MEASUREMENT WHILE INSTALLING OPTIMIZE ESP INSTALLATION PROCESS FOR INCREASED SAFETY AND EFFICIENCY ON THE ESP INSTALLATIONS IN PERMIAN BASIN WELLS

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ABSTRACT

This paper describes an artificial lift case study where three pilot test wells were installed using measuring-while-installing (MWI) equipment during the process. The final results enabled us to meet the goals and expectations of these test wells. The main test objectives were to reduce the time to run the electrical submersible pump (ESP) in the well, to increase the ESP reliability while installing, to monitor the installation with real-time data, and to concurrently monitor rig crew activity.

The use of MWI equipment during the ESP installation is a technique that reduces unnecessary manual steps through automation, saving rig time. The technique also reduces HS&E concerns and provides the ability to continuously monitor real-time downhole gauge data such as automated cable conductor resistance measurements and cable integrity. The battery-operated equipment avoids the need for an electrical collector/slip ring system on the spooling unit.

This paper describes the equipment, process and final results after the well tests, where the MWI equipment was used to reduce the installation time by minimizing manual intervention during the electrical tests and to collect real-time data during installation. In addition, results are shared from an economic analysis that demonstrated cost savings achieved from using the MWI equipment compared with other traditional artificial lift installation methods. These results indicate the potential benefits to use this new technique and equipment in Permian artificial lift operations.

OBJECTIVES/SCOPE

The main objective of this work is to analyze and demonstrate the operational and economic benefits of using the new measuring-while-installing (MWI) equipment during the ESP installation. This technique reduces unnecessary steps through automation and saves rig time. The technique also reduces HS&E risks and provides the ability to continuously monitor in real-time downhole gauge data such as automated cable resistance measurements and cable integrity.

INTRODUCTION

The Permian Basin activity has been affected by the oil downturn, but it still is one of the most active and challenging basins across USA. The electrical submersible pump (ESP) is one artificial lift method used by operators when a quick return on investment (ROI) is a priority. These ESP systems are used in conventional or unconventional wells around the Permian basin, placing an increasing pressure on the ESP vendors to explore new technologies and processes to improve productivity and to reduce production and intervention costs.

The Electrical Submersible Pump system is one of the most common artificial lift methods used due to superior production flexibility. The ability to operate in wellbores with drastic fluctuations in pump intake pressure (PIP) and harsh wellbore conditions (H2S, frac sand, emulsion, etc.) makes ESP a preferred artificial lift method.

The majority of the ESP well interventions in the Permian basin could cost to the operators more than $500,000 and more than four days without production or what is also known in the industry as non-productive time (NPT). This could translate into an average of $550,000 of total NPT and lost production for an ESP failure. This situation prompted ALS companies to identify opportunities to reduce the installation time, reduce HS&E risks and increase efficiencies in ESP Installations. These capabilities would reduce potential short-run failures that could increase the operator's intervention costs and NPT.

BACKGROUND

The ESP system is composed of downhole equipment (motor(s), seal(s), gas separator, pump(s), and cable) and the surface equipment (variable-speed drive or switchboard and transformer(s)) (see Fig.1). The power cable conducts the necessary electrical power or voltage to the downhole motor and communicates the downhole data to the surface for analysis and interpretation by the surface equipment (drive or switchboard). Artificial lift system (ALS) engineers utilize the downhole data to monitor and optimize the ESP performance and extend its run life.

A conventional ESP systems installation process involves stopping the run-in hole operations to verify the cable and system integrity. During these stops the cable and system are tested by applying voltage to the power cable to verify its insulation. Usually, this is a common practice in most ESP companies. When installation operations are stopped for these verifications field service technicians or field engineers approach the cable reel spool to prepare cable and then test integrity of the system. The integrity test is mostly composed of two tests. The first test uses an ohmmeter to verify the resistance between phases. These three readings should all be equal to guarantee integrity. The second test applies a specific voltage to each cable phase (separately) to measure its insulation against ground. This test is usually performed using a "megger". All three readings must be above a certain value that depends on the cable condition as well as the downhole motor type. This last test sometimes may be optional because some downhole gauges have limitations when exposed to these voltage tests. In this case just resistance readings are taken on each phase against ground.

A common practice is to stop and check the integrity of the system and cable while installing. Suggested checks should occur every hour of the installation or every 1,000 to 1,500 feet (305 m to 457 m); whichever works better for the application, depending on the well survey and the operational conditions.

The cable resistance degrades as the system is installed in the well due to the temperature increases caused by the geo-thermal gradient of the well and reservoir. This degradation is not a concern as long as it is gradual and not abrupt. These resistance changes are regularly identified by the field service engineer during the electrical test performed on every stop-and-check step.

A gradual change indicates the cable and downhole equipment is in fluid and is heating, while an abrupt change would indicate that the cable might have been damaged during the installation. If at any time the phase-to-phase readings become unbalanced, normally the operator is notified about the condition to make arrangements to remove or pull the equipment from the well. As the cable and downhole equipment are pulled, field service personnel begin to identify the failure point. When the failure point has been recognized, then personnel will determine whether a field repair can be conducted or if the cable string should be replaced. After the failure point has been resolved, then ESP installation operations may continue.

The electrical test of the power cable (connected to the downhole motors and gauge) consists of three steps: continuity testing using an ohmmeter, phase-to-ground insulation, and phase-to-phase insulation using a high-voltage tester such as an insulation tester (Megger).

These tests should be performed in a safe place away from the wellhead. The tests are regularly performed at the power cable reel located at least 75 to 100 feet from the wellhead (see Figure 2).

The power cable tests performed are cable continuity and ground electrical test, and the phase-to-phase test (see Figure 3):

If this is part of Figure 3, then you should move it closer and place the caption ("Figure 3") below it. If this is a new figure, then place the caption below it and title it "Figure 4".

THE NEW METHOD

The measurement while installing (MWI) system is a new technique or method that enables real-time monitoring of the downhole gauges and automated cable integrity measurements during the ESP installation process. The MWI system provides the ability to monitor parameters from the downhole sensor while running in hole. The MWI also has the ability to create a time-stamp log of the equipment installation. In addition, using current leakage readings from the downhole gauge through the MWI equipment enables field personnel to monitor the cable integrity and detect grounded downhole equipment immediately. This capability saves downtime and identifies problem areas in the wellbore in a faster manner than the conventional method.

The MWI drives installation efficiency by removing unnecessary steps through automation, saving rig time and increasing HS&E whilst providing the ability to continuously monitor real-time downhole gauge data via any wireless device (i.e., smart phone or tablet) without the need for installation of any special software or App.

Benefits from using the MWI system include:

- Support for the WellLIFT gauge family (Centinel also supported)
- Monitors downhole conditions while installing
- Monitors gauge data and cable integrity as it is installed in the well
- Improves operational efficiency
- Reduces the chance of NPT
- Negates stopping of operations to take measurements. No longer have to stop installation operations to verify cable and system integrity.
- Enables more measurements to be taken during installation
- Enables early fault identification, reducing NPT
- Reduces the safety (HS&E) risks associated with manual electrical tests or "megging"

In addition to these direct benefits, the usage of the MWI system could help the operator to decrease operational expenses during the deployment of ESP systems as a main production method in a field. Table 1 shows the benefits in time and USD from 1-100 wells.

The MWI system is installed inside the ESP cable drum and secured in place for the duration of the installation (see Figure 6). The configuration of the system is extremely simple and intuitive. The only tasks required for the user are to set the device time, set the "megging" voltage, and start a job file. Everything else is pre-configured to be plug and play for maximum efficiency. All the downhole gauge data, automated measurements, and user notes can be monitored in real time and are automatically recorded for the duration of the job. The information can be downloaded at the end of the job for reporting purposes.
The user accesses the system interface via a web browser; there is no special software or App required. (See Figure 7). Multiple synchronized wireless connections enable multiple users to monitor the data simultaneously during installation. All the data could be graphed and trended (see Figure 8 and Figure 9).

RESULTS, OBSERVATIONS, CONCLUSIONS

1. The MWI System reduces operational costs (see Table 1) and improves the OPS visibility during the ESP Installations (see Figure 8).
2. Real-time current leakage measurement enables quick identification of cable damage during the installation.

3. No need to stop operations to take measurements. No longer have to stop installation operations to verify cable and system integrity, reducing the HS&E risks associated with manual electrical tests or “megging”.
4. Real-time measurements enable early identification of faults, reducing NPT and identifying the exact point of the failure.

NOMENCLATURE

HS&E = Heath, Safety & Environment.

NPT = Nonproductive time

OD = Outer diameter

OPS = Operations

ESP = Electric submersible Pump

MWI = Measure While Installing

RIH = Run In Hole

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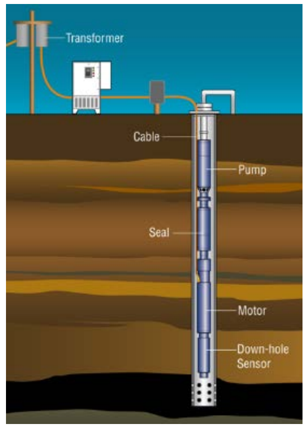


Figure 1

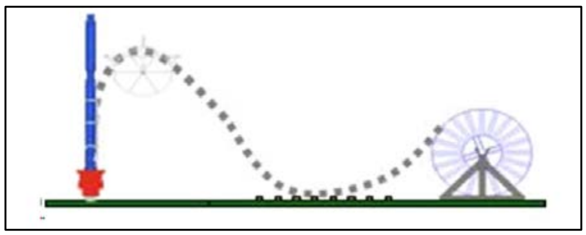
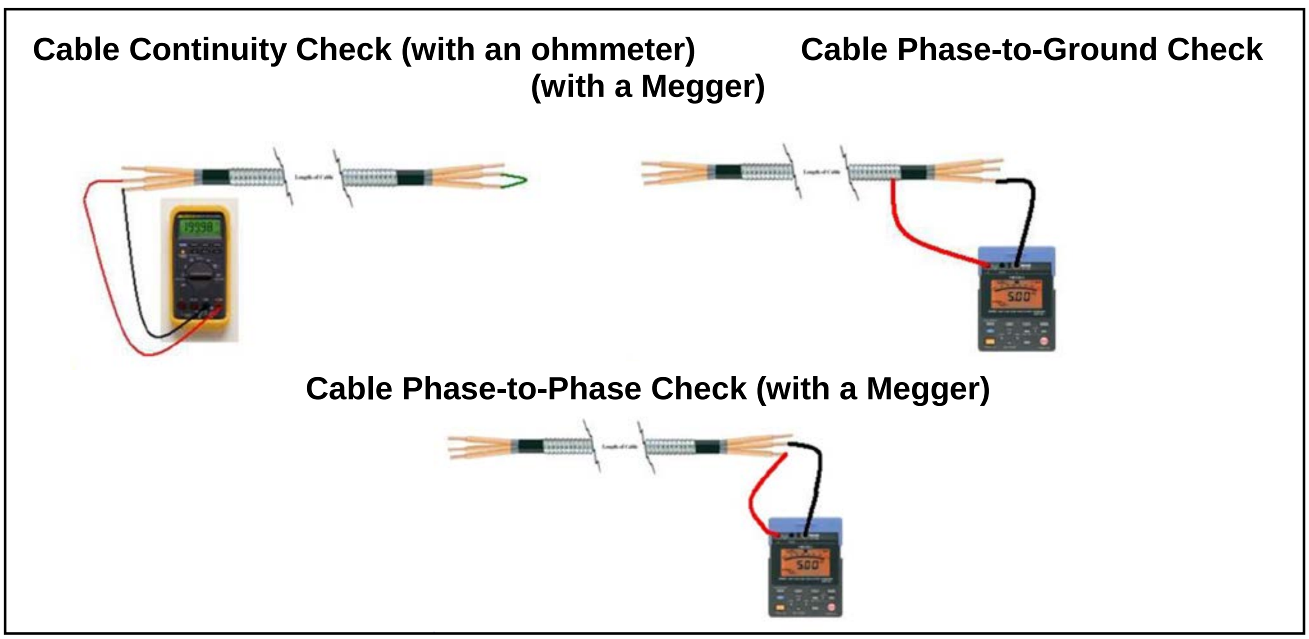


Figure 2



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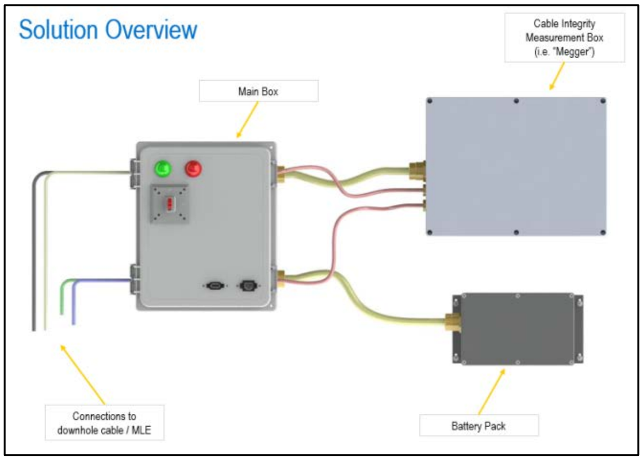

Figure 4

Avg Well Setting Deep	8,500	FT
Electrical Test every	1,000	FT
Regular operation	**9**	**Times**
Time per Stop	30	Min
Total Time MIN	255	MIn
Total Time HR	4	Hr
Rig Cost	824	Hr
Saving Rig Time	3,502	USD
Saving ALS Techs (crews)	871	USD
Saving per Wells	**4,373**	**USD**
Installs Per Month	50	
Installs per Year	600	
Total Saving per Year	**2,623,950**	

Table 1 – Standard operation time vs. rig cost

Figure 5

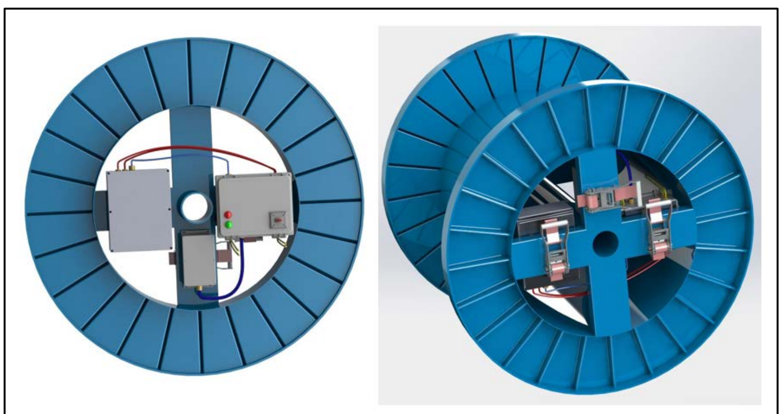

Figure 6

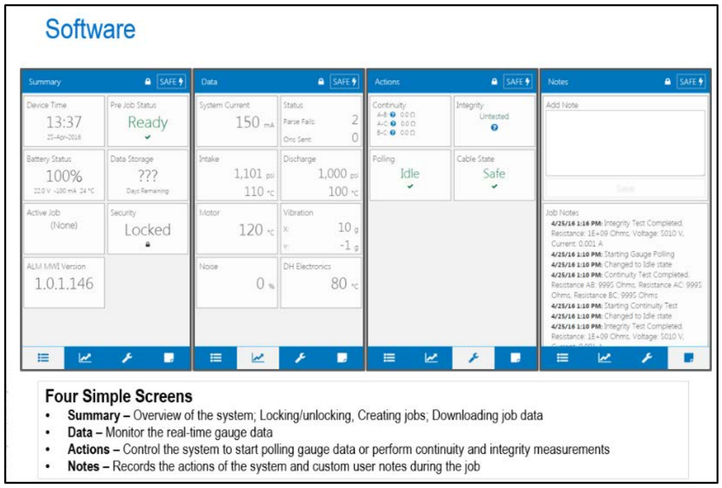

Figure 7

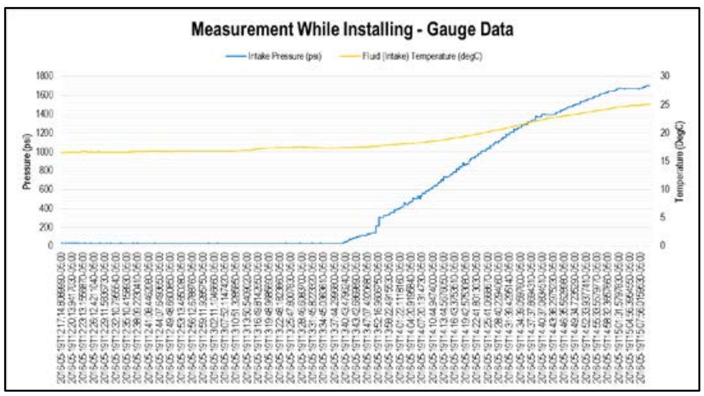

Figure 8

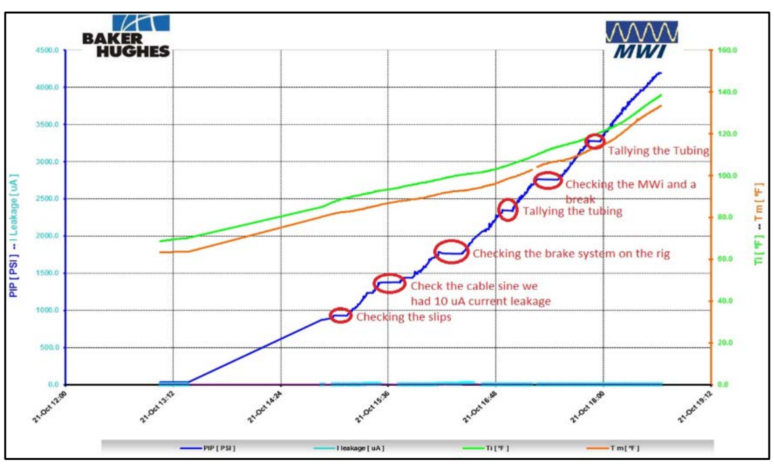

Figure 9