DNV helps GlobalSantaFe go the extra mile

THE AVERAGE DAYRATE of modern deepwater drilling and production mobile offshore units ranges between $200k and $300k. That translates to roughly $10,000 per hour. There are major economic losses when the rig loses uptime. Accidents and equipment failures can significantly affect uptime depending on the effect on personnel, environment, equipment, the well, etc. The consequence costs can escalate from the tens of thousands of dollars into the hundreds of millions or more.

To avoid these scenarios a proactive approach was utilized for **GlobalSantaFe's** deepwater drilling vessels Development Driller I and II. An independent third party was engaged to conduct a total system review of the integrated active heave hoisting system with the intention of issuing a "Fit for Purpose" statement. **Det Norske Veritas**' Offshore Standard DNV-OS-E101 "Drilling Plant", October 2000 was used as a measure to evaluate the integrated hoisting system.

The derrick access basket on GlobalSantaFe's deepwater rig is part of the hoisting system evaluated by Det Norske Veritas.

THE CHALLENGE

The last ten years the drilling industry has seen a technical revolution going from local and manual operation of machinery to advanced computer controlled and screen operated systems in interaction with field instruments and machinery. Such modern sophisticated machinery comes at a price: complexity. With complexity comes an increased requirement for design reviews, failure analysis and the integration of subsystems to reduce the probability of failure or shutdown of the entire system.

The integration of the hoisting system subsystems becomes even more essential when several vendors provide the subsystems. Each vendor must have the same understanding of the importance and consequences of single point failures in their subsystem to the overall system. To ensure a consistent overall safety level of the system, all the subsystems are to be subjected to the same level of scrutiny. Critical control signals, command signals, sensors, man-machine interface, etc., all need to be evaluated as part of one complete system. This "system integration" is often complicated due to the commercial agreements between the customer and each vendor. The vendor's requirements for confidentiality will also add to the complexity of a proper "system integration" process.

The hoisting system is indispensable to any drilling rig (onshore or offshore); the system becomes even more essential when it is an active heave drawworks, providing the block hoisting and lowering functions as well as heave compensation. The requirement of combining all these functions into one system dramatically decreases the tolerance to failure or shutdown. Therefore, it becomes essential to eliminate (or drastically reduce) the number of single point failures in any critical part of the integrated active heave hoisting system, whether it is the mechanical machinery, power supplies, operator controlled system, drive system, network, drawworks control system, power management system, brake system, etc.

This "system integration" more often than not tends to be overlooked as a part of the overall system design. The commercial relationship between the various vendors and the buyer have proved to be a complicating factor.

RESULTS

The review has contributed to several technical and operational improvements of the system. Main achievements are:

• Increased safety and availability of the integrated hoisting system highlighting interactions between subsystems and identify and evaluate the safety critical items;

• Increased safety and availability by identifying single point failures in individual subsystems potentially leading to loss of the subsystems or overall integrated hoisting system;

• Increased safety and availability by identifying the need for an improved operator message system giving an improved distinction between safety critical alarms, status information, and more extensive explanation to required actions;

• Increased availability by improving the failure detection (using advanced PLC logic or additional instrumentation), by adding instrumentation and PLC logic to eliminate false failure detection, and by adding parallel instrumentation to allow maintenance during operation;

• Increased awareness of the criticality of all items in the system to the overall performance of the integrated system; and

• Increased safety and availability by identifying the main issues for maintenance.

SYSTEM DESCRIPTION

The integrated active heave hoisting system as defined in the study covers all the subsystems necessary to enable hoisting/lowering and heave compensation of the drawworks hook load (e.g. drill string, BOP, riser).

The drawworks control system controls the speed of the drawworks drum based on the requested speed from the operator, signals from the motion reference units measuring the heave of the vessel and the power available from the power plant system.

Based on these inputs the overall speed required to handle both hoisting/lowering and heave compensation is calculated and given to the variable speed drive system that controls the AC-motors on the drawworks. The motors are used both to provide hoisting power and for dynamic braking of the load. To enable the regenerative power due to the motor braking, a resistor system is provided as part of the variable speed drive system. A hydraulic operated disc brake system is provided for emergency and park braking.

The main subsystems of the integrated active heave hoisting system are:

• Driller's Control System (Sense Technology)

• Drawworks Control System (National Oilwell)

• Mechanical System (National Oilwell)

•Variable Speed Drive System (VSDS) (ABB Industry)

• Vessel Power Management System (PMS) (Kongsberg-Simrad)

The driller's control system includes the operator's control chair (the main man-machine interface) and the control system associated with receiving commands from the operator, operator displays, communication with the drawworks control system, critical signals to and from the operator's control chair.

The drawworks control system (DW) includes all the critical sensors, the main (and backup) drawworks control system PLC's, the logic behind the programming, the critical command and control signals sent to and from the drawworks control system, the interaction with the mechanical systems, etc.

The mechanical system includes the main drawworks mechanical components (drum, main shaft, motor mounts, gears, lubrication system.) and mechanical brake components (hydraulic circuit, interface to DW control system, solenoid valves, control valves.)

The variable speed drive system (VSDS) includes the main frequency converters for the electric motors, the regenerative resistor system, drilling control system, drill floor power management (related to the hoisting system), and the critical command and control signals sent to and from the VSDS.

The vessel power management system (PMS) included the power supply (including some of the major electrical components) to the VSDS (and thus the drawworks motors), the power management philosophy as it relates to the Integrated active heave hoisting system.

THE ANALYSIS

Failure mode and effect analysis (FMEA) studies can be very effective tools to analyze complex systems and point out design faults. They can be particularly effective when analyzing control systems and the interaction between several subsystems.

The methodology chosen to carry out this analysis involved a series of failure mode and effect analysis (FMEA) sessions precluded by a Hazard Identification (HAZID) session. The HAZID session was used to identify the main components or subsystems of the integrated hoisting system and the interfaces between these, and also the main hazards (or failure categories) on the overall system in case of failures. These results were then used as input to the FMEA sessions A separate FMEA session was carried out on each of the major subsystems; in some cases several sessions were required to capture the full depth and detail associated with each system.

FMEA PARTICIPANTS

Including the designer, the rig owner, and an independent third party proved to be a very effective format to carry out the FMEA sessions.

Each party provided a fresh perspective to the discussion that would have otherwise been incomplete without the active participation of the three parties.

The designer brought thorough knowledge and understanding of the system being analyzed. The designer's input was essential to the success of the study.

The rig owner contributed the usage of the equipment and system in real life situation. The rig owner's input was particularly useful when evaluating the effect on the rig and its crew, i.e., the reaction of the driller to alarms, operational procedures that mitigated the effects of failures, the magnitude of the maintenance burden on rig personnel.

The third party brought an independent view to the technical discussion. This served to facilitate and stimulate the brainstorming dialogue. Also technical experience from previous studies and accident investigations proved to be useful input to the sessions.

FMEA FORMAT

FMEA is a structured brainstorming technique focused on identifying potential failures and their effects on a specific system. The methodology breaks down systems into specific components, which are in turn analyzed one by one. All components and their failure modes are defined on specific FMEA worksheets.

During the work session each component and its failure mode is analyzed with regards to the effect on the system, detection of the failure and if any safeguards are in place to avoid or minimize the effect.

Some questions answered are:

- How can each part conceivably fail?
- What mechanisms might produce these modes of failure?
- What could the effects be if the failures did occur?
- Is the failure in the safe or unsafe direction?
- How is the failure detected?
- What inherent provisions are provided in the design to compensate for the failure?

SYSTEM DEFINITIONS

The first task for the team was to define the integrated active heave hoisting System main functions. The four main functions agreed on were hoist, lower, hold/stop/park and heave compensate

These four functions were to be carried out at the rated load and within the operational parameters of the integrated hoisting system.

The ability of the integrated active heave hoisting system to accomplish these four main functions without jeopardizing life, property, or investment were the driving factors in assessing the consequences of failures to components, signals, logic faults, human error, etc.

The next step was to divide the system in question into individual components. The level of detail desired will dictate the number of components "bunched" together and defined as well. Defining the function of the component was essential to the analysis.

This step established the role of the component in the overall system and helped the team determine the effect of its failure on the overall system. A thorough detailed description makes reviewing the FMEA spreadsheet a trouble-free process.

Establishing failure modes and failure causes was the next step in the FMEA process. The failure modes provided a description of how a component failed, i.e. no signal sent, valve does not open, etc. These modes were based on standard predefined modes. The failure causes provided a description of the source of the failure, i.e. overheat, instrument fault, corrosion, and contamination.

FAILURE EFFECT LEVELS

The failure effects or consequence categories were analyzed on three levels: local failure effect, system failure effect and global failure effect.

The local failure effect is the effect on the individual component (or group of components). This was to establish the sphere of influence of the failure.

The system failure effect is the effect on the particular system that the component is a part of. This was used to determine the cascading effects of failure to the system.

Finally, the global failure effect evaluated the consequences on the entire integrated hoisting system and possibly to the rig. This was important to analyze in order to evaluate the true ultimate consequence of any component failure.

FAILURE EFFECTS CATEGORIES

The global failure effects are divided into three consequence categories: loss of control, loss of heave compensation and shutdown (loss of uptime).

Loss of control is any single point failure leading to dropped load, unintentional movement leading to a collision, unintended movement leading to a safety hazard, or any other unintended movement leading to engaging the emergency braking system.

Loss of heave compensation is any single point failure leading to loss of active heave compensation during any of these operations:

- Well Testing
- Stuck Drill Pipe
- Landing BOP
- Landing Casing
- Pulling BOP
- Well Completions
- Work Over Operations
- Emergency Disconnect
- Well Control Procedures

Shutdown is any single point failure leading to a shutdown of the integrated hoisting system.

The main effect of this consequence would be loss of uptime and thus jeopardizing the investment in the rig and the integrated hoisting system.

RECOMMENDATIONS

Reducing (or eliminating) the number of single point failures, leading to any of the three defined failure categories, was a major goal of the review team.

As issues began surfacing through the sessions, recommendations and action items were assigned, aimed at modifying the system or the operation of the system to achieve the goal of no single point failures.

The proactive approach undertaken by the owner has significantly reduced the risks associated with equipment failures, human error and shutdowns.

This forward-thinking risk management plan has increased safety, increased equipment availability, increased rig uptime, and re-affirmed investor confidence in the owner.

REFERENCES

This article is based upon the paper **Reducing the Risk of Integrated Hoisting System** by **Wael Abouamin**, **Det Norske Veritas**; **Gerry Lansdell**, **GlobalSantaFe**; and **Knut Haga**, **National Oilwel**l.