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Digital BOPE Testing – A Case Study Leading to Improved Technical Assurance While Reducing Time Requirements and Cost in Onshore Drilling Operations

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Abstract

A digital blowout prevention equipment (BOPE) pressure testing system was deployed on a remote land drilling rig in Argentina in October 2017 to replace the older testing method using an analog circular chart recorder. This paper presents a case study of that deployment, focusing on change management, cost savings, and overall BOPE testing improvement.

Results from the deployment include a 50% reduction in BOPE test time with subsequent savings that amount to 6 times the cost of the digital test equipment, improved safety, improved efficiency in addressing problems that would result in a failed test, improved data reliability, and repeatability in subsequent BOPE pressure tests.

Introduction

Testing Requirements

BOPE must be maintained, inspected and pressure tested periodically to ensure that it will function properly when needed. Two test methods were compared over a 16-month period on a drilling rig deployed in Argentina beginning in 2017.

One method was the traditional protocol using a circular pressure recorder to map the progress of testing and record the results on a paper chart. The other method used an analog pressure transducer that transmitted data digitally to a computer with software developed to monitor test progress without the need for interpreting data from a paper chart. See Fig. 1. The digital system automatically determines whether the test is successful or not. Both methods conform to API RP 53 - Recommended Practice for Blowout Prevention Equipment Systems for Drilling Wells.

Figure 1

The analog circular pressure chart recorder was patented in 1888, and is still in wide use today. The digital pressure testing system is a PC-based standalone system with three modules: test planning, test monitoring, and automated reporting. Each module contains numerous features including BOP stack drawings, individual component test sequencing, "pressure chart" visualization, and automated pass/fail determination.

It has been well-documented that both process safety improvements and time savings are achievable using digital BOPE pressure testing technology (see Paper SPE-199558-MS). This is one of the first times that the digital system has been deployed for onshore BOPE testing. Although the US Bureau of Safety and Environmental Enforcement has regulated the use of digital BOPE testing, it is still a neglected process both onshore and offshore outside of the US.

Description and Application of Equipment and Processes

Existing analog process

The existing equipment and processes for BOPE testing on the rig in October 2017, at the start of deployment, were considered standard for most remote drilling operations. The drilling contractor supplied a high-pressure, low-volume pump with manual controls. A bourdon tube pressure gauge was used by the pump operator to achieve the test pressure at each stage of the testing process. An analog circular chart recorder recorded testing pressure versus time. Testing was performed by the drilling contractor's toolpusher or his designee. No third-party testing contractor was involved.

The test procedure included the following steps:

- The valves were "lined-up," the test pump operator provided pressure test pressure for that stage of the test, using the analog gauge on the skid;
- The BOPE components were then isolated from the pump via a valve, and test pressure was visually monitored by the tester using recorded data from the circular chart until it stabilized;
- Pressure was held at the stabilized level for the prescribed time indicating a successful, or "passed" test, according to the Drilling Contractor's Pressure Control Manual; and,
- The chart was marked by the tester, approved by the Drill Site Supervisor, after which the test sequence was repeated for the next stage of the test, until all BOPE components were tested.

This method involves several human judgment calls. The test pressure was read visually off the circular chart, and the tester was required to monitor progress using only the circular chart. The width of the line on the chart is often several psi, so errors are common in determining the rate of pressure stabilization and final pressure. At some point, a human must determine that pressure has stabilized and the test is successful before moving on. No historical data, other than the chart itself, exists for future test planning, trouble shooting and analytical analysis on future tests.

The test sequence (the valve line-up ensuring that all components were tested) was kept in a "tally book," and not recorded in any other more permanent record or report. The analog circular pressure charts were filed on the rig. No digital test data were captured or recorded.

Digital Testing Procedure and Equipment

The procedure for digitally testing BOPE is similar in some respects to the old analog procedure but quite different in others. These steps include:

- Pressure is applied to the test component using the pressure pump;
- Once the test pressure is reached, the BOPE component is isolated and monitored digitally;
- Variations from expected pressure performance during stabilization can be used to quickly identify whether or not the test is likely to be successful (if it is not, the test is terminated and crews can begin repairs);
- Successful test criteria, such as 3 psi/min for 5 minutes with a maximum pressure drop of less than 5% (previously input into the digital pressure system software) is compared with actual pressures in real time by system software; and,
- Once software signals that the test is successful, the pressure is bled off, the valves are re-aligned, and the next test is initiated.

Digital testing uses equipment packaged in a protective hard carrying case and consists of an intrinsically safe, ruggedized laptop with a 4-20mA DAQ (data acquisition system) and networking capabilities. Also included are pressure transducers and communications cables. The digital pressure sensor equipment takes the place of the analog circular pressure chart recorder in the testing process. All other components of the BOP testing system remain the same.

The digital testing software consists of several modules. The operator can build schematics of the components to be tested, plan valve line-up for the test, determine pressure test parameters, and input regulatory and contractual pass/fail criteria. This ensures that all components are tested properly, sequentially, and completely. A module visualizes the test on the computer screen allowing high-definition monitoring on the tester's computer (and any other screen that is networked to the computer), records the data in a database at 9 Hz recording frequency, and automatically indicates when a test has been passed.

No paper records are necessary. A tamper-proof reporting module produces a PDF report file, with all the key data of the test including test criterion used and schematics of the valve line-ups. Key performance indicators including the time between tests and time to pressure test are also reported electronically.

During the test, the software constantly monitors pressure values received from the pressure transducer and determines whether the test is likely to pass or fail. Temperature trend matching is not included in the product's software. If pressure is not following the expected trend, indicating that the test is likely to fail, the procedure can be aborted quickly and troubleshooting by rig crews can begin without delay.

The visualization module continuously indicates the test status including the likelihood of success. A key feature of any digital system is it intuitiveness and ease of use. No interpretation of circular chart data by the tester is required, and the speed of data processing simplifies the process.

Description of Initial Deployment

A data gathering and assessment phase was initiated prior to deployment. Two individuals formed the deployment team and traveled to the rig site. One team member was from the digital pressure testing contractor and the other from the operator. Their duties included conducting the initial test with the digital testing equipment and training rig personnel to operate the system.

The main activities of the deployment team were to:

- Inspect the rig equipment;
- Review the rig specific BOPE testing process and other procedures;
- Build a test plan using the computer software;
- Establish an optimum pressure transducer installation site and lay out the digital testing equipment;
- Hold general familiarization sessions with the rig crews;
- Train designated staff so they could operate the digital testing equipment;
- Conduct the first BOPE test using the digital testing equipment; and,
- Document the visit making necessary recommendations for further testing operations.

Process Improvements Identified at the Initial Deployment

The direct time savings attributable to the digital testing equipment is outlined in the Presentation of Data and Results section below. In the initial deployment and training effort, 3 hours of BOP test time improvements were identified by crews (after a cost benefit analysis was endorsed by the operator and drilling contractor). These included:

- Increasing pump skid flow rate to reduce the 40-minute pump time required for high pressure tests;
- Replacing the check valve in the kill line with one that could be mechanically locked open, thereby eliminating the need to remove the valve during kill line testing;

- Adding a bleed valve to the high-pressure line at the pump skid to allow for quicker depressurization;
- Moving the tie-in point for the pressure transducer to the kill line and lower stack valve, thereby reducing the number of individual tests required by two;
- Eliminating the improperly calibrated chart recorder and poor-quality charts; and,
- Acquiring a test fixture and crossovers to enable off-line testing of the internal BOP (IBOP) and full-opening drillpipe valve (TIW valve).

Process Improvements Opportunities Identified Subsequent to the Initial Deployment

Because of the consistency of digital testing, key performance indicators were generated. Also, rigorous and consistent reporting generated continuous improvement in several areas. In the almost 3 years since the initial deployment, several issues have, or are being, addressed.

This was the first deployment in Argentina, a Spanish speaking country. At first, the user manuals and training material were not translated into Spanish due to cost for a single deployment. However, as the number of deployments increased, the cost of translation became viable. Now user manuals and training material are available in Spanish.

One deficiency identified early on involved performance dips caused by staff change-outs on the rig. Whenever the trained, experienced tester (the toolpusher or his designee) moved away from the rig, testing performance declined, until the newly-appointed tester became familiar with the digital testing software. User manual documentation and training material have steadily improved over time, but it always takes some time for an individual to develop the skills required to efficiently operate the system.

There was also a reluctance of the staff on the rig to contact the 24/7 support provided by the digital pressure testing contractor. Help was available to the rig but it was not used for whatever reason. This was a regrettable shortcoming of the deployment.

In a related area identified for improvement, the rig had poor international telephone communications, but it had a strong internet connection. So, VoIP (voice over IP) access to the 24/7 support was added. This obviated the communications barrier, and staff on the remote rig had ample, ready access to all available system support.

Another shortcoming involved communications issues between the pressure transducer and the computer due to damaged cabling and grounding issues. These caused the crew to return to the older, standby circular chart recorder on occasion.

Three potential improvement solutions are being investigated to avoid future communications interruptions on the rig. These include using a semi-permanent cable to avoid damage to connectors inside the case, adding redundancy to the physical cable bundle, and using WirelessHART communications or other wireless communication networking technology between the pressure transducer and the computer.

Presentation of Data and Results

Prior to the Initial Deployment

Prior to the deployment of digital pressure testing, 16 wells were evaluated for BOPE testing performance using the analog system. The average test time was 20 hours per well. Time spent trouble shooting failed tests and repairing equipment was 8 hours per test. When this "non-productive time," was removed, the average test time was 12 hours per well.

Results of the Initial Deployment

One of the principle benefits of replacing the analog circular pressure chart recorder with PC-based digital pressure recording software is the elimination of human interpretation and subjectivity. Test results are digitally analyzed leaving human judgement out of the pass/fail criteria. See Fig. 1.

Another benefit is that crew efforts are more efficient. Crewmembers are not used for other tasks on the rig, since a failed test is identified quickly by the software so repairs by rig crews can begin immediately instead of waiting until the end of the test.

Digital system has enabled rigorous test planning. The test planning software module was a key tool to understanding whether or not the BOPE system was being tested correctly. It also identified opportunities to reduce test time.

The first deployment of the digital pressure testing equipment resulted in a 9.2-hour test, including "non-productive time," when two failed tests required re-greasing valves. This performance set a new "best in class" benchmark for BOPE testing on the rigs. With the 3 hours of further identified process improvement mentioned above, the technical limit was established at a 6-hour duration test.

Also, the simplicity of the system is such that onsite personnel can run the testing process, ensuring reliable results, without the need, or expense, of a third-party testing contractor.

Results after the Initial Deployment

Time savings due to early detection of a leak (and probable failed test), in contrast to waiting for a full-length test using the analog circular pressure chart recorder, was not clearly identified during this deployment. Comments from the field indicate that this feature is appreciated by the rig crews and supervisors.

Now complete BOPE tests are being routinely conducted in 6 hours, which equates to 50% time savings. This is partly due to the implementation of process improvement suggestions mentioned above. Much of it involves crew learnings and acceptance of the new digital test process. This time savings has been sustained for several years.

This time savings also points to an improvement in personnel safety. Rig personnel are now exposed to less BOPE test pressure time, and the risk of a failure during testing than they were previously. While there have been no reported injuries or losses using either method of testing on this rig, the global industry does still report several incidents per year, thus this risk reduction is worth consideration. Exposure that could result in damage during testing, such as dropped objects on the high-pressure pump line, was also been reduced by half.

Process safety improvements to the testing process include data consistency and test repeatability on subsequent BOPE tests. The reliability of data generated by the digital test method increases confidence that the entire BOPE set on the rig has been tested thoroughly and properly.

The time savings, when translated to rig spread cost, represents about 6 times the monthly charge for the digital testing equipment. This does not include the time savings in troubleshooting and repairing leaks by rig crews. Improved efficiency, simplicity, repeatability, and reliability of data collected during the test procedure adds to the attractiveness of digital testing for onshore rig BOPE.

Conclusions

Digital BOPE testing in onshore drilling is both feasible and attractive from several standpoints including improved personnel safety and process capabilities, reduced rig time and testing cost, and the generation of repeatable, reliable data. Human interpretation of chart-recorded data is no longer necessary. Instead, computer software can be relied upon to signal both failed and successful tests in less time and with fewer errors than the old testing method.

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