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COST EFFICIENT ARTIFICIAL BUOYANT SEABED
DRILLING SOLUTION
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Abstract

Atlantis Deepwater Technology Holding has developed an artificial buoyant seabed system to be used with smaller semi-submersible or ship drilling vessels, with lower specifications and running costs, for both exploration and development. This is highly significant in the present climate of high rig rates with demand far exceeding supply. The ABS system will allow operators not only to make the decision to suspend drilling operations and retrieve the short drilling riser much later, but when these decisions are made the fiscal and disruptive impact to the industry will be considerably less. The design is being advanced by 2H Offshore to take account of the demanding ocean conditions in different parts of the world. The efforts include riser analysis to optimise system configuration and establish structural integrity, and developing the design and specifications of the system components to a level suitable for construction and installation. This paper presents the outcome of some of the work carried out to make the system "project ready".

1. Introduction

The issues of the recent Gulf of Mexico hurricanes had a significant impact on the oil and gas industry due to extensive asset damage, production loss and market disruption. This has led to a change in the traditional definition of asset management for the industry. The management of storm risks is now incorporated into the activities of most operators.

Drilling in deepwater has been the domain of advanced drilling vessels capable of supporting a 21" low pressure drilling riser, equipped with a subsea BOP, spanning the full water depth of the well location; however as water depth increases, the length and weight of this drilling riser becomes a heavy burden for any drilling vessel. A recent approach by the industry is to extrapolate the surface BOP drilling method, as used on shallow water jack-ups, into deeper waters; the drilling riser used is usually of a smaller diameter to drill for smaller casing sizes thus demanding a smaller tensioning requirement from the rig. Both surface BOP and subsea BOP methods have their pros and cons in terms of efficiency and operating limitations.

In view of the above, Atlantis Deepwater Technology Holding (ADTH) has developed an artificial buoyant seabed (ABS) system to be used with smaller semi-submersible or ship drilling vessels. The technology allows a conventional shallow water drilling riser and its subsea BOP to be run to the ABS as they would be for a real seabed. On the approach of bad weather, the riser can be disconnected and retrieved, leaving the now "new-surface" BOP behind on the ABS for well control. The design is being advanced by 2H Offshore (2H) to a level suitable for construction and installation. This following sections summarises the typical results of the analysis carried out to confirm the system's structural integrity and operational characteristics.

2. The Solution

The Atlantis Deepwater System represents a unique and very simple approach for meeting the deep and ultra-deepwater challenges of offshore drilling. An artificial buoyant seabed (ABS) is installed at shallow depth, typically 200-300 meters, and replaces the functions of the real seabed and no equipment remains on the real seabed. A tieback

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of the well casing, e.g. the 20" casing, is used as a "tether" to anchor this "new seabed". An artist impression of the ABS drilling system is shown in Figure 1.

The wellhead and BOP are placed on the ABS, which provides enough buoyancy and tension in the tieback string to keep the well in a near vertical position. The offset of the ABS and well is controlled by the top tension resulting from the buoyancy.

The cost efficiency from the use of the ABS system comes in a variety of areas, with the main ones being:

- Use of the Atlantis concept will increase the efficiency of the drilling operations considerably, as there is no need to run the BOP and the drilling riser through the water column to the seabed, merely down to 200-300 meters. In some cases this could save more than a week's rig time.
- A second/third generation rig, in combination with a taut-leg polyester mooring system, can be used instead of a higher rated drilling unit. The result of this is that the day rates can be reduced as much as 30% for most areas.
- For the well maintenance operations to be performed during the field lifetime, the availability of rigs will increase considerably, and the costs reduced similarly. All operations can be performed with cheaper rigs.

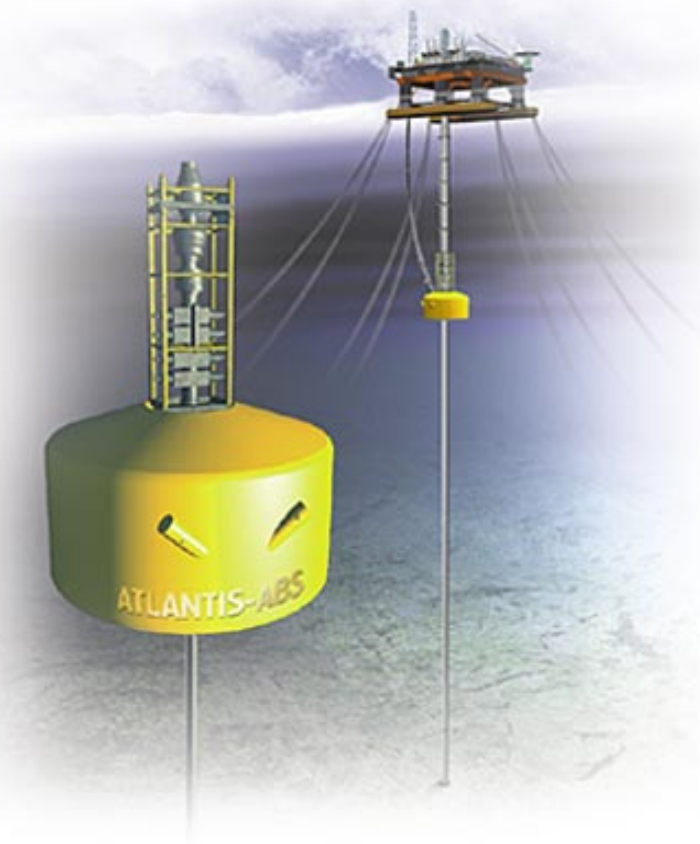


Figure 1. Atlantis ABS Drilling System

For the ABS technology to be used, the system design must demonstrate that it can manage the environmental conditions and substantiate in an industry accepted manner that any and all risks associated with the technology are as low as reasonably possible in the planned areas of application, such as India, China and the GOM. Therefore, the ABS system must be as safe as current methods, such as subsea BOP or surface BOP systems.

In order to support the argument behind the ABS system, it has been considered that design documentation has to be established with respect to:

- Riser Analysis
- Quantitative Risk Assessment

The studies have enabled ADTH and 2H to identify components to complete the full system that are designed to withstand the environmental conditions in the perceived areas of application. The next phase on completion of the documentation and procurement will be the planning and implementation of a full marine demonstration trial, for which several possible locations are being reviewed.

3. Riser Analysis

The riser analysis consisted of a review of information and data provided for the expected application areas in order to compile the design basis. An important part of the design basis was the definition of environmental loading conditions, drilling riser configuration and drilling vessel configuration and responses applied in the analysis.

3.1. Modelling

Based on the design information provided, an analysis model of the ABS drilling system was created. This model included all components from the seabed to the drilling vessel, including vessel interface, LP drilling riser system, ABS unit, and tieback string. In addition, the seabed soil support and interface with the subsea mudline wellhead and conductor were also included in the model to allow the loading in the conductor and subsea wellhead to be checked. Where appropriate, multi-string models were utilised to represent the inner casing string, tieback string in the ABS unit, and sub-mudline conductor / casing programs. Figure 2 shows a schematic model of the ABS system in drilling mode.

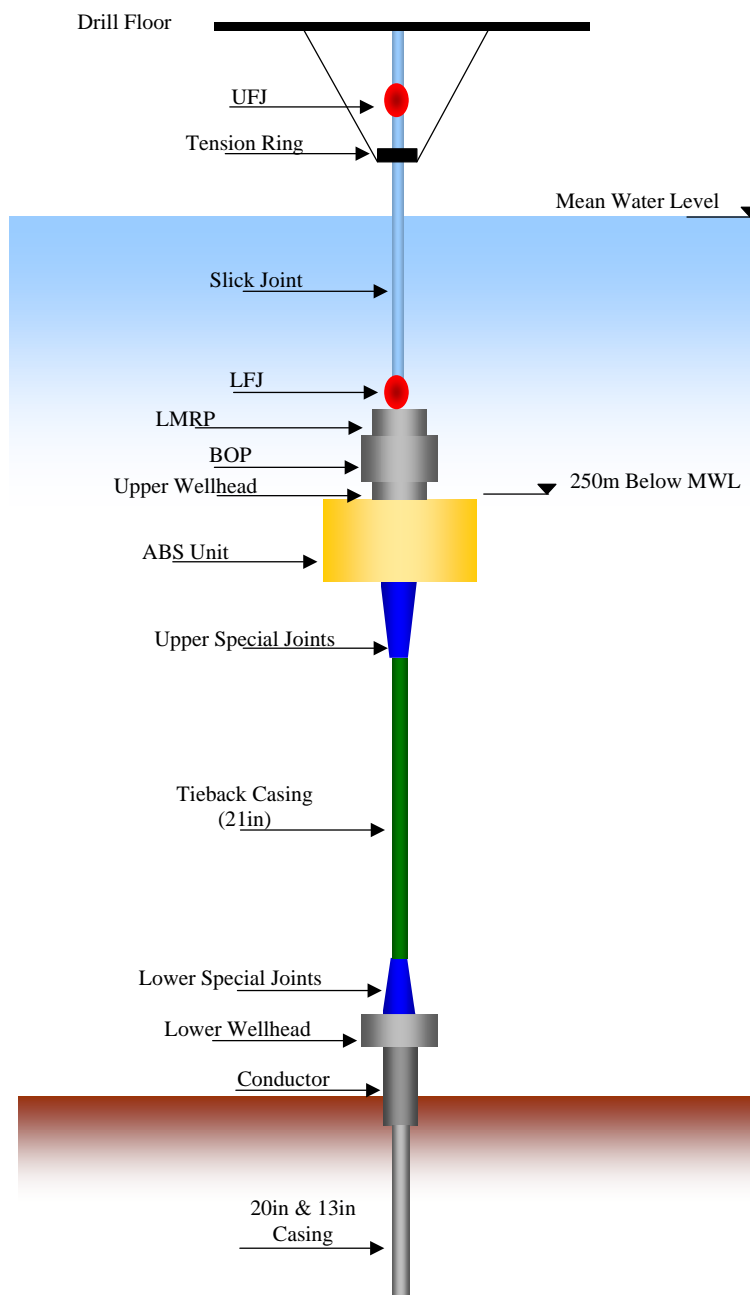


Figure 2. Analytical Model of the ABS Drilling System

3.3. Tension Optimisation Analysis

Analysis was conducted to define the optimum tension distribution in the ABS system and drilling riser for the expected application areas. This tension was defined based on the water depth, expected maximum mud weight, and drilling riser buoyancy, and would also optimise the distribution of tension / buoyancy between the ABS unit and the tension pulled by the drilling rig. The tension level and distribution was selected based on maximising the operating window of the ABS drilling system, to ensure that the tie-back casing remained under tension in the event of a tensioner failure or flooding of a buoyancy tank compartment.

3.4. Operating Limitations Analysis

Analysis was conducted to define the operating limits of the connected ABS drilling system considering a range of vessel offset and environmental loading conditions. Operating limits were defined based on typical conventional drilling riser limitations such as upper and lower flex-joint limits, riser and conductor stress limits and riser stroke at the vessel. Operating windows were defined based on drilling, connected non-drilling and survival criteria as defined in API 16Q. Figure 3 shows a graph of flex-joint angles in the marine drilling riser as a function of rig offsets in a typical water depth of 1,800 m. It indicates that a vessel offset range of approximately 5% of water depth is possible to maintain flex-joint angles of less than 2 degrees to minimise wear of marine riser components from drill string rotations.

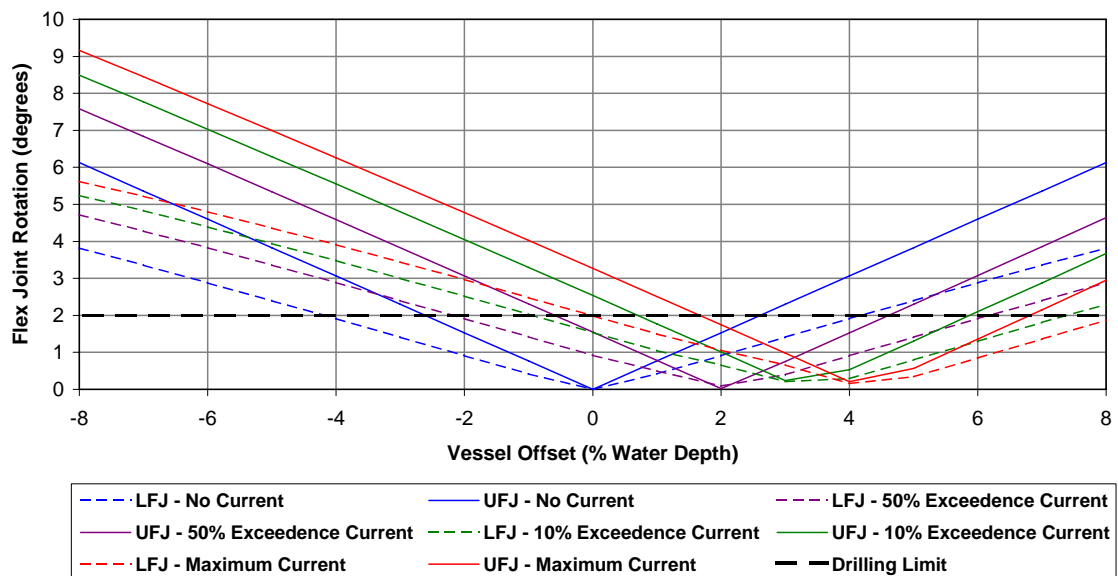


Figure 3. Variation of Upper and Lower Flex-Joint Angles with Vessel Offsets

3.5. Extreme Storm Analysis

Extreme storm analysis was conducted to assess the response of the ABS system and wellhead and conductor under maximum environmental loading conditions. This was conducted with the following scenarios / ABS system configurations:

- Before LP drilling riser and BOP is installed (i.e. only tie-back string and ABS installed);
- LP drilling riser and BOP fully connected;
- LP drilling riser disconnected, BOP remains connected to ABS system.

The design conditions also included a flooded buoyancy compartment, well control situation, etc. to ensure that all potential scenarios were considered. As discussed previously, the initial assessment focused on the use of existing hardware designs for the upper and lower taper joints etc. Figure 4 shows the stress distribution in the tieback string with one flooded compartment.

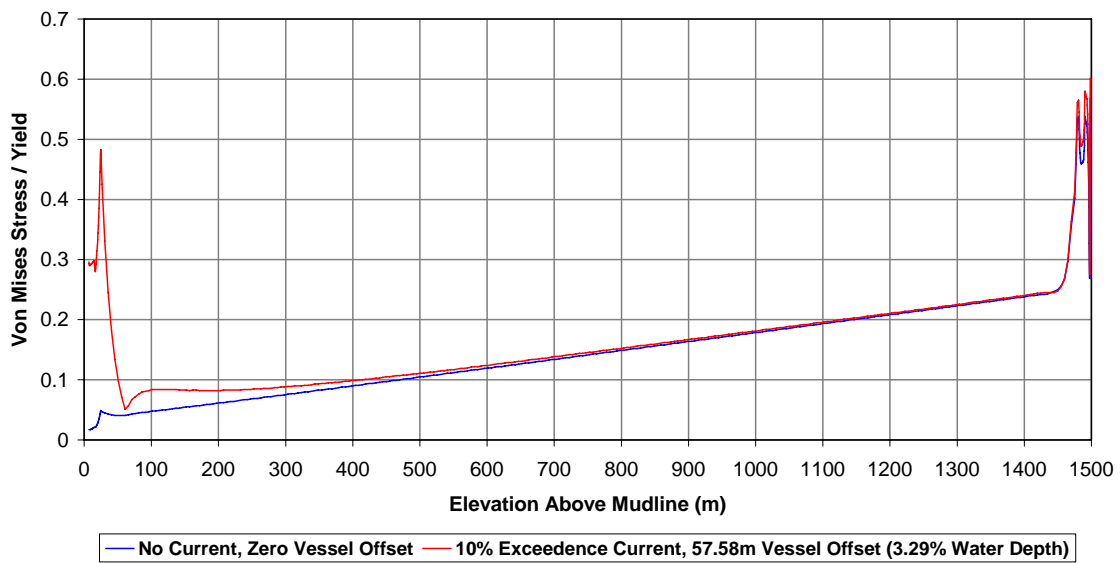


Figure 4. Stress Distribution Along Tieback String with Flooded ABS Compartment

3.6. First Order Fatigue Analysis

A first order fatigue analysis was conducted to define the acceptable usage duration of the ABS system and drilling riser. Due to the ABS buoyancy tank being located well below the wave loading region, this analysis considered the drilling riser connected scenario only. The first order fatigue life of the system was established based on the expected fatigue details for the ABS and drilling riser system (including the conductor and wellhead). First order fatigue damage was found to be negligible.

3.7. VIV Fatigue Analysis

A Vortex Induced Vibration (VIV) fatigue analysis was conducted to assess the response of the ABS system, drilling riser, subsea wellhead and conductor. The analysis was conducted using SHEAR7 based on exceedence current profiles, and considered the same three ABS system configurations as detailed in the extreme storm analysis. Long term VIV fatigue lives were defined based on the duration of the exceedence current events and the expected fatigue details of the tieback string components. Figure 5 shows the typical variation of VIV fatigue life along the tieback string.

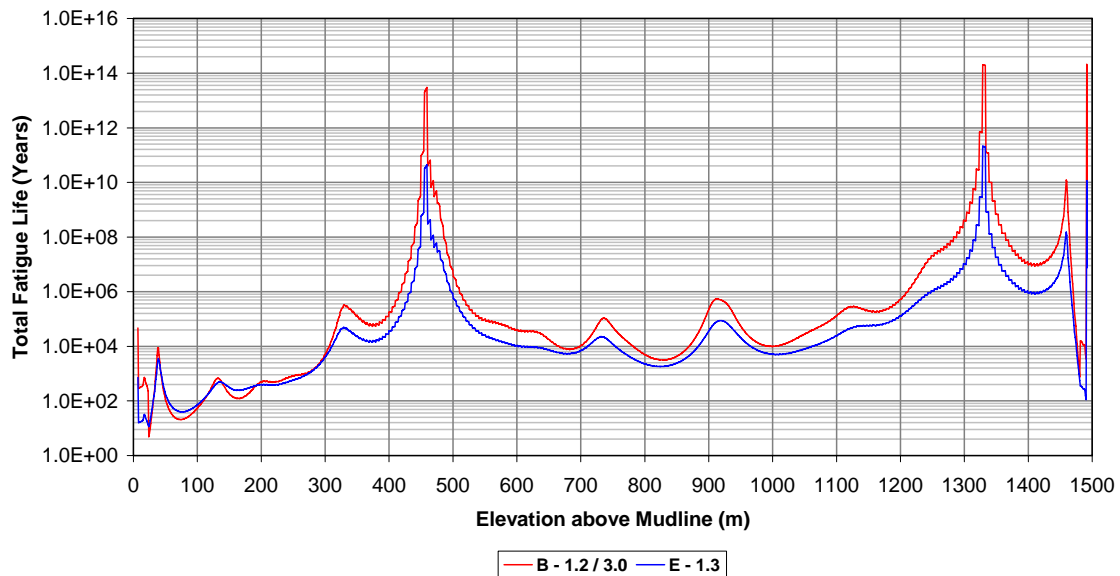


Figure 5. Variation of VIV Fatigue Life Along Tieback String

3.8. Installation/Retrieval Analysis

An installation / retrieval analysis was conducted to consider the deployment of the ABS system. The analysis assessed the stress and deflections of the tie-back casing as it is deployed through the ABS unit under a range of environmental loading conditions. Analysis were conducted to consider the deployment of the tie-back string at quarter depth, mid depth and near landing.

3.9. Sensitivity Analysis

Sensitivity analyses was conducted to consider the variation in tieback string dynamic response to selected parameters, such as applied tension and hydrodynamic coefficients, to demonstrate that the response of the ABS system was robust.

4. Quantitative Risk Assessment

The Quantitative Risk Assessment (QRA) covered three areas:

- Evaluation of risk of blowout
- Evaluation of the frequency of interruptions to operations
- Reliability of the Atlantis Artificial Buoyant Seabed

The hazards considered included “internal events” and “external events”. Internal events referred to failures within the system, failure of pumps, pipeline, errors made by personnel in following procedures, etc. External events referred to hazards that were outside of the systems, such as weather and sea conditions, collisions, etc.

In order to get a good understanding of the operations and hazards, interviews were conducted with key personnel. Based on the information collected, analysts prepared questions relating to scenario development and frequencies of events.

4.1. Model Development and Quantification

Analysts used the information derived from the earlier interviews to define blowout scenarios and operation interruption scenarios. Models were defined using fault trees to evaluate the undesirable consequences. The models included hardware failures as well as human errors. The scenarios generated were risk ranked. Major contributions to the scenarios were identified from this. RISKMAN software was used to define the fault tree models and to quantify them

4.2. Documentation of Findings

The QRA work is the subject of another paper and will be published in due course.

5. Conclusions

Drilling operations can be conducted safely utilising the Artificial Buoyant Seabed technology:

- It is designed and constructed with existing technology in accordance with accepted industry standards
- Analysis of the ABS system in a 1,800m deep drilling location with an environment similar to Brazil has shown that
 - Extreme Stresses are acceptable in the tieback string with the help of special taper joints at the upper and lower terminations, even in the flooded ABS compartment condition.
 - A good drilling window in terms of vessel offset can be achieved with the optimisation of tieback string tension applied by the ABS buoyancy and the marine drilling riser tension applied by the rig’s tensioner system.
 - The ABS system is little affected by wave loading, even in the drilling riser connected case, so first order fatigue in the tieback string is negligible.
 - Fatigue life of the tieback string from VIV damage is acceptable given that the string is retrieved regularly and inspected at suitable intervals.
- QRA of the ABS drilling system with near-surface BOP has not identified any major risk that is more onerous than the subsea and surface BOP drilling systems.