



## Reconfigurable Riser – Enabling Drilling Solutions for the Future

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### Abstract

Drilling offshore oil and gas wells has become increasingly challenging as water and well depths have increased. In many regions, drilling hazards such as very narrow margins between collapse (pore) and fracture pressures, pore pressure uncertainty, pore pressure regression, high pressure and high temperature have resulted in significant additional cost due to the time required to rectify the problems associated with these hazards.

Many drilling techniques and methods have been developed to mitigate similar problems on land. For example, most of what are now classified as Managed Pressure Drilling (MPD) methods have their origin in land based operations, i.e. mud cap drilling and under balanced drilling. These and other techniques and methods have been deployed successfully offshore from fixed installations such as jackup<sup>(1, 2)</sup> drilling units with minimal modification due to the similarities between equipment used on land and on fixed installations offshore.

Application of these methods and techniques would bring significant value to offshore drilling operations conducted from floating drilling units as well. However, to date, with few exceptions<sup>(3)</sup>, these drilling methods have not been considered for use from floaters. Consequently, wells drilled from floaters employ drilling methods which are basically unchanged from those used since the early 1900s and which often compound the above-referenced problems when encountered.

### Introduction

One recent paper<sup>(4)</sup>, discusses a method employed to assess the impacts resulting from drilling hazards encountered over a four year period of drilling in the U.S. Gulf of Mexico. The financial impact associated with these hazards over this period represented some 31% of the total drilling cost and approximately 30% of the total well construction time (Fig 1). The paper concludes that well-pressure related hazards were the most significant contributors to this cost.

In the paper the authors describe a methodology employed to incorporate the knowledge gained from the assessment into subsequent work which resulted in an almost 50% reduction in trouble time to 16% which was largely achieved through; "... emphasis on better planning and quantification of ECD, deepwater geopressures, and drilling margins." (Fig 1)

Quitau et al<sup>(1)</sup> describe the results achieved by employing a variation of mudcap drilling from a jackup to drill a fractured carbonate formation characterized by significant lost circulation, H<sub>2</sub>S, and well control problems. By employing this MPD method, the average time spent drilling the reservoir section of the well was reduced from 16 days to 5 days per well. (Fig 2)

In both instances, significant drilling challenges and hazards were overcome by employing improved planning or drilling methods, resulting in much improved drilling efficiency, and performance.

Combining similar approaches (planning improvements and appropriate drilling methods) could significantly reduce well construction cost, while minimizing risks associated with drilling hazards.

A number of recent developments in offshore drilling from floaters could be adapted to facilitate the deployment of MPD drilling methods and techniques.

This presentation discusses the application of both surface BOP and "reconfigurable" marine riser to enable the deployment of these drilling techniques.

### Surface BOP

Recently, for a variety of reasons, operators and contractors have begun to adapt surface BOP equipment for use from floating drilling units.<sup>(5)</sup>

Key to this equipment configuration to date has been the use of conventional oilwell casing as a high-pressure riser or conductor between the seabed and a surface BOP supported in the moonpool area of the drilling unit (Fig. 3). In some instances, the capability to disconnect at the seabed is provided while in others it is not.

While not new, this most recent application of surface BOP from moored floating drilling units began in early 1996 in the relatively benign environments of Southeast Asia. Since then, a significant number of wells have been drilled in water depths ranging from as little as 45ft to as deep as 9,472ft (Fig 4.). These included the recent use of a Dynamically Positioned 5<sup>th</sup> Generation semisubmersible drilling rig using surface BOP equipment to drill a total of four wells in the moderate environment offshore areas of Brazil and the Eastern Mediterranean Sea offshore Egypt<sup>(6)</sup>.

There are a number of vessel-related characteristics and environmental (Met-ocean) considerations which limit the broad applicability of surface BOP. These include: moonpool space and configuration, riser tensioning capacity, mooring capacity, and hook load path capacity, as well as water depth, weather and current profile.

From a well construction point of view, one of the principle limitations of the Surface BOP equipment configuration is the constraint on well design and operations imposed due to the casing riser's relatively small ID, typically 13 3/8", which limits this technique to wells that can be drilled with relatively few casing strings. This limitation is more restrictive when contemplating development drilling and to date no development wells have been completed using this technique.

This equipment configuration is essentially similar to that of a fixed offshore installation (platform or jackup drilling unit) and is therefore readily adapted to the requirements of drilling methods depending on surface pressure control achieved through the use of a rotating control head (RCH). These include the Managed Pressure Drilling methods detailed in Quitzau et al<sup>(1)</sup> and Park et al<sup>(2)</sup>, which were employed to address specific drilling hazards, such as massive lost circulation while drilling sour fractured carbonate reservoirs, and achieving improved well deliverability through underbalanced drilling and completion operations.

### Marine Riser Surface Pressure Control

Recent adaptations of existing marine riser and subsea BOP equipment configurations for use with managed pressure drilling methods have been made (Santos et al<sup>(3)</sup>).

Initial use of this equipment configuration resulted from a Petrobras-sponsored JIP, the results of which are described by Lage et al<sup>(7)</sup>. Subsequently, the means<sup>(8)</sup> for adapting a RCH to the top of conventional marine riser was commercialized (RiserCap<sup>TM</sup>).

More recently, this equipment configuration (Fig 5) has been used to drill a number of wells in Southeast Asia. These wells are characterized by massive lost circulation zones and in some instances elevated pressures and temperatures. Pressured mudcap drilling methodology similar to that described in Quitzau et al<sup>(7)</sup> was employed to successfully drill these wells without incident.

The principle limitations of this equipment configuration are related to the burst and collapse pressure resistance of the slip joint packer and marine riser. The slip joint packer/seal assembly is typically rated to 500psi dynamic operating pressure, and therefore limits the maximum annular pressure to less than this value. The collapse resistance of the marine riser varies depending on riser tube properties, and could be a limiting factor if the drilling method used (ie UBD) results in the riser being subjected to external differential pressure. These issues are discussed in Santos et al<sup>(3)</sup> and Lage et al<sup>(7)</sup>.

With the current design, the RCH is installed on top of the collapsed (stowed) slip joint, eliminating the connection (ball joint) between the top of the riser and the rig. While not necessarily detrimental to the marine riser, it does require active vessel position management to optimize the relative offset between the rotary table and the RCH to minimize RCH seal assembly wear which may be accelerated if this offset is too large when the drill string is present.

Currently the available RCH equipment is sized for use with BOP sizes usually employed on land rigs, jackups, and platform rigs. Typically this is a 13 5/8" BOP. This arrangement currently limits the applicability of MPD methods using this approach to BHA/Bit diameters that are small enough to fit through the equipment, i.e., 12 1/4" BHA and smaller.

### Concentric High Pressure Drilling Riser

In an effort to optimize TLP design, a novel drilling riser was developed<sup>(9)</sup>.

After considering TLP design implications and detriments of both, a single high-pressure riser combined with surface BOP, and a more conventional subsea BOP and riser configuration; a hybrid design emerged utilizing the marine riser typically used in offshore drilling for use in low-pressure applications, and when required, a high-pressure inner riser consisting of casing, which would be run concentrically inside the marine riser. In both instances, well control was maintained by the use of a surface BOP installed atop the riser.

In this arrangement, the lower connection between the riser and wellhead was made using a subsea connector and wellhead configuration typical of that used with a subsea BOP. The lower connection of the inner riser was established via an internal tieback hanger and seal assembly. Once installed and landed in a surface wellhead supported by the marine riser, the inner riser effectively isolates it from the wellbore enabling high-pressure drilling operations to proceed. (Fig 6)

This riser configuration is essentially the same as used on fixed offshore platforms or jackup drilling units and is functionally very similar to surface BOP configurations employed from floating drilling units. It is readily adapted to the requirements of MPD methods.

The principle limitation of this riser configuration is that it was not developed for use from floating drilling units which require the capability to disconnect the marine riser at the seabed while maintaining a mechanical means of well control. This capability is achieved by a subsea BOP.

### Design Considerations and Current Equipment Limitations

Accepting that a conventional riser and subsea BOP will preferentially form the basis of a reconfigurable riser system requires a thorough review of existing components as a number of these may require modification prior to applying certain MPD methods.

Application of MPD drilling methods may result in the riser and subsea BOP being exposed to external differential pressure. This requires all components and seals be able to operate in this environment.

These components include but are not limited to:

- Wellhead seals / gaskets
- BOP ram body seals / gaskets
- BOP bonnet seals / gaskets
- Auxiliary line seals / gaskets
- Auxiliary line connector seals / gaskets
- Riser connector seals/gaskets
- Failsafe valves bi-directional sealing capacity
- BOP ram bi-directional sealing capacity

Additionally, consideration needs to be given to the gas (N<sub>2</sub>, produced gas) permeability of any BOP and riser elastomer or rubber components. These elements may be exposed to aerated drilling fluid or produced gases and may be susceptible in to failure due to rapid evolution of gases entrained within elastomer/rubber components in the event of component exposure to sudden pressure drop.

In addition to the components noted above, these include but are not limited to:

- BOP ram sealing elements
- BOP bonnet seals
- Flex Joint elastomer elements

The rotational capability of certain flex joint designs may be impaired if exposed to external differential pressure. This would increase the bending stress and moment on both the marine riser and wellhead and would need to be considered in the wellhead conductor/foundation design and riser analysis.

The currently available surface pressure control equipment drill through sizes will need to be increased to accommodate drill string diameters including 17 ½” bit diameters to enable MPD methods to be applied in regions where this well section is problematic.

### Overcoming the Limitations – “Reconfigurable” Riser

As discussed previously, it is possible to employ managed pressure drilling methods offshore from floating drilling units by utilizing either a surface BOP configuration, or a marine riser equipped with surface pressure control. However, these equipment configurations have limitations which will most likely impair the broader application of MPD methods offshore from floating drilling units.

In order to overcome these limitations and ensure the broadest opportunity to benefit from advances in MPD methodology, the equipment configuration required to employ MPD needs to build on the accepted standard equipment presently available to the industry.

A “reconfigurable” riser and BOP system design would incorporate the beneficial features of the riser and BOP configurations discussed previously without detriment to operability or limitation on current well design and completion practices. It would incorporate features that enable the system to be safely and efficiently “reconfigured” to accommodate the requirements of any particular drilling method employed.

In conjunction with the design and development of the *Enterprise-Class* of DP drilling vessels, Transocean developed the means <sup>(10)</sup> to deploy a concentric casing riser string within a 21” marine riser. Having this capability enables the marine riser to be converted from low-pressure riser to high-pressure riser by effectively isolating the 21” marine riser from the wellbore.

This has significant benefit when contemplating

employing MPD methods from floating drilling units. It enables drilling to proceed with the same wide range of well geometry options and equipment currently employed for offshore well construction. The same is true of development drilling and well completions.

Such a system is currently under development (fig 7) with plans for deployment in late 2005 to enable underbalanced drilling using aerated drilling fluid. Other possible applications of this equipment configuration to achieve Dual Gradient and Under Balance Drilling are discussed in Hermann et al. <sup>(11, 12)</sup>

## Conclusions

Significant improvements in offshore drilling efficiency have been achieved through better planning and in the case of fixed offshore installations through the adaptation of land based mitigating drilling methods.

Applying these drilling methods and techniques offshore from floating vessels has been limited primarily due to the previous lack of enabling equipment and techniques such as surface BOP and RiserCap™ which restrict the application to wells with relatively simple geometries, or wells being drilled in relatively shallow water.

In order to overcome these limitations while retaining the flexibility in well design afforded by currently available standard equipment and benefiting from MPD techniques a "reconfigurable" marine riser system is required which builds on existing Subsea BOP and riser systems.

## Acknowledgments

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## Nomenclature

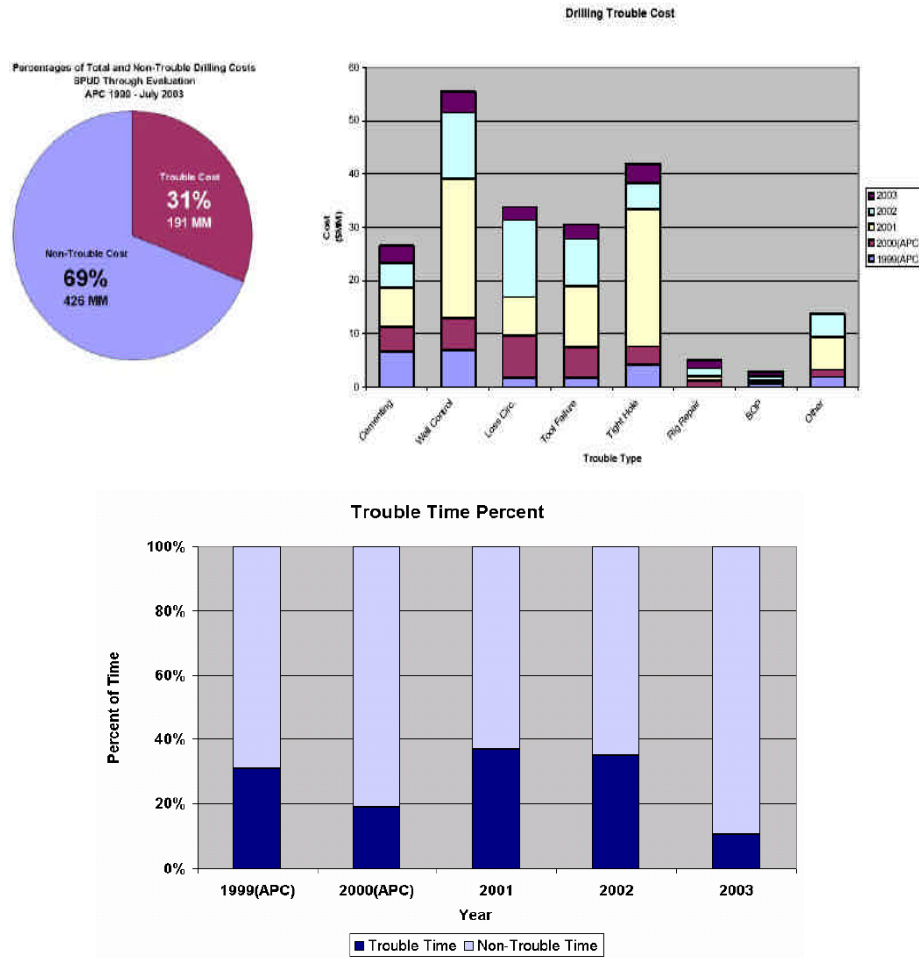
*BHA* = bottomhole assembly  
*BOP* = blowout preventer  
*MPD* = managed pressure drilling  
*RCH* = rotating control head  
*SBOP* = surface BOP

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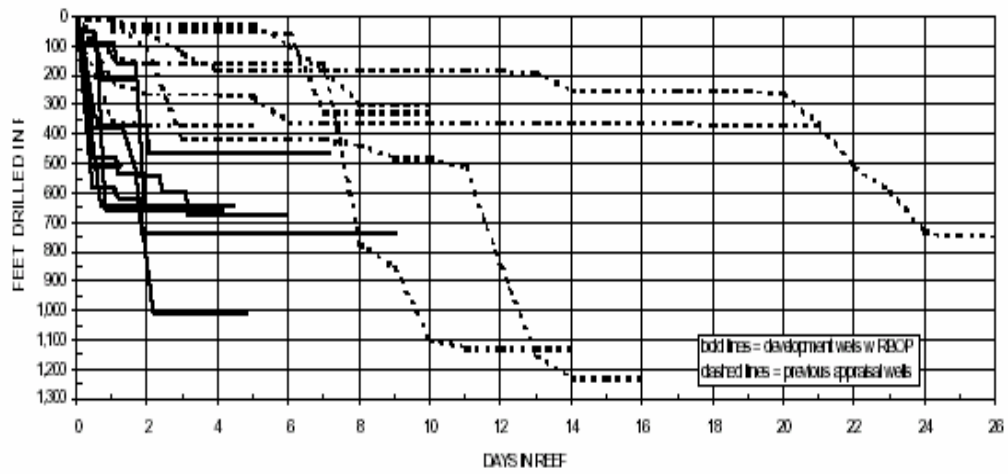
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2001.



**Fig. 1- Impact of Drilling Hazard Trouble Time (After Iyoho et al, OTC 16290)**



	PREVIOUS APPRAISAL DRILLING	DEVELOPMENT DRILLING
# Wells	7	9
Total reef footage drilled	4,493	5,629
Total reef drilling days	109	42.6
Average feet / well	642	625
Average days / well	15.6	4.7
Average feet / day	41	132

Fig. 2- Reservoir Drilling Performance comparison conventional drilling vs. MudCap drilling (After Quitzau et al, SPE/IADC 52808)



**Unocal**  
Sedco 602



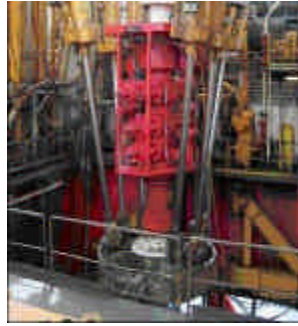
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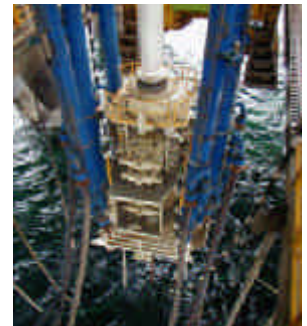
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**Shell**  
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**Unocal**  
Ocean Baroness

**Fig. 3- Typical Surface BOP configurations**  
(Source: author, IADC/SPE Surface BOP Conference Presentation)

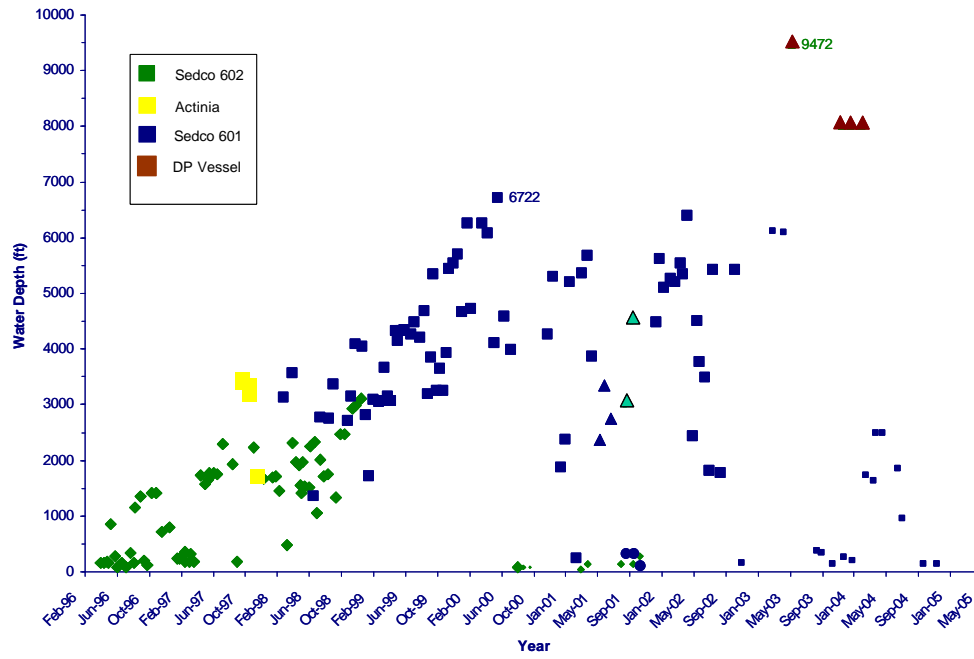
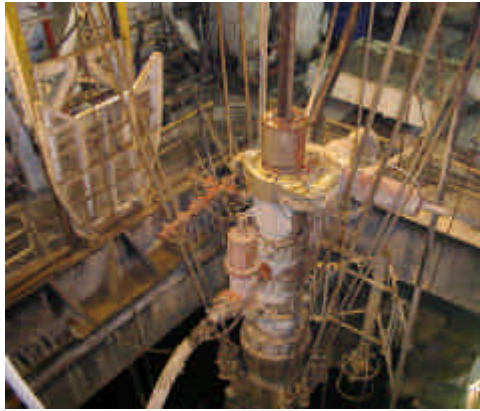


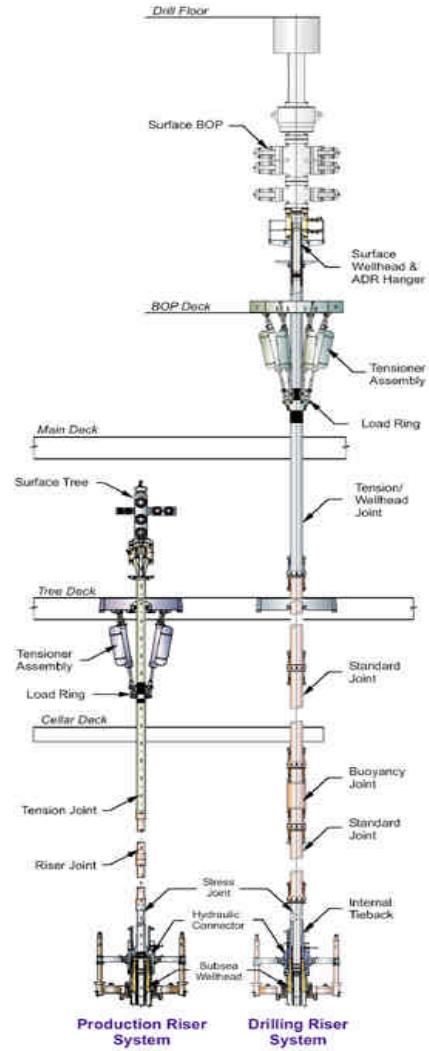
Fig. 4 - Surface BOP Work History



**Fig. 5a – RiserCap™ Configuration offshore Brazil**  
(Source: Lage et al, SPE 71361)



**Fig. 5b - RiserCap™ Configuration Sedco 601 SE Asia**



**Fig. 6 – Typical TLP HP Riser configuration**  
(Source: Vetco Gray, Deepwater Dry Completion Units Brochure)

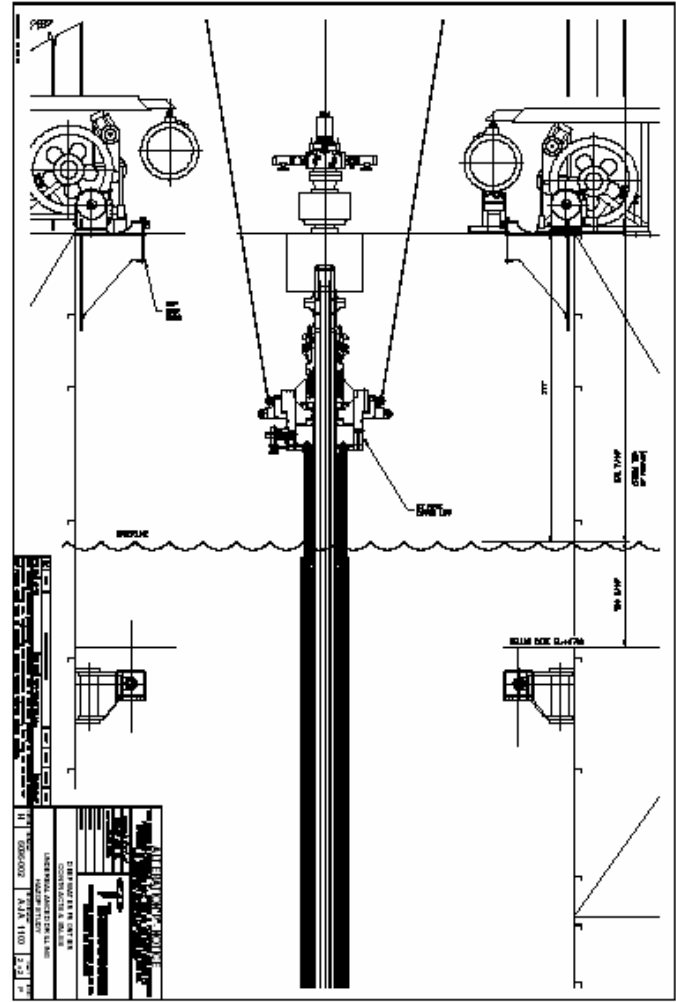
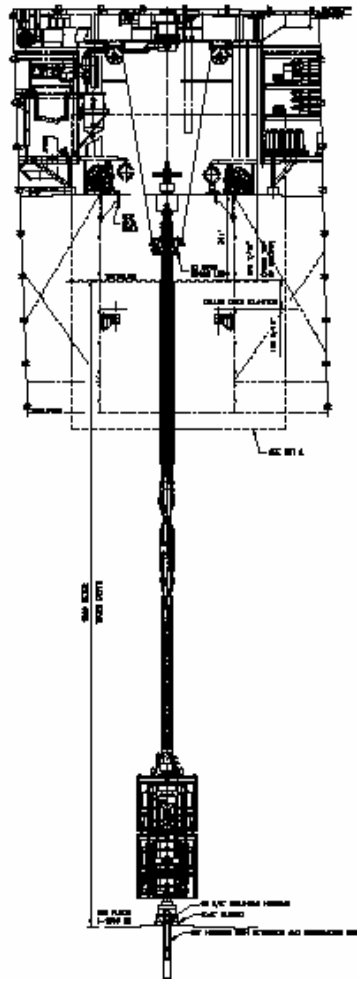


Fig. 7 – Reconfigurable Marine Riser