ABS Leads Industry in Addressing Jackup Safety Through Targeted R&D

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The key to safety in jackup operations is constant risk management. This white paper presents some of the challenges facing the global jackup fleet along with the research and development (R&D) efforts ABS has undertaken to address those challenges.

As the leading offshore classification society, ABS is investing in a multi-pronged program to promote jackup safety. Jackup safety issues constitute a significant number of the nearly 200 research projects being carried out by engineers in the ABS Technology group. Headquartered in Houston, this group includes technology centers in Brazil, Singapore, China, Korea and Canada. Research spans a broad spectrum of safety issues related to jacking systems and equipment, units moving on and off location, spudcan fixity, soils and floating stability.

Results from R&D work provide data ABS engineers use to develop and enhance the ABS Guides and Rules owners and operators follow to improve the safety of operations.

As a classification society, ABS is in a unique position to convene industry partners within the jackup community to share knowledge and experience that can be leveraged to promote jackup safety.

ABS is an active participant in jackup safety discussions in the International Standards Organization (ISO), the Society of Naval Architects and Marine Engineers (SNAME), trade organizations such as the International Association of Drilling Contractors (IADC) and International Organization of Oil & Gas Producers (IOGP), industry seminars, and other forums.

The objective of all of ABS' efforts is to enable efficient implementation of safe solutions.

Building a Foundation for Safety

Reliable technology, a strong safety culture and effective operational procedures are critical to creating a safe work environment. As operating environments and operational expectations change, technologies are introduced, and new ways of doing things emerge.

Today, the global jackup fleet comprises more than 650 units, and more than 50% of these units are more than 30 years old. Evolution in the sector is inevitable, but as operational expectations change, there has to be a clear understanding of how new challenges may be leaving these older assets behind and how lower-specification units could continue to perform safely on many challenging sites

Moving on and off Location

Jackup incidents during rig moves are more frequent than incidents while the rig is elevated, and they result in substantial cost to the industry. While the methods for assessing elevated jackup units during operations are well established, the industry needs a better understanding of temporary modes (moving on and off location) because it is in these temporary modes that the majority of non-productive time and property loss takes place. ABS and industry partners are working on a project to develop more rational analysis methods that can assist in developing operating limits for jackups during rig moves.

Many factors can affect the loads and responses of a jackup moving on location, but there are four physical behaviors that are considered critical in assessing the maximum responses resulting from jackup leg impact on the seabed. These are jackup global motions in random seas, the leg lowering process, the transient impact of the spudcan on the seabed, and jackup structural dynamic responses.

Through this project, ABS has been instrumental in introducing simplified analysis models that will help identify issues and better understand limiting conditions for moving on and off location. This unique work places ABS ahead of industry in addressing an important challenge.

Jackup Dynamics Monitoring

Monitoring of jackup motions and seastates while moving on and off location, when combined with a better understanding of limiting conditions, gives rig owners a decision-making tool to improve safety and operational efficiency.

A project unique to ABS is the initiative to promote motions and seastate monitoring systems for jackups moving on and off location. In comparison to operators of fixed platforms and floating production units, jackup owners historically have made little use of monitoring.

ABS is developing Guidance Notes and capabilities to assist jackup owners in observing key metrics during rig move operations along with methodologies that can be used to produce real-time guidance during operations. Using the same monitoring system, motions data can be gathered while the jackup is elevated on site to get measurements of response characteristics such as natural period and leg foundation fixity.

Soils and Foundations

Nearly one-third of all jackup accidents result from soil and foundation issues, which is why a number of important R&D projects are looking into spudcan concerns. Over the last decade, ABS has been involved in numerous joint industry projects (JIPs) on jackup spudcan foundations. These include a JIP on spudcan footprints, a spudcan soil fixity JIP, a spudcan/pile interaction JIP and the INSAFE JIP, which addresses punch through concerns. ABS has synthesized this knowledge to provide *Guidance Notes on Geotechnical Performance of Spudcan Foundations*.

The JIP on spudcan/pile interaction applied both centrifuge and numerical models to gain a better understanding of the circumstances under which mitigation measures would be effective in moving on location. The goal was to provide industry with a rational guideline of possible measures that could be taken to avoid an incident.

The INSAFE JIP provided guidelines on the extent of site soils investigations needed to avoid punch-throughs. The voluntary guidelines to assist operators are based on data collected from industry experience preloading jackups on site.

Reinstalling a jackup close to existing footprints left by previous spudcan extractions can be problematic. Instead of the vertical loading experienced during normal installation, when a jackup is reinstalled close to existing footprints, the spudcan footing is subjected to eccentric and inclined loading arising from the combined effect of uneven seabed and soil shear strength variation in the vicinity of the footprint. The spudcan footprint JIP looks for practical solutions to this common situation.

ABS also has carried out research on a top-mounted spudcan skirt. This is a novel approach to enhancing spudcan performance by installing plates above the spudcan. Research showed that a top-mounted skirted spudcan has improved global bearing capacity, spudcan fixity and resistance against punch-through, without compromising hydrodynamic performance.

LRFD

ABS has worked with the industry for the past 30 years on the issue of jackup site assessments, participating in industry standards development through organizations like SNAME and ISO to provide safety guidelines for site assessments. During this process, major efforts have gone into addressing leg foundation fixity. ABS has worked with prominent universities, including Cambridge and Oxford in the UK, National University of Singapore and the University of Western Australia, interpreting and applying their findings in pursuit of solutions.

For decades, the US standards for the structures of offshore units were based on the Working Stress Design (WSD) method. Recently, ISO 19900 series promoted the use of design criteria in the Load and Resistance Factor Design (LRFD) format, applied to both fixed and floating structures. To align with current trend of standards, ABS is upgrading its classification rules to provide relevant LRFD-based classification criteria as an alternative to the existing WSD-based criteria.

These new LRFD-based classification criteria will be published in the ABS *Guide for Load and Resistance Factor Design (LRFD) Criteria for Offshore Structures*. The new ABS LRFD-based criteria will not only help maintain the leading position ABS has in the offshore market but also assist ABS clients in meeting local requirements and better utilize their experience and resources. In addition to this new Guide, ABS is planning to publish an LRFD version of the ABS *Guide for Buckling and Ultimate Strength Assessment for Offshore Structures* as well.

Seismic Studies

ABS also is playing a key role in working with industry to better understand the impact of new ISO requirements for earthquake assessments for elevated jackups. As some operators are beginning to adopt the ISO document, ABS has commissioned a study to better understand how to apply the document and assess the impact on rig owners. The objective is to make a smooth transition to this document given potential business interruption due to the time required for each full earthquake assessment, particularly given the number of rigs in the world and the number of sites. A better understanding of this methodology by industry is essential to finding firmer ground on this issue and transitioning to this ISO document as operators begin to require its use.

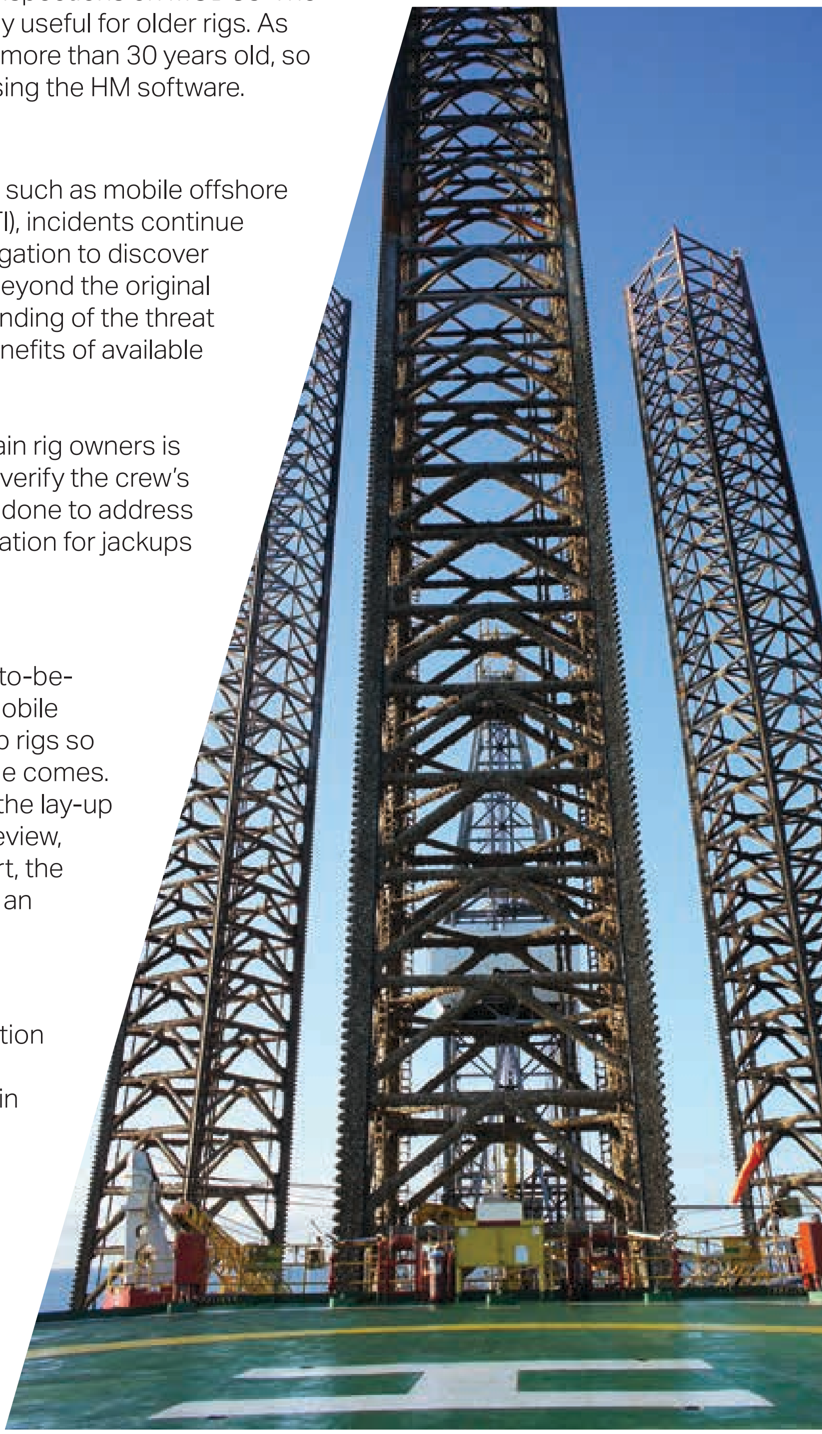
Inspection and Survey

To remain in safe operational condition, jackup hull structures must be regularly inspected for coating condition, corrosion, deformation, fractures and compartment and space cleanliness. ABS requires inspection of the hull structure in the presence of a surveyor immediately following a damage or failure and recommends the same type of inspection any time a jackup has undergone a difficult move on or off location.

For equipment, ABS offers a program that provides for inspections according to a process called condition-based maintenance (CBM). Instead of inspecting rigs and associated equipment on a prescriptive calendar-based schedule, ABS surveyors conduct inspections based on rig activity and equipment usage.

Because the jacking system is so critical to safe operations, it is very important that the system be maintained in good working order. Leg jacking systems are examined, and the pinions and gears of the climbing pinion gear train of rack and pinion systems are examined as far as practicable to identify defects or wear. Every 5 years, a Special Periodical Survey is performed on the leg jacking system. In addition to the requirements of the ABS MODU Rules, the ABS *Guidance Notes for Inspection of Rack and Pinion Type Jacking Gear* provides a minimum baseline for the inspection.

ABS is looking for new ways to improve inspections and renewals for hulls and leg structures. This is vitally important because hull inspections are critical to asset integrity. ABS developed the HM (Hull Manager) software to carry out systematic inspections on MODUs. The software is applicable to jackups and will be especially useful for older rigs. As noted earlier, over half the world's jackup fleet is now more than 30 years old, so many rig owners could soon see the benefits from using the HM software.



Watertight Integrity

Industry experience demonstrates that while vessels such as mobile offshore units are designed to provide watertight integrity (WTI), incidents continue to test them. It is not uncommon for an owner investigation to discover that flooding has progressed to hull compartments beyond the original breach. The industry is looking for a greater understanding of the threat of progressive flooding during an incident and the benefits of available control measures.

One control measure that ABS has proposed to certain rig owners is a program of comprehensive, owner-driven audits to verify the crew's maintenance performance. There is more work to be done to address WTI, and there certainly appears to be a future application for jackups under tow during rig moves.

Lay Up

For rigs that are going to be out of service, the soon-to-be-released ABS Guide for Lay Up and Reactivation of Mobile Offshore Drilling Units provides guidance for laying up rigs so they are best placed to re-enter service when the time comes. At present, there is no requirement to involve ABS in the lay-up process. At the owner's request, however, ABS can review, survey, and confirm by issuing a factual Lay-up Report, the actions that should be taken to preserve and protect an asset that is being taken out of service.

Classification of Drilling Systems

ABS also is rewriting the ABS Guide for the Classification of Drilling Systems. Originally published in 1986, the Guide has been modified to accommodate changes in both the processes and the industry standards, with the latest version published in 2012 and updated in 2014. It includes requirements specific to a drilling system, its subsystems, equipment or components, spanning design, fabrication, onboard installation and testing and maintenance. Following this Guide has allowed manufacturers, shipyards and owners to impose an additional level of quality and safety measures that have been attractive to the offshore industry.

Recognizing the potential value to industry in offering sub-class notations, ABS began collecting information to revamp the guide. In March 2015, ABS formed the Offshore Equipment Advisory Committee with the purpose of gathering industry expertise on offshore equipment to amend the Guide so that it is more useful to asset owners. When the new Guide is published, it will provide multiple notations from which owners can select the most critical for their particular assets. By expanding the number of notations, ABS provides more specific guidance that will be more precise in application.

Wind Tunnel Testing

ABS is leading an industry effort to update the SNAME guideline document on wind tunnel testing that was issued in 1988. Wind tunnel testing has been widely used in the design of jackups and floating production installations (FPIs) for many years. Jackup legs experience significant wind loading that is dominant in the stability calculations when the unit is afloat and is an important loading for the elevated site assessment. The U.S. Coast Guard has a strong interest in this effort for their approvals of FPIs.

Looking at the broader picture, this leads to the question of how to conduct more accurate wind load estimates during the design cycle of jackups and other offshore structures to develop methodologies suitable for clients looking for acceptance from regulatory bodies. In addition to wind tunnel testing, ABS is updating its proprietary software, Eagle Wind, an empirical tool for performing simplified loading calculations. And ABS engineers continue to develop computational fluid dynamics (CFD) approaches to be used as part of the wind tunnel testing process as well as for wind load estimates of jackups and floating production installations.

Operating in Ice

The ice class requirements for jackups are above and beyond those for jackups operating in open water because of the need to contend with ice. ABS has undertaken an extensive R&D program aimed at improving safety in Arctic operations, and critical among these projects is one that addresses ice loads. The prevailing design consideration is based on ice loads resulting from different forms of sea ice.

These are highly localized impact loads or concentrated loads along the ice/structure contact area, which are quite different in nature from hydrodynamic loads applied to a jackup working in more temperate regions. There are the technical issues specific to a jackup operating in ice, for example, leg shape factors, shielding effects, torsion moment due to the unbalanced leg forces, etc. The structural analysis procedure required and the acceptance criteria are different from those for open water jackups.

Research at ABS is evaluating how localized ice loads should be considered for hull strengthening for jackups working in Arctic regions where they will be subjected to ice while transiting to and from the work site as well as potential ice impact on location. ABS has been developing a framework to guide the industry in designing and assessing ice-capable jackups, which includes how to assess the loads in ice environments and how to analyze the global rig and local leg strengths with the acceptance criteria when the jackup is elevated. The framework will be the base document for the formal ABS guide/rule on Arctic Jackup development.

Industry continues to innovate and to look to ABS as a partner on this journey. ABS often is asked to review design drawings and verify that a new design is viable. When ABS reviews a design and approves it, the design can be granted Approval in Principle (AIP). Through the AIP process, ABS issues a statement affirming that a proposed novel concept design complies with the intent of ABS Rules and appropriate codes. At the AIP stage, risk is assessed on a high level through qualitative techniques. The ABS Singapore Offshore Engineering Department recently was contracted to evaluate an ice-capable jackup design that was subsequently awarded AIP. The Singapore Innovation and Research Center, Corporate Shared Technology and the Harsh Environment Technology Center provided ice-related support to the AIP.

Although it is not a part of rig design specifications, ice management (IM) is another important focus area for ABS. Successful IM is integral to most energy-related offshore activities in the Arctic and will play a key role in establishing maximum design loads. The aim of ice management is to detect and characterize (understand) and then influence and control the ice environment in the vicinity of the offshore installation. ABS is investing in IM as one of the many aspects of its harsh environment R&D program.

Providing for Personnel

Safety begins and ends with people. To more fully realize the benefits of Human Factors Engineering (HFE) and ergonomics, HFE needs to be integrated into the earliest asset design stages. To address this, ABS developed a Guidance Note on how to integrate and implement HFE into the design of an offshore asset. Complementary ABS supporting documentation includes the ABS ergonomic guide, which addresses selected working areas on each vessel, including topsides design, enclosed space design, operations, maintenance and designs for valve access and use.

The ABS Ergonomic Guidelines do not single out jackup rigs, but they do recognize the unique hazards that may be associated with them.

While safety is the number one concern, ABS also is concerned with crew habitability. A crewmember who is provided with an appropriate environment for work and rest is likely to be more productive, less likely to perform an unsafe act and has better morale. ABS has developed guidelines for crew habitability that addresses vibration, noise, lighting and climate. Many of these can be eliminated or greatly mitigated at the design stage.

To support improved safety, ABS has engaged in a collaborative effort with Lamar University and multiple industry partners to gather data on safety incidents so they can be analyzed. Viewing the data allows researchers to identify and classify strengths and weaknesses, allowing leading safety indicators to identify the safety metrics most strongly associated with safety performance in each organization.

By keeping the information confidential and making the database available to industry, ABS is providing tools the industry can use to improve safety performance.

The Future of Jackup Safety

Tomorrow will bring new challenges, and the guidance ABS provides will have to contend with evolving expectations for jackup performance.

ABS is addressing concerns ranging from high-pressure/high-temperature drilling challenges to the critical issue of software integration with our Integrated Software Quality Management (ISQM) process, which is a proven method for mitigating software errors that can affect the safety of a unit and its crew.

At ABS, we are continuously developing and improving Rules and Guides because we know that industry is changing and that for a classification society to add value, our Rules and Guides have to be relevant and appropriate. Our continuing program of Rule development is integral to the class-centric focus ABS pursues in helping the offshore industry improve safety, efficiency and reliability.

Our goal is to advance technology innovation to secure safer seas for future generations. Every day stakeholders look to us to help them protect people and property and preserve the natural environment. That is our mission at ABS, and to us, there is nothing more important.

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