Job Logger from electronic depth measurement data of a slickline collar log is shown in Fig. 17. Note the repeatability of the electronic depth measurement system from 8,900 feet to 9,100 feet, utilizing the slickline collar locator run at various speeds across the same interval. Also note the flat depth response (with line tension increase) representing the casing collar. This flat depth response indicates that the slickline drag mechanism has momentarily stopped the downhole tool assembly and the electronic depth measurement system is correcting for the toolinduced line stretch.

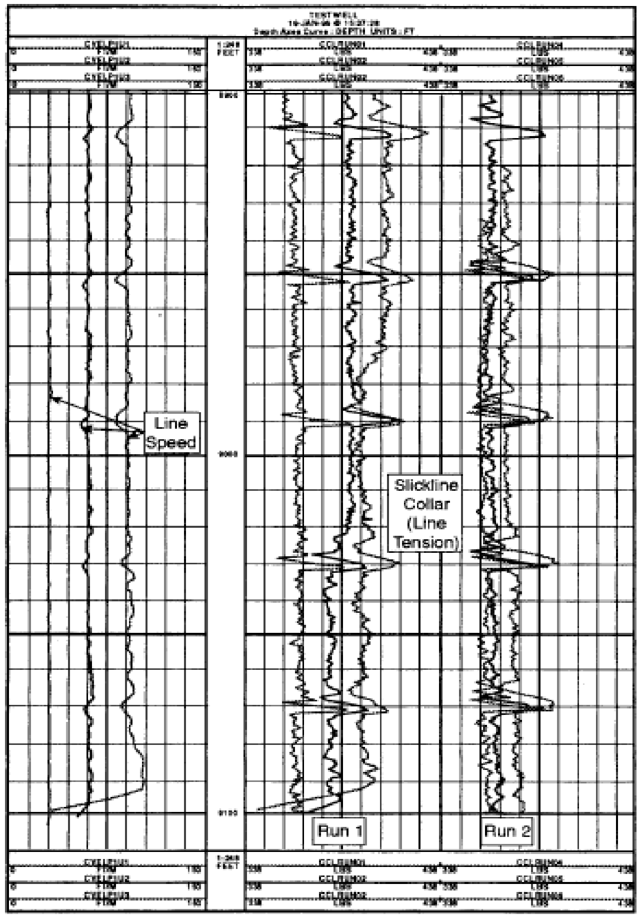


Figure 3.1: Slickline Collar Log Run at Various Speed[5]

The repeatability at various speeds and the precise correlation of collars provides the necessary tools for accurately setting plugs and packers with the DPU and perforating tubing or casing with the ETD on slickline. Because the ETD provides the capability for firing detonators, its usage can be expanded into providing conventional electric line services such as cutting tubing or casing, activating dump bailers for dumping sand or cement, and/or setting tubing or casing patches. The combined usage of the ETD, DPU, and electronic depth measuring system provides a cost efficient plug and abandonment system An additional advantage to the use of the slickline collar locator is that it does not transmit its response as an electronic pulse. This eliminates one problem inherent in the operation of other conventional electric line collar locators At times, electric line collar locator signals are attenuated over the depth surveyed and are hard to distinguish between background noise signals in flush joint pipe. When this situation occurs, another less cost efficient correlation tool such as a gamma ray or neutron tool is required. With the slickline collar locator, the collar response signal is transmitted at the surface as a line tension increase or decrease, which is not dependent on amplification of an electronic pulse. The signal is only transmitted between the electric line collar locator and the drag mechanism in the tool string therefore creating a positive signal.

Another important consideration in slickline operations is wire integrity and maintenance. Improperly maintained wire can break or fail prematurely as a result of stress fatigue, causing property damage or downtime. By incorporating the slickline inspection device with the electronic depth measurement system, locations of defects or abnormalities can be detected, allowing steps to be taken to prevent untimely wire failure. In addition, job records can be maintained to help establish maximum limits for safe wire line usage in specific environmental conditions.

3.2 Wireline Intervention Design & Method:

In order to support my research, various slick line activity using he newly proposed technology has been studied. Variation of method and operation were operates using this advanced slickline technology which proven in helping the operation to be a much more reliable advantage in term of cost effectiveness.

3.2.1 Wireline intervention A: Plugback and Tubing Cut

Well data provided: Single completion; tubing: 2.375-in, 47.7lbm/ft casing; 5.50-in, 17 to 20lbm.

Plug an existing depleted zone and then, to cut the tubing 11 ft above the upper packer. Later, a rig was to be used to remove the tubing and recomplete the well. The tubing was standard threaded and coupled tubing with a collar recess at each connection. The upper packer, a hydraulic-set type, was run with the tubing. The completion diagram showed that the packer was only 6 ft in length and was located several hundred feet from the nearest nipple with several full joints of tubing above and below. The plan was to use the AMS and data logger to locate and record the depth of the collar recesses below and above the packer. When the top of the packer depth was establish, the ETD would be used to cut the tubing at the desired location, 11 ft above the packer (which was located at 9,530 ft).

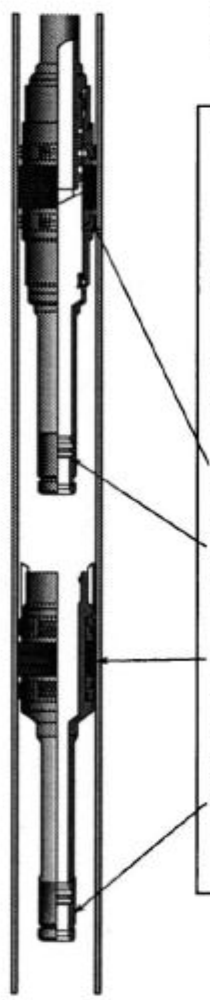
A slickline lift boat equipped with a portable AMS, data logger, and ETD tool was used for the job. The first trip in the hole with slickline was with a gauge cutter run to the end of the tubing. The second run was to set a plug in the nipple, located at 10,481 ft. The third run in the wellbore was to run a correlation to establish the location of several collars above and below the packer. A collar stop was run several hundred feet below the packer and then pulled up and dropped a few feet until it set down in a collar recess. This process was repeated until several collar recesses were located above and below the packer. With the location of the top of the packer now established, a depth correction was made in the measurement system panel before the last run with the ETD tool to ensure that the tubing cutter would be properly positioned. The ETD tool with cutter was lowered into the well and positioned, and the tubing was cut. All runs were recorded with the data logger, and information was provided concerning the fluid levels encountered while going into and pulling out of the hole. The position of the upper nipple profiles was also recorded on the job log, and the expanded log was verified when the tool fired.

One week after the tubing was cut, a workover rig was moved on to the wellsite to pull tubing. The last joint pulled was approximately 20 ft in length, which placed the cut approximately 83⁄4 in. from the target of 11 ft above the packer. This meant that the slickline electronic measurement system was less than 4 in. off depth at 10,000 ft. Customer cost to perform these services with slickline and the service vessel were about the same as they would have been if the customer had used a low-cost E-line company to do the work off a barge. The advantages were that different types of equipment and associated crews were eliminated, no grease seal head was required, and mobilization of equipment from different vendors was eliminated.

3.2.2 Wireline Intervention B: Set Packers with DPU:

Well data: Tubing: 2.375-in, 4.7lbm J55 tubing EUE 8 thread/in connection; casing size: 5.50-in, outside diameter to 9,100ft, perforations at 8,910ft; casing ID: 4.88-in; drift ID: 4.72in; gas well with water level at 6,000ft.

The objective was to set a permanent packer and a retrievable packer in the same well with the DPU and the AMS. The first operation was to run a gage ring and a junk basket with slickline tool string to supply information about the ID of the casing, fluid environment, and time to trip into the hole. Then, a permanent packer was to be set at approximately 8,900 ft, and a retrievable packer was to be set at a depth of approximately 8,275 ft.



TUBING 2-3/8"

CASING 5-1/2" 17#

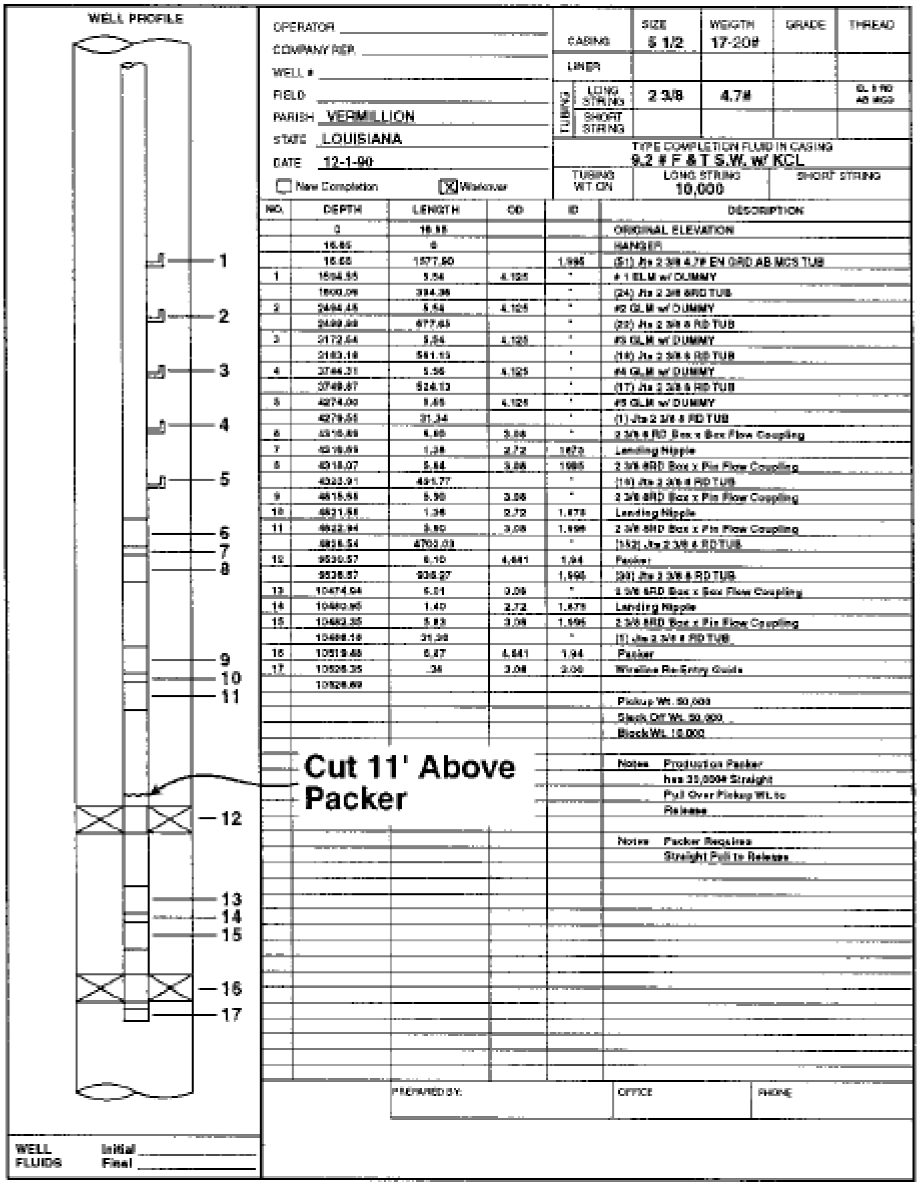
DESCRIPTION	ID	OD	LENGTH	DEPTH
KB ZERO SLICK JOINT, PUPS TO SPACE OUT		10.00		
TUBING JAY LATCH LOCATER	1.97	3.19	1.13	
B MOLDED SEAL ASSEMBLY	1.95	2.69	1.01	
A MULE SHOE GUIDE	1.95	2.70	.42	
5 -1/2" RETRIEVABLE PRODUCTION PACKER 2.75	4.64			8275
TUBING ADAPTER TO 2- 3/8" EU	1.94	4.51		
6 FT. PUP 2-3/8" EU 4.7 N80	1.99	2.38	6.17	
1.875 X NIPPLE 1.88	2.71	1.17		
WIRELINE RE-ENTRY GUIDE	2.05	3.00	.58	
5-1/2" 13-20# PERMANENT PRODUCTION PACKER (WITH SCOOP HEAD)	2.75	4.54	3.45	8900
SWAGE SEAL BORE THREAD BY 2-3/8 EU	1.98	3.63	.29	
6 FT. PUP 2-3/8 OD EU 8RD 4.7# N80	1.99	2.38	6.18	
1.875 X LANDING NIPPLE	1.875	2.71	1.20	
WIRELINE RE-ENTRY GUIDE	2.00	3.06	.33	

Figure 3.2: Completion guide for setting packer with DPU[5]

The well was fractured and equipment rigged out of the way. The junk basket run showed that the perforations were covered with about 50 ft of proppant, which was cleaned out with CT. When the pipe was clear, the equipment was rigged up for the dummy run, and the minimum travel time was established. Packer/DPU assembly was attached to a tool string. At about 6,700 ft, the tool string hung. After four tries to lift the tools and then attempt to go through the tight spot, the operator successfully went through. The 8,900-ft location was reached in 9 minutes of travel time. Setting was started. The hangoff weight was 520 lbm when the brakes were set. Noticeable weight loss shown by the differential weight indicator on the AMS indicated that the packer was set. After 30 minutes, an attempt was made to pull free of the packer assembly. The pulling tool sheared off the DPU. The power unit was fished, and it was found that the setting sleeve was fouled with frac sand. Had the conditions been clean, the sleeve would have come off without any problems. The DPU was loaded with a new set of batteries and was prepared to set the second packer. The dummy run encountered no obstacles to the setting depth. Travel time was set at 80 minutes as with the previous packer. The setting process was started, and a sudden weight loss of 120 lbm indicated that the setting was completed. The tool string and the DPU were removed from the well.

3.3.3 **Wireline Intervention C: Set Retrieveable Tubing Patch With Slickline DPU.**

Data of the well as stated in figures below:



OPERATOR		CASING	SIZE 5 1/2	WEIGTH 17-20#	GRADE	THREAD
COMPANY REP.		LINER				
WELL #		TUBING LONG STRING	2 3/8	4.7#		EL 8 RD AB MCS
FIELD		TUBING SHORT STRING				
PARISH	VERMILLION	TYPE COMPLETION FLUID IN CASING	9.2 # F & T S.W. w/ KCL			
STATE	LOUISIANA	TUBING WT ON	LONG STRING 10,000	SHORT STRING		
DATE	12-1-90					
☐ New Completion	☒ Workover					

NO.	DEPTH	LENGTH	OD	ID	DESCRIPTION
	0	16.55			ORIGINAL ELEVATION
	16.55	0			HANGER
	16.55	1577.90		1.995	(51) Jts 2 3/8 4.7# EN 8RD AB MCS TUB
1	1594.55	5.54	4.125	"	# 1 GLM w/ DUMMY
	1600.09	394.36		"	(24) Jts 2 3/8 8RD TUB
2	2494.45	5.54	4.125	"	#2 GLM w/ DUMMY
	2499.99	677.65		"	(22) Jts 2 3/8 8 RD TUB
3	3172.64	5.54	4.125	"	#3 GLM w/ DUMMY
	3183.18	561.13		"	(18) Jts 2 3/8 8 RD TUB
4	3744.31	5.56	4.125	"	#4 GLM w/ DUMMY
	3749.87	524.13		"	(17) Jts 2 3/8 8 RD TUB
5	4274.00	5.65	4.125	"	#5 GLM w/ DUMMY
	4279.55	31.34		"	(1) Jts 2 3/8 8 RD TUB
6	4310.89	5.60	3.06	"	2 3/8 8 RD Box x Box Flow Coupling
7	4316.69	1.38	2.72	1875	Landing Nipple
8	4318.07	5.84	3.06	1995	2 3/8 8RD Box x Pin Flow Coupling
	4323.91	491.77		"	(16) Jts 2 3/8 8 RD TUB
9	4815.58	5.90	3.06	"	2 3/8 8RD Box x Pin Flow Coupling
10	4821.58	1.36	2.72	1.875	Landing Nipple
11	4822.94	5.60	3.06	1.995	2 3/8 8RD Box x Pin Flow Coupling
	4828.54	4702.03		"	(152) Jts 2 3/8 8 RD TUB
12	9530.57	6.10	4.441	1.94	Packer
	9536.67	938.27		1.995	(30) Jts 2 3/8 8 RD TUB
13	10474.94	6.01	3.06	"	2 3/8 8RD Box x Box Flow Coupling
14	10480.95	1.40	2.72	1.875	Landing Nipple
15	10482.35	5.83	3.06	1.995	2 3/8 8RD Box x Pin Flow Coupling
	10488.18	31.30		"	(1) Jts 2 3/8 8 RD TUB
16	10519.48	6.87	4.441	1.94	Packer
17	10526.35	.34	3.06	2.00	Wireline Re-Entry Guide
	10526.69				
					Pickup Wt. 50,000
					Slack Off Wt. 50,000
					Block Wt. 10,000
					Notes Production Packer has 35,000# Straight Pull Over Pickup Wt. to Release
					Notes Packer Requires Straight Pull to Release

Figure 3.3: Well data for tubing cut job[5]

A gas lift valve lift valve was stuck in a side pocket mandrel causing a leak into the tubing casing annulus. This leak was consuming lift gas at high rates, reducing liquid hydrocarbon production by 40% (3,000 BOPD), and compromising safety standards.

A 51⁄2-in. tubing-retrievable patch was designed to be run on slickline, set with the DPU, and with the maximum allowable ID to reduce the choking effect during production. The equipment proposed for the job included the appropriate patch for the retrievable packer and the slickline DPU. First, the gas lift valve was located by conventional methods, and slickline was flagged at the counter. The job was completed without difficulty.

Based on this chapter, the author stress on that the advantages of using the newly found technology which help to reduce cost expenditure and carry out a successful operation.

CHAPTER 4:

FINDINGS AND DISCUSSION

4.1 Wireline Intervention A

Operation: Plug Back and Tubing Cut

Findings:

For this wireline intervention operation the component that used as a combination to perform a plug back and tubing cut were the AMS, Data logger and ETD. In breaking down the component according to its function, AMS and data logger act as tools to measure the depth with providing the real-time data correlation downhole. As for the ETD act as tool to perform tubing cut per operation basis. For this well intervention operation, 3 run were made which each one of them carried out different task and purpose.

The first run was to run in hole a gauge cutter until the tubing end. Then for the second run, was proposed to set the a plug in the nipple that located at 10,481ft and the third run was tu run a correlation to determined the several float collar above and below the packer. The process repeated until several collar recesses were properly locates top and below the packer. After the collar recesses depth correlation was run in hole again before run an ETD for the tubing cut in order to ensure the tubing cutter was properly in place.

All run were recorded by the data logger and information regarding the fluid level encountered while run in and out of the hole. Other than that the location of the upper nipple was precisely accurate and also recorded on the job log. Last but not least the expandable log was verified when the tool was fired.

Discussion:

After the operation of tubing cut is performed, the workover team and unit came to the operation location. The project was successfully operates. The slickline electronic measurement was less than 4in. off depth at 10,000ft. Customer cost to perform these services with slickline and the service vessel were about the same as they would have been if the customer had used a low-cost E-line company to do the work off a barge. The advantages were that different types of equipment and associated crews were eliminated, no grease seal head was required, and mobilization of equipment from different vendors was eliminated.

4.2 Wireline intervention B:

Operation: Set Packers with DPU

Findings:

For this set packers operation, the component that used were the DPU/ETD and AMS. The purpose of the job was to set two packers at different depth with one being the normal packer and the other one was the retrievable packer. Both had depth of 8275ft and 8900ft respectively. Consist of two operations where the first run was made by running downhole the junk basket and gage ring with slick line tool string to obtain the information regarding the casing ID, fluid environment and the time needed to trip in and out of the hole. However the well was fractured where the junk basket indicates that the perforation zones were covers with 50ft of proppant. CT unit clean up the well. The DPU assembly was attached to a tool string. After 4^{th} attempts, the location for the packer depth 8,900ft was reached in about 9 minutes. The AMS acts as one of the indicator to indicate that the packer was properly set.

30 minutes needed for the assembly to set free out of the shows by the sheared off of the DPU tool. The power unit that being use to set the first packer was successfully pull out the fished and shows that the setting sleeve was fouled with frac sand. The cleanup task is being carried out and the DPU was loaded again with batteries to set the retrievable packer at 8,275ft.

Discussion:

The job proved that the sensitivity and depth control of the AMS provided valuable information concerning the packer assembly during the setting process and that the DPU further enhanced the operation because of its operational efficiency. Comparable solutions would not have been as cost efficient.

4.3 Wireline Intervention C:

Operation: Retrievable Tubing Patch with slickline DPU

Findings:

The use of AMS and DPU were clearly seen again with the AMS acts as a memory tools that provide accurate locating of holes in tubing string and other crossflow situations in wellbore whereas the DPU again act as the tool to set and retrieve downhole tools on slickline equipment without the usage of explosive charges. During this operation of retrieve the tubing patch, the operators encounter a stuck gas lift valve at the pocket mandrel that cause the leak into the tubing casing annulus. This leak contributing to increment of gas at high rates thus reducing the hydrocarbon production by 40% estimated to be 3000 BOPD.

To overcome this problem, a 5.50 inch of tubing-retrievable patch designs to run on slickline where it set with the DPU and providing with maximum allowable ID to prevent and reduce the choking effect during production. First the gas lift was POOH via the conventional method and slickline was flagged at the counter.

Discussion:

The solution provided the desired increase in well production and a reduction in lift gas use. An analysis of the economic value of the services performed indicated that the use of the DPU and slickline eliminated the costs of an electric crew, equipment, and a rig; loss of production from a well shut-in resulted in an approximate U.S. $25,000 cost saving..

CHAPTER 5

CONCLUSION AND RECOMMENDATION

With the research and methodology via case history, the objectives of this research are well adequate to achieve the main target and meet the requirement of this project. Awareness on how the slickline operates and the development of the slickline technology should be introduced to people nowadays to provide them with clearer picture on how technology developed and knows the basic. However, with this research the author hope that people will learn more and continue with the research in order to improve the oil and gas industry within their own country. Nevertheless, slickline in decade’s time will be one of the most wanted technology because of its cost effectiveness and user friendly.

In addition, Slickline can now accurately locate downhole tubular goods/profiles, accurately produce quality logs from downhole memory surveys at half the cost of traditional logging services, support all new completion technologies that require accurate depth measurement, set bridge plugs and packers without use of explosives, and perforate and/or cut tubing or casing. As shown in the last case history, slickline equipment can also facilitate CT operations.

As for the conclusion, Slickline continues to offer the lowest cost well workovers without compromising operational safety and efficiency. The advances in slickline capabilities within the last decade have been overwhelming, and if this trend continues, who can say what its capabilities will be in the future.

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