Surface BOP management and design guidelines

ON JACKUPS, PLATFORMS and tension-leg platform operations it is usual for the BOP to be located at surface. This configuration permits ease of access for maintenance purposes, a reduction in the required redundancy, and increased operations efficiency. Improved performance is due to the time being saved running the BOP and riser since the riser is casing rather than a special flanged joint.

Conversely, semisubmersibles are synonymous with running large BOPs to the seabed with a large diameter riser providing a low-pressure conduit back to the rig.

The placement of the BOPs at the seabed also significantly increases some of the HSE risks such as gas above the BOP, risks associated with the handling of the riser, and availability of drilling rigs for relief well drilling in the event of a blowout. If a high-pressure riser and surface BOP (SBOP) system can be demonstrated to be as safe or safer than current oilfield practice, many of the risks could be eliminated.

To date no detailed design guidelines have been available, so existing TLP design guidelines were used as a starting point. A quantitative risk analysis (QRA) identified loss of containment (blowout) as the main hazard associated with SBOP and riser loss as the main contributor to this hazard. Making the riser safe is the primary objective of the design process.

The design emphases are:

- Pressure in riser
- Station keeping assurance
- Maintaining required riser tension
- Fatigue of riser connectors

The major difference with the SBOP process to conventional subsea drilling is the integrated approach with various disciplines such as geologist, well designer, riser designer, drilling engineers and drilling operations.

MANAGEMENT SYSTEM

In some areas all offshore drilling operations must comply with a safety case. A major requirement of safety case legislation regime is the ability to demonstrate that the risk associated with major accident events are as low as reasonably practical (ALARP).

For SBOP technology to be used safely and responsibly, the system design must be able to demonstrate that metocean conditions have been managed such that the risks are ALARP. In practical terms this means that SBOP system must be as safe or safer than current subsea BOP systems. A key to understanding and designing a reliable SBOP system lies in adopting a very thorough risk assessment process. This includes developing a sophisticated QRA.

PERFORMANCE STANDARDS

The integrity and safety of wells depends on many factors, including design, construction, maintenance, intervention and abandonment. Through planning, monitoring and feedback, and by observing stringent standards and procedures, Shell controls each of these factors ensuring that a life-cycle management system is implemented and wells are designed and constructed with full consideration of all hazards and all relevant standards with the aim of reducing risk to people, the environment and business to ALARP.

Competent people using up-to-date written procedures and safe work practices maintain well integrity throughout its lifecycle.

Quality assurance principles are applied, implemented and regularly reviewed which identifies responsibilities and procedures and ensures the design intent is being realized.

Cooperation and effective communication is maintained with third parties and appropriate authorities.

Performance standards for SBOP activities are segregated into four types, covering both the facilities and management systems and include mooring systems and analysis, riser design and analysis, risk assessment and integrity management, and operating procedures.

MOORING SYSTEM GUIDELINES

The mooring system is a critical component of the SBOP system on a semisubmersible drilling unit. The only aspect of a SBOP system that differs significantly from a TLP or a jackup drilling system is the mooring. The integrity of the mooring system has a very high impact on the riser integrity since the riser bending stresses are related to the amount of the rig offset. Although other influences stress the riser and provide fatigue damage over time, Shell says the single largest loading is due to rig offset.

Typically SBOP applications will be on second and third generation semisubmersibles for operations in deep water (>600m). This will be beyond the normal water depth rating of the current mooring systems on this type of vessel, according to Shell. Typically the solution will be to convert shallow water rigs to deeper water rigs using a pre-laid mooring system. There may be cases in which adding a wire to an existing mooring system is possible, especially in shallower water depths.

The mooring and riser design is interrelated and design iterations are generally needed. The mooring is designed to maintain the vessel within minimal optimum offset limits hence lessening the bending stresses on the riser.

Active winching as a routine function of the mooring design should only be incorporated under special conditions and after a thorough peer review of the alternatives. Active winching is an option for extreme metocean events. Specific procedures for each rig are required.

Under normal operating conditions the rig can perform drilling operations without any constraints due to weather. For the purpose of designing the mooring system the upper limit of the environmental operational conditions is defined.

As a result of environmental conditions varying considerably throughout the world it is not possible to prescribe a mandatory return period to be used for this design load. Where practical it is recommended that the five year return period conditions be used as an upper limit of normal drilling operations in order to avoid excessive rig downtime.

The survival condition defines the maximum weather and metocean conditions the mooring system is designed to withstand while still remaining on location. If these conditions are exceeded, station keeping may be lost and the rig may pull off location eventually causing riser failure. Even if station keeping is not lost the riser may be damaged if the rig offset exceeds the levels determined in the "survival offset" mooring analysis. This defines the upper limit of offset for the mooring analysis load cases.

API 2SK recommends 10-year return conditions to be selected for a drilling unit operating in the vicinity of another installation; this return period was found to provide a high degree of reliability in the mooring system.

RISER DESIGN AND ANALYSIS

Riser design and analysis is an extremely important part of the SBOP Safety Management process. The riser is subjected to specific loads from different sources, many of which combine to increase the overall load levels. It is vital that good oilfield practice be applied in analyzing, designing and monitoring the riser during operations.

The riser analysis process adopted for SBOP consists of screening studies, detailed dynamic strength analysis and fatigue analysis. Although the screening studies may not be considered a necessity they are useful in reducing the number of iterations required to complete the detailed analysis.

The most critical areas of the riser are the seabed and section below the SBOP. The section below the BOP is subject to large wave forces and directly experiences the loading due to vessel motions. If the BOP is a guided system, the extreme bending moments on the riser just below the BOP increases significantly due to reduced rotational capacity. At the surface, the axial tension is at the highest level.

Below the BOP, the riser is also subject to large oscillatory forces due to waves that may cause fatigue damage to wellhead, pipe and the first connector below BOP. A thicker section below BOP will help to resist extreme loads. It is best to keep the first connector as far as away from the point of rotational fixity (i.e., wellhead) at this level.

RISER FATIGUE

Fatigue loading is likely to be either due to Vortex Induced Vibrations (VIV) or wave loading near the sea surface, or combination of both.

The alternating forces due to vortex shedding can cause significant vibration if the frequency of vortex shedding gets close to one of the natural frequencies of the riser. A “lock-in” phenomenon may occur, with a resonant vibration with amplitude of approximately one riser diameter. The first priority of analyzing the possibility of flow induced vibration is to avoid resonance.

If this is not possible the fatigue damage due to VIV needs to be considered. The VIV evaluation should estimate fatigue damage due to VIV per specified season. For this purpose the current exceeding frequencies based on the surface current speed will be required to estimate the cumulative damage during the drilling period for the specified season. If these results show that VIV mitigation is needed appropriate solutions need to be developed.

TENSIONING SYSTEM

The tensioning system is the most critical interface between the rig and the SBOP system. Most 3rd generation rigs that are not upgraded have a tensioning capacity in the order of 640 kip. This capacity may be increased up to 1,280 kips in cases where double tensioning is possible. Double tensioning is achieved by attaching the dead end of the wire to a strong point on the rig while inserting an extra sheave that is then linked to the SBOP tensioning attachment points.

The tensioning system must be checked against the required tension for the designed riser system in different modes of operation. For example:

•Cementing mode: Because of the limited period of cementing operation (6 hrs), the requirement does not have to follow minimum tension requirements based on API-RP 16Q.

•Drilling mode: The tension requirement for this case cannot be lower than minimum tension requirement based on API RP 16Q. Higher tensions may be required in the cases of high bending moments due to offset or vortex induced vibrations. In the calculation of minimum tension no factor is necessary on BOP weight. API factor must be applied on riser and its contents.

The rig structure must be checked with respect to the modification of the tensioning system regarding any change in the geometry of lines, changes to the stiffness of the tensioner or new tensioners. Double sheaving reduces the tensioner stroke by half.

The minimum operating tension requirement is similar to any drilling operation and is defined by the recommendation of the API RP 16Q. The operational tension should not exceed 90% of the installed tension capacity. The results of riser analysis may lead to higher operating tensions than the API minimum operating tension. The need of an anti-recoil device must be investigated depending on the configuration.

CONCLUSION

The management system allows a consistent approach to design and implementation of the SBOP system. As such it is a dynamic system built to learn from previous experience with the ability to extend this approach to more severe environmental areas, deeper water and for severe well programs.

The integrated approach aims to reduce and control the identified risk of a riser failure. The HAZOP is a cornerstone of the process to manage the risk, gather experience and feed back/train operational people to the new techniques.

Comprehensive design bases were established using TLP experience in riser design and analysis.A large effort was made to qualify casing connection to gain a better knowledge of the fatigue behavior of threaded connections.

REFERENCE

This article was prepared from a paper presented at the 2002 IADC/SPE Drilling Conference titled Surface BOP - Management System & Design Guidelines, presented by **P. Azancot** and **E. Magne**, Shell International E&P, and **J. Zhang**, **Shell Global Solutions**.