Technical Session 13: Well Construction Automation	**International Petroleum Technology Conference 2021 - Technical Session 13: Well Construction Automation**
Please fill in your 5-digit IPTC manuscript number.	**IPTC-21471-MS**
Please fill in your manuscript title.	**Jumping On The Digitalization Bandwagon For BOP Pressure Testing**

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Abstract:

Blowout Preventer (BOP) is mainly used to control well pressure by quick well shut in the event of overflow and well kick to prevent blowout on the rigs during drilling, completion, workover, and plug and abandonment phases of well operations. Regulators, Operators and Drilling contractors have put in place the requirement to test BOP systems as a method of inspection and assurance in this process safety critical steps. During well operations regular BOP pressure testing will need to be conducted to ensure its integrity and functionality as per testing requirement. In most cases BOP pressure testing is conducted online using rig time although it can also be conducted offline in some circumstances.

BOP Pressure testing is considered flat time during well operations and the operators' goal is to minimize flat times for rig time saving thus operating cost reduction. Flat time reduction can be achieved by reducing BOP pressure testing period and improving the efficiency in the entire testing process. As such a digital pressure testing system was deployed to multiple offshore drilling rigs in Malaysia beginning in September 2019 as innovative technological solutions.

This paper represents the digital pressure testing system deployment study on both subsea and surface BOP drilling rigs for direct comparison with the process in use of the analog circular charter recorders (CCR) for BOP Pressure Testing. The study has shown an average 22% reduction in test times, improved safety, improved efficiency in recognizing failed tests faster, improved data reliability and repeatability of BOP pressure tests.

Introduction:

BOP systems must be maintained and inspected to ensure that the equipment will function properly. A BOP test is a sequence of pressure tests of portions of the well control equipment, until the entire well control system is tested. Tests can be either offline (not part of the critical path of well operations) or online (a so-called "flat time" activity that is part of the critical path). The cost for online testing is the time required for this activity multiplied by the full spread day rate of all the time-based drilling contracts.

When the digital pressure testing system was deployed in September 2019, analog CCR (Bristol, W.H., 1888) were being widely utilized. The digital pressure testing system is a PC based standalone system that takes the place of an analog CCR. The CCR is antiquated testing equipment patented in the 1800s. The system includes schematic building, test planning, test monitoring, automated pass determination and report generation. A test's pass/fail determination relies on human interpretation of the analog data plotted by the CCR. Reports of the tests are generated by hand. This process enables errors, inconsistencies, invisible lost time and is not consistent with process safety initiatives.

This paper introduces the digital pressure testing system which removes subjectivity and needed interpretation for pass/fail determination. The high-resolution data is objectively assessed in real time producing fast and precise results. These digital results and data are then reported instantaneously. The digital data is available granularly for measuring, comparison, and reporting, and increased quality and quantity of data allowing for more reliable results, better assessment, and improvement opportunities of the pressure testing process.

Description and Application of Equipment and Processes:

Digital pressure testing system is an advanced digital pressure recording system that allows the operator to precisely monitor and record pressure tests. The easy to use and intuitive interface allows operators to input the pressure test parameters as well as their pass/fail criteria. Both the test pressure and pressure decay rate are clearly graphed on the display screen. Digital pressure testing system provides an automated and objective means of determining pass/fail results, which provide with a higher level of safety and validity to the pressure test process by removing the subjective interpretation of CCR. Operators can quickly validate pressure test results using the digital pressure testing system, and can save substantial time and money. The pressure test data is recorded five times a second in a secure log file. The basic digital pressure testing system includes a ruggedized computer which can be detached for convenience. The digital pressure testing system features both Wi-Fi and cellular communication capabilities.

This system is widely used for BOP and Choke Manifold Pressure Tests. This system can be used for applications that utilize a CCR for Pressure Decay Testing Method. Some equipment and test examples are BOP & Choke Manifold Wellbore Testing, BOP Operators, Valves, Casing, Riser, Accumulators, EDS, Soak Testing, and Well Integrity Testing.

The process to deploy and maintain this system is a simple. The process that consist of front-end loading, delivery, installation, testing, classroom and on the job training, and 24-hour support by technology provider to the end user. Front end loading entails transposing of the test procedures into the system as templates, identification of testing efficiency improvements, and training.

Presentation of Data and Results:

A big leap of improvement for BOP pressure testing was explored when the digital pressure testing system that replaces analog CCR was deployed on drilling rigs in Malaysia beginning in September of 2019. The data and results are based on a 1-year Key Performance Indicator (KPI) study of 3 offshore rig deployments. The rigs consisted of 2 Subsea and 1 Surface BOP applications. Prior to deploying to each rig, the applicable schematics and test procedures were transposed into the digital database. Due to inherent logic in the software and better illustration of data to the user, this effort identified efficiency through reduction in the quantity of tests needed to complete a test cycle. It also identified untested components that were previously believed to be tested in manually created and reviewed procedures. These digital procedures then became the approved templates to be used repeatedly for future testing promoting consistency. Upon installation and training of the digital system and initial test cycle was completed while simultaneously running CCR and digital pressure testing. This allowed for the direct

comparison of time savings and resolution of data.

The digital pressure testing showcased a significant time savings, increased confidence in testing results. From deployment findings it was found that the digital system had higher resolution of data, precise control of test criteria and objective pass/fail reporting as compared to CCR. It was then decided that the CCR would no longer be used as the primary means of testing and resulted in the digital pressure testing kit becoming the document of record. As the study progressed periodic assessments of KPI took place. Some of these KPIs are the length of time to perform a low and high pressure test known at Time to Pressure Test (TPT), the time to perform a test line up between two tests known as Time Between Pressure Test (TBPT), and the time to pump up to desired test pressure known as Time to Pump (TP). These assessments allowed for measuring performance and comparison of data both within the same rig from one test to the next and across multiple rigs. One assessment resulted in the identification of a rig that was in line with overall objectives set forth yet had abnormal pump times. Identification allowed for processes to be assessed and subsequently modified. The modified process improved performance and the respective rig became Best in Class. This type of decomposed data and process improvement using this data is not readily available while utilizing CCR.

The application of this digital pressure testing system recognized an average 22% time savings per pressure test with a BOP test cycle savings of approximate 1 hour for Surface BOP and 2 hours for Subsea BOP (as demonstrated in Figures 1-3). The best-in-class BOP test time was 14 mins for Surface BOP and 15 mins for Subsea BOP.

Global data and results are based on 2 year KPI study of 11 offshore rig deployments. The application of this digital pressure testing system recognized a 28% time savings per pressure test on a Subsea BOP and a 37% time savings per pressure test on a Surface BOP (as shown in Table 1).

Cost Benefit Analysis of digital pressure testing costs, time saved, and rig rate concludes a Return on Investment (ROI) within the first month of deployment and estimated up to 0.5-1 mil USD in 24 months (as shown Figures 4-5) depending on the rig type and cost.

Conclusions:

The results of this digital pressure testing system deployment study have delivered on the objectives of improved process and personal safety while reducing rig time. To achieve these benefits, the industry should digitize the BOP testing process, moving away from analog CCR. Lastly the use of this technology should be extended to pressure testing outside BOP testing and anywhere CCR are being utilized.

Acknowledgments:

I cannot express enough thanks to PETRONAS, Project Teams and BOPX management for their continued support and encouragement on the new technology application. The completion of this deployment study could not have been accomplished without their full support. I also offer my sincere appreciation to IPTC and the organizing committee for the opportunity given on this technical paper submission, review and acceptance. Finally, my deepest gratitude to my caring and supportive family members for your moral support and encouragement. My heartfelt thanks to all.

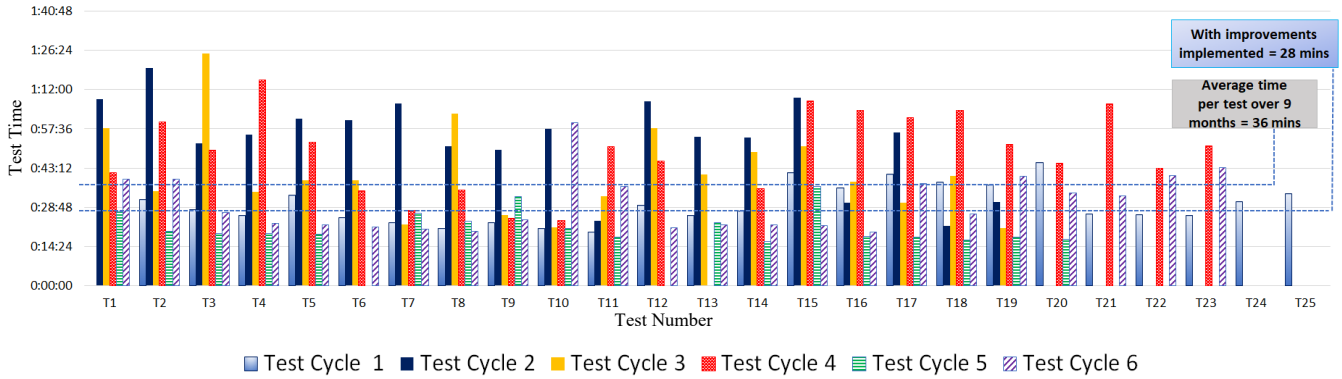
Nomenclature:

BOP – Blowout Preventer
CCR – Circular Charter Recorder
EDS – Emergency Disconnect System

KPI – Key Performance Indicator
PC – Personal Computer
TP – Time to Pump
TPT – Time to Pressure Test
TBPT – Time Between Pressure Test
ROI – Return on Investment

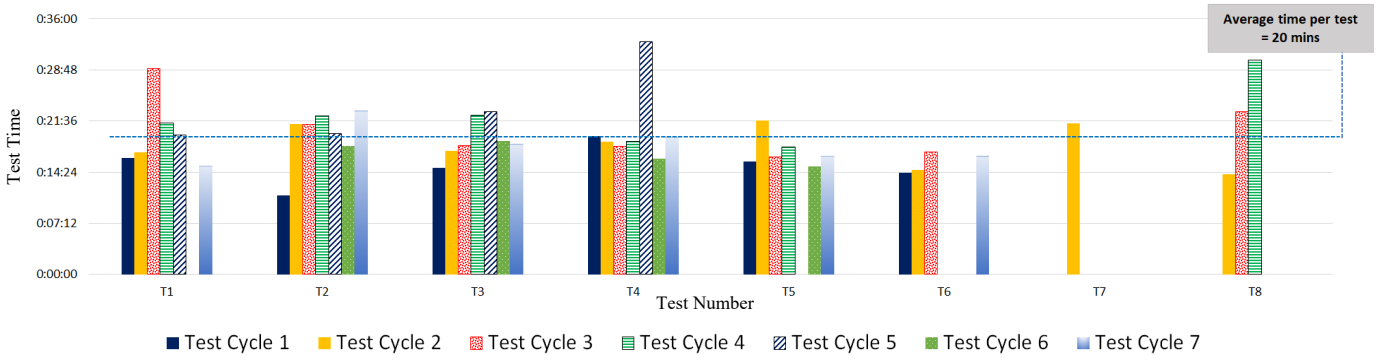
References:

Bristol, W.H., 1888, US Patent 389,639



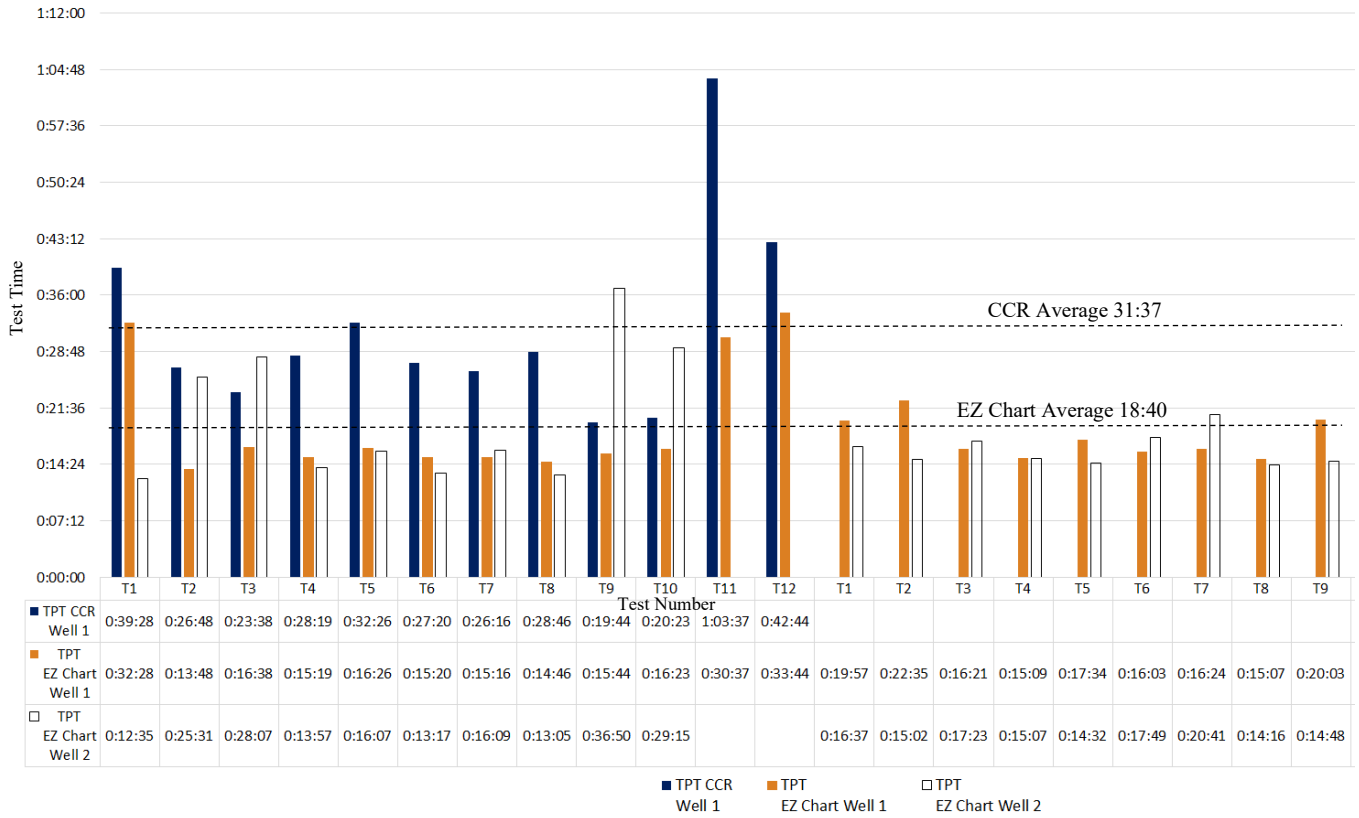
- **TPT process improvements, gives an average time of 28 mins per test**
- **Current estimated average time savings of 2 hours gives 10% per test cycle**
- **The benchmark best in class test time for the subsea BOP is 19 mins per test**
- **Digital pressure testing system uses 5 mins LP and 5 mins HP which saves 5 mins per test and complies with API Std 53**
- **The ability to measure and manage through the capture and reporting of KPIs. Savings are calculated from operator supplied field data.**

Figure 1: Time to Pressure Test (TPT) using Digital Pressure Testing System for Deepwater Rig A with Subsea BOP



- **Current estimated average time savings of 1.0 hour gives 15% per test cycle**
- **The benchmark best in class test time for the Surface BOP is 14 mins per test**
- **Digital pressure testing system uses 5 mins LP and 5 mins HP which saves 5 mins per test and complies with API Std 53**
- **The ability to measure and manage through the capture and reporting of KPIs. Savings are calculated from operator supplied field data.**

Figure 2: Time to Pressure Test (TPT) using Digital Pressure Testing System for Jack-Up Rig B with Surface BOP



- **Potential total time savings of 221 mins utilizing digital pressure testing system (EZ Chart) compared to CCR.**
- **EZ Chart TPT gives an average time of 18 mins per test with an average 42% time savings**
- **The benchmark best in class test time for the Subsea BOP is 15 mins per test**
- **System allows crew to use 5mins LP and 5min HP which saves 5 mins per test due to digital pressure testing with EZ Chart and complies with API Std 53.**
- **EZ Chart was used to pressure test Rig Equipment, Casing Cement job during the wells.**
- **Combined Time Between Pressure Test (TBPT) on average is 10mins with best-in-class 1min 27seconds.**

Figure 3: Study of Deepwater Rig C Time to Pressure Test (TPT) of Subsea BOP and Choke Manifold utilizing Digital Pressure Testing System

Table 1: EZ Chart Average Time Savings

INSTALLATION	Circle Chart Recorder TPT Avg. [min]	EZ Chart TPT Avg. [min]	TPT Savings
Drillship & Semi Subsea Stack	39	28	28%
Platform, Jackup Surface Stack	33	21	37%

- **EZ Chart Average Time to Pressure Test (TPT) Savings Per Test. (TPT is the time to complete an individual Low-Pressure and High-Pressure Test)**

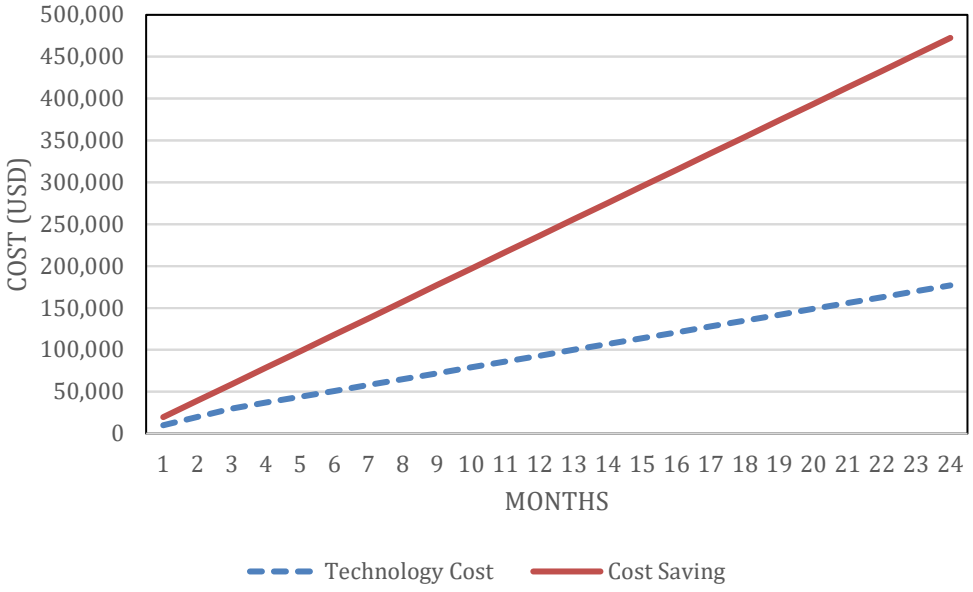


Figure 4: Cost Benefit Analysis for Jack-up Rig Type

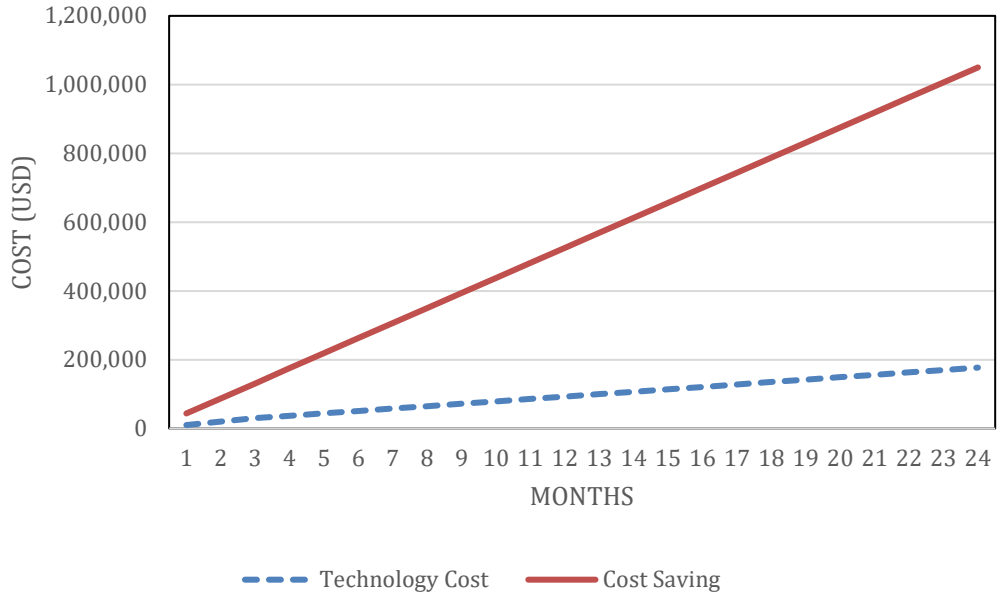


Figure 5: Cost Benefit Analysis for Drillship Rig Type