Subsea test valve in modified BOP cavity may help to minimize cost of required BOP testing

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CONSIDERABLE INDUSTRY resources have been expended to ensure the safe, reliable operation of well control equipment. Design methodologies, reliability studies and rigorous testing efforts have been created to ensure that blowout preventers (BOPs) will work as required, when required. During actual drilling operations, contractors are required to test BOPs at specific intervals. These vitally important tests carry a considerable cost in terms of rig time spent conducting the test, particularly in deepwater. The reasons for testing are fixed — however, the costs associated with the testing are not.

A device known as a Subsea Test Valve (SSTV), installed in a modified BOP cavity, can eliminate the need to trip drillpipe and install a test plug when conducting required testing. The SSTV uses a relatively simple design philosophy and proven technology to allow BOP testing without retrieving drillpipe to the surface or running additional tools.

This effort began as an attempt to gather data from an end user on how much time (money) is saved by using the SSTV in operations. Sorting through the data to come up with a single "number" turned out to be more difficult than originally anticipated. Ultimately, the process turned into an exercise in using actual rig tripping time data to determine a way to calculate expected outcomes based on real inputs.

SSTV DESIGN

The SSTV is designed to be used in the lowest cavity of a BOP stack and seals around the drillstring in the well (Figure 1). The SSTV can be thought of as a set of standard variable bore ram blocks turned upside down, with the sealing surfaces contacting the bottom of the cavity instead of the top. The BOP test pressure applied above the rams energizes the downward-facing "top seal," while the variable bore packer is bi-directional. This arrangement allows pressure to be applied above the SSTV to test all the cavities above it, while isolating the well from the test pressure. In the SSTV cavity design, what normally is referred to as the "top seal" is actually a bottom seal, effecting a seal on what is usually a wearing surface. This surface can be designed with a replaceable wear plate to allow the cavity to be returned to manufacturing tolerances during overhaul and repair activities. Using the SSTV replaces the traditional practice of running and setting a BOP test plug, potentially saving a great deal of tripping time.

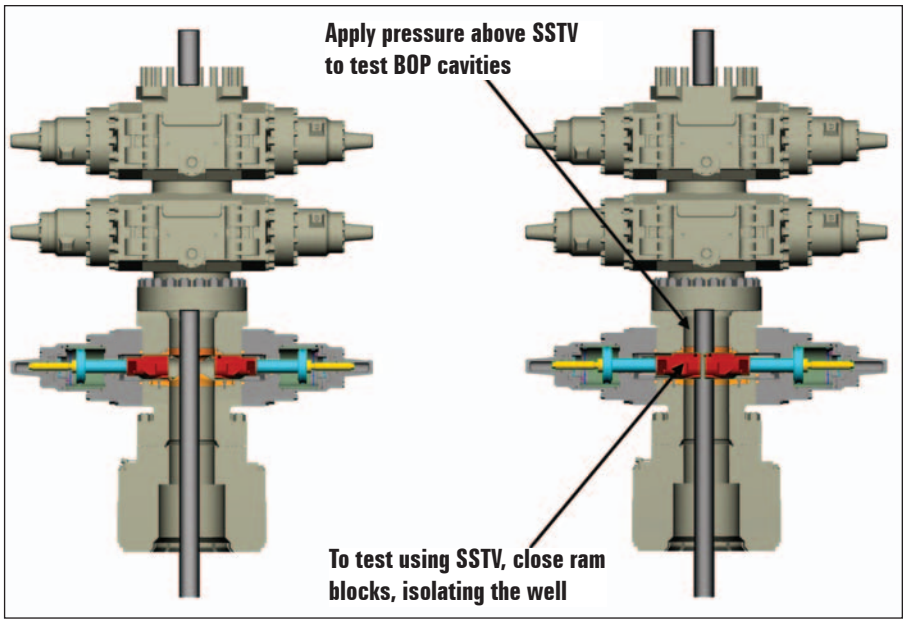


Figure 1: The Subsea Test Valve, installed in a modified BOP cavity, is designed to be used in the lowest cavity of a BOP stack and seals around the drillstring in the well.

TESTING USING THE SSTV

Normal procedures for conventional subsea BOP testing require the drill string to be pulled from the well and a test plug that seals in the wellhead be run into the bore. Once testing is complete, the test plug is removed from the well, and the drill string is tripped back in and drilling can be resumed. These operations can be summarized as:

- POOH (drill string)
- RIH (wear bushing/test plug)
- Test the plug
- Test BOPs
- POOH (wear bushing/test plug)
- RIH (drill string)
- Resume drilling

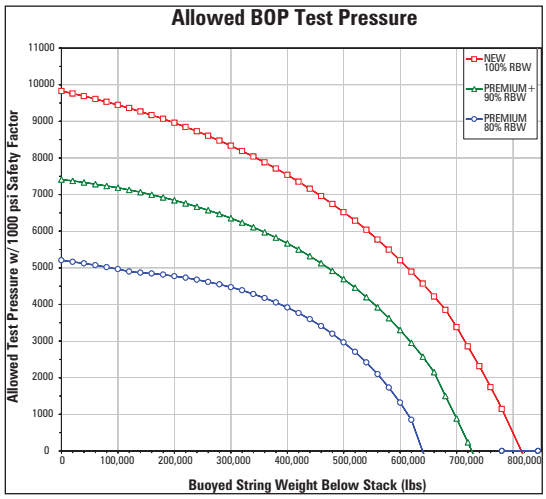
What is not always considered is the time associated with circulating of the well prior to pulling the string out to ensure well bore stability and integrity during the test, and the well check once the string is back in the well. With the drill string out of the well, there are risks associated with well influx and well stability that are not usually quantified as part of the test cost.

Using the SSTV can mitigate much of the risk associated with BOP testing, as any tripping time is significantly reduced, and the drill string never needs to be completely tripped. To test the BOPs using the SSTV, the drill string is only pulled up either off bottom, to a casing shoe or to a point where a suitable-size pipe is in the SSTV cavity. If there is only one size of pipe in the hole, the drill string can be pulled up to a hang off point, or where the rams being tested and SSTV can be closed on pipe and not on a tool joint.

In cases where a tapered string is being run, testing can be completed in 2 steps. Testing on the smaller-size pipe can be performed either prior to pulling back to the shoe, or after running back in once the larger size has been tested above the shoe. Similarly, the larger size can be tested first or second, depending on user preference. In both cases when using

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Avg
Drillship													
POOH	3508	2968	2340	2591	2990	2810	2243	1734	2502	2772	2170	2740	**2614**
RIH	2593	2670	1816	2300	2673	2239	2138	1633	2139	2377	1990	2411	**2248**
Semi													
POOH	2518	3325	2935	2793	3325	2488	1545	1956	1812	2082	2549	2240	**2464**
RIH	2344	3188	2203	2886	1890	2499	N/A	1648	1800	1805	1768	1977	**2183**

Table 1 (above): Tripping speeds for selected drillship and semisubmersible. Table 2 (below right): Average tripping speeds for all rigs of specified type. Figure 2 (below left): Reduced test pressures to prevent drill pipe collapse.



	All Semi-Submersibles	All Drillships
POOH (ft/hr)	2554	2362
RIH (ft/hr)	2270	2087

a tapered string, the BOP test is completed in 2 steps. One caveat: The actual test pressure may have to be adjusted depending on the collapse pressure of the drill string with the added factor of the tensile load hanging below the rams. Curves for maximum pressure that can be applied for each style drill pipe have been developed. (See Figure 2 above.) However, in most cases, this has not been a factor.

These operations, which reduce the number of drill string round trips to the surface from the conventional 4 to 0, can be summarized as:

- Pick up off bottom to appropriate test point (depending on drill string and spaceout)
- Close SSTV
- Test BOPs
- Open SSTV
- Repeat for tapered string
- Resume drilling

When reading the above procedure, one might ask how the blind/shear rams are tested. In most cases these rams are tested after casing set points and tested to the casing working pressure. These tests are not normally conducted at the same intervals as the ram, choke/kill valves and annular(s).

In cases where there are tools in the hole that are larger than any of the rams can seal on, regulatory agencies do not require testing on these components Examples would include casing, drill collars, or specialized drilling tools, as these are not normally in the BOP during drilling operations, or if they are, they're only in the hole for a limited time.

SSTV BENEFITS

Many new technologies in the drilling industry carry the promise of increased operational efficiency and reduced costs. Quantifying the actual savings achieved is a difficult proposition. Drilling data records include trouble events such as stuck pipe, equipment downtime, etc., so the data is hard to mine for actual time savings for a specific piece of equipment. Since the SSTV actually saves tripping time when testing the BOPs, an attempt has been made to quantify potential savings using actual average tripping times from a sample set of deepwater rigs. These times can then be used to calculate the potential savings from using an SSTV. Additionally, methods to project future savings are presented in a form where assessments based on water depth and bit depth below the mudline can easily be made.

FIELD RESULTS

One drilling contractor utilized the SSTV on a 5th-generation rig operating in more than 6,000 ft of water in the Gulf of Mexico, where BOP testing is required every 14 days. Mining the data for specific SSTV time savings results was more difficult than originally thought. Apparently, after the initial record keeping, the results were overwhelmingly positive, and data was not tracked in detail anymore.

On this particular 240-day well, 9 total trips were saved, equal to approximately 6 days of rig time. Doing the math, a trip every 14 days would imply 17 trips saved, not 9. However, when running casing or testing the wellhead, the SSTV cannot be used, so the benefits do not accrue during these operations. One indication that the feedback from the contractor and operator was positive is that the contractor has ordered new stacks for deepwater drillships, all with SSTVs included.

Calculating savings based on actual average tripping times: Based on the number of variables that dictate actual tripping time, an effort was made to smooth out the effect of random events on-board drilling rigs. Data was collected on tripping times, both Run in Hole (RIH), and Pull out of Hole (POOH), from 13 vessels in **Transocean**'s fleet, 5 semisubmersibles and 8 drillships. Not all of these had an SSTV installed. This exercise was performed strictly to determine an average speed across the fleet.

Table 1 shows sample running speeds for a drillship and a semisubmersible for a calendar year. All values are in ft/hr.

The difference in POOH and RIH speeds are apparent, and Table 2 shows the averages calculated for all 13 vessels.

Noting that the POOH times are on average 13% higher than RIH times, these are listed as separate variables in the equation for determining the time savings using an SSTV, which can be written as:

Where

$$t_{test} = \left(\frac{2D_{wd} + D_{BML}}{V_{POOH}}\right) + \left(\frac{2D_{wd} + D_{BML}}{V_{RIH}}\right) + t_{misc}$$

ttest = tripping time when testing "conventionally" (Potential Savings)

Dwd = water depth (ft)

DBML = depth below mudline (ft)

VPOOH = speed while pulling out of hole (ft/hr)

VRIH = speed while running in hole (ft/hr)

tmisc = miscellaneous rig up time for tools

The equation can be used to estimate the total tripping time required to perform a BOP test when operating in a given water depth with the bit a specified distance below the mudline. Note that the time to actually perform the BOP testing is not included, as it is assumed to be the same whether using an SSTV or testing conventionally. When using an SSTV, the value calculated above would be reduced if tripping is required to space out properly to test, or a tapered string is run and multiple test points are required.

Using the semisubmersibles data, Figure 3 shows that in 5,000 ft of water, with the drill bit 5,000 ft below the mudline, using an SSTV to test the BOPs could save up to 12 ½ hours of tripping time. Using the 5,000-ft curve as a baseline, Figure 4 shows the savings per test based on depth below mudline for a given rig dayrate. Using a $500,000/day rig rate, a single test using an SSTV in 5,000 ft of water with the drill bit 5,000 ft below the mudline could save as much as $260,000 of rig time. Note that the time and savings presented above are for a single test. The water depth will remain constant for a given well, but the depth below mudline will vary for each required BOP test point as the well is being drilled. The projected days vs. depth curve can be used to sum the savings at each required test point to determine the estimated total savings for a given well.

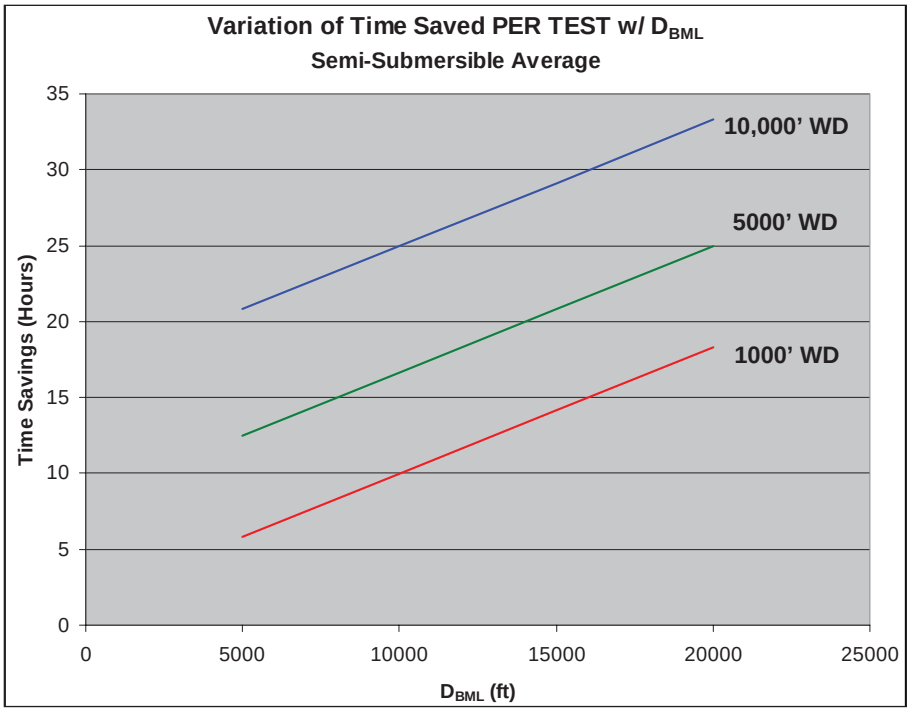
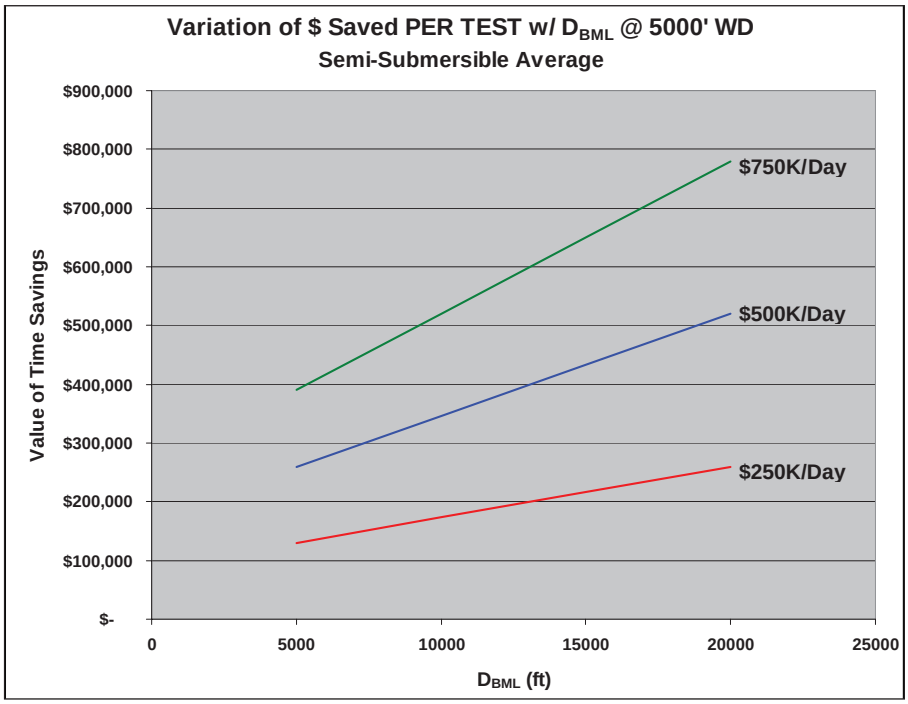


Figure 3 (above): In 5,000 ft of water with the drill bit 5,000 ft below the mudline, using an SSTV can save up to 12½ hrs of tripping time. Figure 4 (below): With the 5,000-ft curve as a baseline, this graph shows the savings per test based on depth below mudline for a given rig dayrate.



OTHER OPPORTUNITIES

The data clearly shows that substantial savings are possible by using an SSTV on offshore drilling vessels to conduct required BOP testing. Although data was gathered for this study from floating rigs, there are other areas where using an SSTV may prove to be beneficial. Even land drilling operations may benefit from using an SSTV, particularly when drilling through zones where hole conditions make tripping pipe difficult.

This article is based on a presentation made at the 2006 IADC European Well Control Conference & Exhibition, 4-5 April 2006, in Amsterdam.

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