New Technology in Deepwater: Increasing Operation Uptime and Safety While Reducing Risk

A. INTRODUCTION

Oil exploration continues to drive the threshold depths at which we drill; as a result, downtime necessary to inspect and maintain deepwater drilling components has increased. From a technological standpoint, mechanical components such as those used in blowout prevention, drilling riser connections and associated equipment have mostly remained unchanged, even as the environment in which they are used has drastically changed. The reality is that we are placing rigs in deeper water, and drilling deeper. Deeper water, deeper drilling depths have caused us to rethink our systems and methods that have been reliable for many years. SafeStack Technology, LLC, applies innovation and creativity through sound engineering principles to present products that will save the operator money, downtime, and uncertainty.

SafeStack provides practical, downtime-reducing solutions to problems with conventional marine riser systems. Time required to recover the marine drilling riser (MDR) is lost production time. This conventional method of pulling the MDR to access the Lower Marine Riser Package (LMRP) has been taken for granted as a necessary step required meet industry and governmental requirements, as well as to ensure the safety of the operation. New technology from SafeStack drastically reduces the amount of downtime required to service and maintain subsea components. Reduced downtime is increased operation; both translate into tremendous cost savings. Further, SafeStack's technology also reduces risks naturally incurred in deepwater and ultra deepwater drilling and production. Fundamental to SafeStack's innovations is a new, better approach to assembly of the blowout prevention (BOP) system.

Further, given the thrust toward 20 kpsi-capable components, the SafeStack system is highly qualified to install and remove these components, without additional modifications needed with other systems.

B. A THREE-PART, REDESIGNED, ENHANCED BLOWOUT PREVENTION SYSTEM

SafeStack's BOP has three parts, each one improving and enhancing the conventional BOP system:

(1) The Riser Disconnect Package (RDP) introduces increased operational efficiency. The RDP will quickly, reliably disconnect in any situation. Below the disconnected RDP there is (or can be, depending on the needs of the operation) a latch/sealing surface for SafeStack's proprietary latching mechanism, including a light dome enclosure, or a connection ready to attach another BOP capping stack. The RDP may also carry a resident work-class Remotely Operated Vehicle (ROV). Once the MDR is disconnected, the LMRP can be recovered quickly, since the MDR can remain in place.

(2) The modified LMRP allows the installation of an upper stab plate (connected to an RDP that is fitted with additional valving, controls and instrumentation). This improvement allows real-time, continuous monitoring of the BOP during both drilling and production.

(3) The wellhead connector, rams and stab plate are fitted with the ram preventers as required for safe and efficient drilling. SafeStack's proprietary hydraulic release connector and interface hub may be installed at this lowest connection point, allowing for component above to be disconnected quickly, reliably, and safely without an ROV.

Seal surfaces can be built into any device at the modular connection point so that a light dome or capping stack can be installed.

1. The Riser Disconnect Package

SafeStack greatly improves the conventional BOP system, because its system allows the MDR to remain in place (just moved aside) when the LMRP is recovered. SafeStack's system includes a stab plate that holds the multiple channels for high pressure fluid and the essential control system power and signal lines. The main bore connection has a hydraulically controlled release connector/interface hub pair. The interface hub can face either up or down, as can the release connector. Of course if the interface hub is facing up, the release connector will face down, and *vice versa*. When the interface hub is facing down (*i.e*., integrated into the flex joint on the MDR), the operating mechanism, attached to the release connector, will be recovered with the LMRP. When the interface hub is facing down and the release connector facing up (called the "inverted" position), the pair will be disconnected by the resident work class ROV's control system, with an ROV intervention panel mounted to the exterior of the RDP frame as a backup control. The resident work class ROV that will have the capacity to observe and intervene, at any time, to maintain all regulatory required functions of the BOP system.

SafeStack's RDP connection system does more than enable the recovery of the LMRP under unplanned failure conditions; it also enables the quick disconnection of a lost riser string so operations can access the LMRP control and instrumentation system. Further, use of the SafeStack release connector/interface hub system between the Lower Stack and the LMRP allows access to the Lower Stack control and instrumentation system.

Bypass circuits can now also be quickly accessed in order to install a lightweight containment dome or capping stack. The containment dome can be much lighter than a conventional one when SafeStack's proprietary latch flange and latching mechanism are used. Since it is not always possible to rapidly get to the primary well bore and seal it, at least one additional connection point is essential. SafeStack's system allows the option of integrating a latch flange (providing a sealing surface) to the interface hub and also to the release connector. A lightweight dome replaces the heavier conventional one, and attaches to the latch flange. SafeStack's connection-sealing system is not designed to support rated BOP pressures, rather it is engineered to contain the flowing pressure of the well bore and redirect and contain its effluent. Well effluent can be channeled through the bypass lines to surface storage, or directed along the main well bore riser to a surface vessel.

SafeStack's system reduces time to contain and capture well effluent, thus tremendously reduces the risk of spillage, and the costs associated with lost production, lost product, and environmental restoration. Because the risk of spillage is greatly decreased, the likelihood of having to spray dispersant is also greatly diminished. Thus the subsea environment is protected not only from escaping well effluent, but also from the unnecessary use of dispersant.

2. The Lower Marine Riser Package

The LMRP's functionality is greatly enhanced when divided into two modules – the RDP and LMRP. The RDP will include the lines feeding the LMRP from the surface, the riser flex joint, and the MDR itself. The LMRP can now be detached (without an ROV) from the MDR, recovered, serviced, re-submerged and reconnected much more quickly than with a conventional system. The advantage of developing the

recoverable LMRP is that this module contains the majority of the complex functional components---equipment that has a higher propensity for failure, thus should be more easily recovered than the present technology allows.

The LMRP module contains several technological improvements. Improvements that translate into much greater flexibility and time savings in both normal operations and emergent situations. A receiver plate is included to the LMRP/RDP interface. Interconnection equipment for the kill, choke, and gas vent, hydraulic and electrical power and communications signal lines are installed. Also, large main bore fluid bypass lines are installed so that well control equipment, such as a capping stack or lightweight dome can be installed when necessary. Not only will these enhancements make it easier to control subsea effluent, but will also minimize the need for dispersant, since little or no effluent will escape containment.

Key enhancements of the LMRP are:

- An upper stab plate
- High pressure connections between the RDP and the LMRP kill & choke Lines, gas vent ports and the hydraulic supply lines.
- Large bypass lines and valves enabling the rapid deployment of the closure cap to the bore
- A subsea, retractable make-break electrical-fiber connector.

a. Lower Marine Riser Package Recovery

Efficient, safe, and timely recovery of the LMRP without retrieving the MDR is now achievable. What may take days with a conventional system may now be done in hours. An exemplar procedure follows.

The RDP is released from the LMRP and the riser is suspended from the rig's spider or hang-off beams. This process will require the set back of the uppermost riser stand and the fitting of a gimbaled suspension module to the riser before landing the riser out on the cellar deck level interface. Depending upon the rig's operating specifications and cellar deck maneuverability capabilities, the riser can be skidded clear of the well center and drill pipe, equipped with a mating connector interface to the LMRP main bore, and run to the LMRP. Via the ROV observation and manipulation capability the drill pipe is guided to the Connector interface and locked to the LMRP. The ROV then addresses the intervention panel and releases the LMRP to Stack connector and all other fluid connectors which bridge the Stab – Receiver plate, thus permitting the removal and recovery of the LMRP. There are a number of variations of this procedure, based upon rig specifications. A dual activity rig may be able to recover the LMRP from the secondary well center; a vessel with a "to seafloor" winch (or a service vessel so equipped) could also affect the LMRP recovery.

b. Lower Marine Riser Package Reinstallation

The reinstallation of the LMRP (or its alternate on a dual stack rig) is accomplished in the reverse order of the recovery operation. ROV and laser targeting will be used to locate, orient and guide the LMRP to the Lower Stack interface hub. The RDP can then be reconnected to the LMRP.

3. Well Control Impact

SafeStack's technology ensures continuous, full functionality of the BOP system. The addition of interfaces to the core circuits enables a more rapid response to an uncontrolled well scenario. Traditional well control is not impacted by these improvements.

a. Spill Containment and Control

As was experienced in the Macondo well blowout, a loss of well control can also mean the loss of the rig and all of the well management systems. The ability to contain the hydrocarbon effluent is hampered by the delay experienced in getting clear access to the well bore. Equally, the lack of access to the control systems located on the LMRP causes significant delays in gaining access to the well bore. All the while, resources are expended, effluent is lost, and dispersant is used.

The SafeStack system addresses conventional shortcomings through the addition of both primary and secondary release and connection systems at multiple levels, in every configuration of the BOP and its operating system. For example, through use of SafeStack's proprietary inverted release connector system, hydrate formation has been shown to be vastly reduced, if not entirely eliminated. This will allow quick, efficient capping of any wild well.

Should the debris field impact the LMRP during a wild well scenario, the LMRP can be rapidly, safely removed by similar techniques as discussed regarding the RDP. Likewise, the same re-entry profiles can be used to reestablish control of the well. SafeStack's multiple, consistent interfaces are critical to the greater effectiveness and efficiency of well control interventions.

b. The Bent BOP Stack Scenario

Although a great deal of thought and engineering continues to be invested in how to control a spillage where the BOP stack is bent, SafeStack has a readily available solution.

SafeStack's tri-modular system allows for two solutions to the bent stack: (1) install a capping stack, or (2) install the SafeStack lightweight dome. Given the ease in which the RDP can be released from the LMRP, the capping stack can be installed as soon as the RDP is released and set aside. However, when it is not possible to set the capping stack, SafeStack's proprietary lightweight dome can be lowered onto the bent Lower Stack to contain and divert the flow of the wild well effluent. No other system is presently known to be able to effectively control a wild well in the bent BOP stack scenario.

C. BOP System Upgrade

The up-grade of an existing BOP system can be accomplished cost effectively through the use of existing core components and the addition of those components required for the expanded specification of the equipment. The approach must be on a case-by-case basis, as virtually no two rigs have identical LMRP-to-Lower Stack interfaces. Field surveys are essential to collect interface data that may well have been altered from the original design and manufacturing program. Due to the planned short conversion window, the structural frames will be remanufactured in the new two-part (RDP/LMRP) configuration, with new components being installed and tested prior to field mobilization. Though the conversion could (and must be planned to) be performed offshore or in a remote location, the first conversion programs will be ideally performed onshore in a shipyard or an area where stable load support can ensure a safe working environment. Due to the weight of an existing LMRP, it will typically be

demobilized from the rig in pieces. The pods, the flex joint, annulars and connector all represent significant mass reductions required for the rig to offload the LMRP. Management of the components that will be modified or have major components replaced will be dependent upon the various manufacturers design; some are known to require modification/replacement, others will be discovered during the field survey. Known assemblies that will need to have components replaced or substituted are:

- Pod Stabs (pods will be simulated during stack up and testing unless spare pod and test sets are available from the rig)
- Upper Annular bodies (to permit 5 inch bypass valves to be added to the assembly)
- Flex Joint body (to integrate the RDP connector)

The conversion of the rig's BOP will involve the transfer of all the redeployable components to the new frame/components, the assembly and testing of the unitized system, the breakdown of core or high mass components, and the transportation back to the rig, where a complete rebuild and test will be performed. This doubling of the assembly and test procedure is to ensure that any issue that could arise can be addressed while the equipment is dockside where corrections can be made off-line from drilling operations.

D. SafeStack's Role in Ultra Deepwater Technology: Installation of 20 kpsi BOP Systems

As we drill deeper, our drilling technology has evolved to meet the higher temperatures and pressures encountered. Components used subsea must be redesigned to handle the higher pressures. Since these components have become heavier, substantial modifications have to be made on the surface rig and vessels to accommodate the increased weight and height of the components. Now that the industry is moving toward 20 kpsi designs, not only have the components become heavier, but have also become taller. With conventional stack design, companies would be required to invest substantial amounts of money in new surface rigs, vessels, and equipment in order to assemble and set the heavier, taller BOP stack.

SafeStack's modular system minimizes the need to invest any money in rig, vessel or equipment redesign. Because the BOP stack is now separable into three components, the BOP stack may be set with present rig and vessel systems with little or no modification. The method for doing so is described below.

The three components of the SafeStack system are the RDP, the LMRP, and the Lower Stack. In operation, the MDR will be connected to the RDP, the RDP will connect to the LMRP, and the LMRP will connect to the Lower Stack. However, for setting the heavier system, the RDP will first be connected to the Lower Stack on the surface rig or vessel. SafeStack's release connector/interface hub set will make the connection. The release connector is versatile; it can be attached to either the RDP or the Lower Stack, with the mating interface hub on the other component (*i.e.*, release connector attached to the Lower Stack, then the interface hub will be attached to the RDP, or *vise versa*). Once the RDP is connected to the Lower Stack, the two components are lowered with the MDR and secured to the wellhead. The RDP is then released from the Lower Stack and set aside, without having to be retrieved to the surface.

The LMRP is then affixed to the drill pipe while being submerged from the rig or vessel. The LMRP will have the SafeStack release connector/interface hub combination as was used between the RDP and the Lower Stack. The LMRP is then submerged and connected to the Lower Stack. The configuration of the release connector/interface hub on the LMRP/Lower Stack connection will be the same as was used on the RDP/Lower Stack when it was set. So if the release connector is set on the Lower Stack, the LMRP's lower connection assembly will have an interface hub, while its upper connection will be a release connector.

Once the LMRP is set on the Lower Stack and communication established, the drill pipe is detached from the LMRP's release connector, and the drill pipe is retrieved. The RDP is then moved into position above the LMRP, lowered, and connected. Communication among the RDP, the LMRP, and the Lower Stack is then established, and normal drilling (or production) proceeds.