

Dry or Wet Trees in Deepwater Developments from a Riser System Perspective

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ABSTRACT

Riser weight increases with water depth. Supporting the risers, tensioning them to control their response, or optimising the platform motions in order to be “riser-friendly” is often one of the most challenging aspects of converting an old floater for use as a deepwater production or drilling platform. A new build platform will address these issues as part of its design for a particular application, but it will soon have payload and water depth limitations when used generically for multiple applications.

A solution is proposed, with a focus on the important issues of well access and riser design, which will remove the payload and water depth constraints from the platform, be it a new design or a conversion.

Utilising direct access subsea tress and free standing single line offset risers (SLOR), a semi-submersible equipped with production and drilling facilities not only challenges a dry tree platform solution, such as TLP and spar, it offers many additional safety and operational advantages. The benefit of this SLOR production system is best realised in the very deep water depths, when the design of top tensioned dry tree risers and their impact on the platform become even more imposing and costly.

This paper compares the merits of the SLOR production system against the more familiar dry tree production systems, and points to ways of implementing this solution in the emerging offshore regions.

KEY WORDS: Deepwater; Riser; Tree; Drilling

INTRODUCTION

Deepwater oil and gas fields are currently developed using wet (subsea) trees or dry (surface) trees, or a combination of both. Once the reservoir characteristics have been determined, the evaluation of development options for a new field is usually focussed around the type of floating production vessel required to develop the field, whilst the well and riser systems are often ignored until the development scenario has been selected.

Dry tree units provide direct access to the wells for workover and improved recovery but require motion optimised hulls to accommodate the riser systems and are considered limiting with respect to water depth and development flexibility. Although widely used for developments in shallow to medium water depth, dry tree units are not considered the optimum way to develop the deep and ultra deep opportunities, despite the industry’s preference to extrapolate field proven solutions.

Subsea developments are suitable for widespread reservoir structures. They provide a degree of vessel and field expansion flexibility with simplified riser interfaces, but at the expense of high drilling and workover costs.

Due to the increasing costs of developing fields in deeper waters, the focus of development solutions should be placed on key ‘enabling’ technologies such as the well and riser systems, and in developing floating production systems which are safe, cost effective, flexible enough to accommodate changes, and capable of being built locally. This is particularly applicable in the upcoming oil and gas plays of the world such as South East Asia where, being remote to the current deepwater activities elsewhere in the world, construction vessel availability is limited and mobilisation costly. The ability to construct or convert the vessel locally will boost employment and the economy of the developing country.

DEEPWATER DEVELOPMENT DRIVERS

The primary design driver is always cost. In deep water, large oil and gas reserves are required for economic recovery of the hydrocarbons. In water depths above 5000ft, reserves lower than 100MMBOE are generally considered marginal if a ‘stand alone’ floating production system is required. This implies that deep and ultra deep water developments will include a large number of wells to recover the large reserves.

A further limitation of both the spar and TLP is their inability to expand the facility to accommodate additional risers in the event of favourable reservoirs being uncovered during production. For the spar, the facilities team needs to fully understand the extent of the reservoir in order to design the spar with sufficient well slots to accommodate the required number of risers. Uncertainty in reserves leads to commercial risks in the pre-investment of additional well slots that may not be required, which ultimately impacts the overall size of the hull and subsequently hull fabrication costs. For the TLP, payload considerations must be taken into account in order that the hull is fabricated with sufficient buoyancy to accommodate the riser loads. Again, over estimation of the number of risers to support is expensive if never used to full capacity, and limiting for future tiebacks if insufficient payload capacity is provided.

In recent years, some attention has been paid to developing dry tree semi-submersibles where, understandably, the main effort is in the design of the hull form to reduce heave so as to be 'riser friendly'. Riser design is still proving to be a significant challenge in these projects so, as yet, this concept has not been selected for a field development.

Wet Tree Systems

Unlike dry tree units, subsea developments have greater flexibility with respect to hull selection. It provides a solution with the ability to develop reservoirs in deepwater environments. Fig. 2 shows the trend of deepwater developments using subsea trees and it can clearly be seen that water depth is not a major limiting factor.

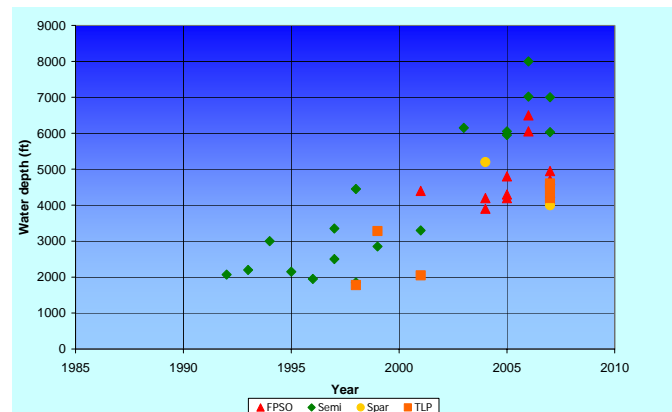


Fig. 2 - Summary of Worldwide Subsea Developments

Pros and Cons

Despite the drawbacks associated with dry tree system in ultra deep water, the benefits of efficient drilling and OPEX cost are paramount. Subsea field developments tend to offer economic improvement in areas such as vessel requirements, reduced offshore construction and development flexibility, but lack the efficient drilling and completion capability. It is interesting to note that the benefits and limitations of subsea and dry tree developments are polar opposites. This is illustrated in Table 1.

Table 1 – Dry vs Wet Tree for Deepwater Developments

Feature	Dry Tree Development	Subsea Development
Drilling Cost	From facility	Requires MODU
OPEX Costs	From facility	Requires MODU
Facilities CAPEX Cost	High cost hull	Choose least cost hull
Offshore Construction	Heavy lift requirements	Depends on riser system
Development Flexibility	Restricted due to hull form	Minimal vessel impact
Riser/Vessel Interfaces	Complex interaction	Simpler interaction
Vessel Flexibility	Restricted to Spar or TLP	Full range
Shut in location	In well bay close to people	Seabed Isolation and Offset
Flow Assurance	Shortest Flow Path	Potentially long tie flowlines

2H Offshore have been involved in the design of riser systems for many of the deepwater field developments in West Africa, Gulf of Mexico (GoM), Brazil, Indonesia and the North Sea. The experience gained from designing complex riser systems heavily influenced by the response of the floating production vessel, has enabled the company to develop riser systems with simpler interfaces.

It is recognised that both dry tree and subsea tree development concepts have drawbacks, and this in turn has spawned the conception of a new field development solution, known as SLOR Production System, which focuses on risers and well systems, addressing many of the fundamental deepwater field development drivers described previously.

ALTERNATIVE DEEPWATER PRODUCTION SOLUTION

The alternative field development solution, termed the SLOR Production System (or SPS in short), is presented herein and shown in Fig. 3.

The SPS is a unique field development solution for deepwater that has a focus on the important issues of well systems and risers. This is unlike conventional field developments that are driven by naval architecture considerations, particularly for dry tree units. This solution considers the pros and cons, then combines the benefits of dry tree and subsea tree systems given in Table 1, and provides the following additional advantages:

- It is illogical to tie back heavy dry tree risers in deepwater;
- Long flowlines on cold seabed are not process flow friendly;
- Maintain direct well access for efficient drilling and workover;
- Minimise riser numbers and simplify their design interfaces;
- Simplify execution by providing contractual flexibility;
- Reduce offshore construction requirements;
- Eliminate requirement for heave optimised platform such as spar or TLP;
- Take advantage of low cost and reliable subsea trees that provides subsea isolation;
- Provide development flexibility for future wells without pre-investment.

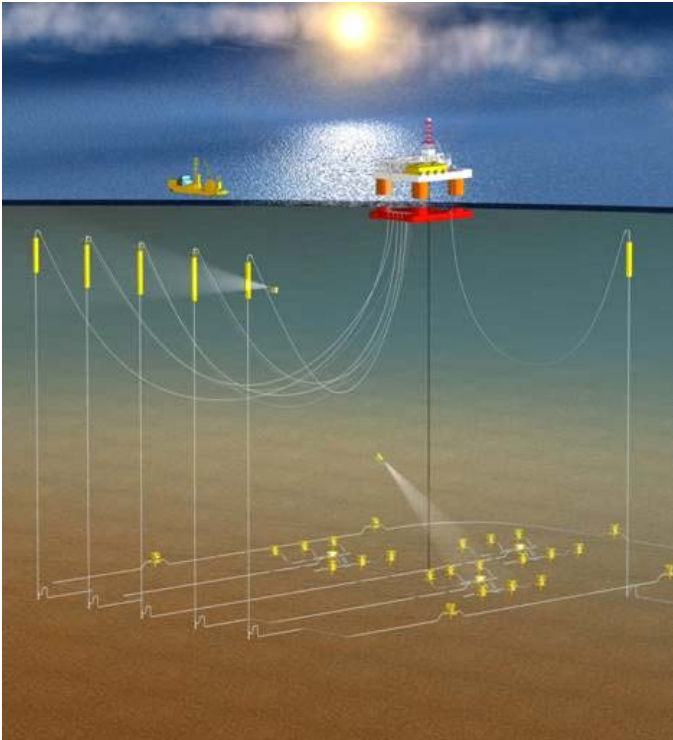


Fig. 3 - SLOR Production System Arrangement

The SPS uses subsea wellheads located below a permanently moored floating production platform. An important feature of this concept is that the riser system is designed to exhibit a quasi static response, decoupled from the vessel motions. As a result the motions of the vessel do not have to be highly optimised leading the operator to select an less expensive production facility that is cheap to construct without having to be overly concerned about the motion response. This may be either a barge for application in a mild Indonesian environment or a semi-submersible for Brazil and the Gulf of Mexico, neither of which require extensive amounts of offshore constructions like Spars and TLPs.

The wells are drilled using a high pressure drilling riser and surface BOP in the same manner as currently conducted from a conventional dry tree platform. The surface BOP provides efficient drilling through the reduction in trip time and minimum down time. The wells are completed with 'horizontal' or 'drill through' trees that locate the tubing hanger in the tree spool. Importantly this arrangement facilitates direct vertical access through the drilling riser or a smaller diameter workover riser into the wellbore, without the requirement of setting plugs and removing the tree.

The subsea wells are grouped in clusters and may be situated on or off a manifold that allows up to 5 wells to be commingled. This allows the number of risers to be reduced by up to 75%. Each manifold is connected via a rigid seabed line to the base of a free-standing riser. The riser may be either a single pipe (Single Line Offset Riser – SLOR) or a pipe in pipe design (Concentric Offset Riser - COR) that provides additional insulation and allows riser base gas lift or active heating through the annulus. These risers can be either welded or threaded construction and are tensioned by an upper aircan located at 50-150m below the surface depending on the environmental conditions.

Each freestanding riser is connected to the production platform by a shallow water flexible jumper. The risers, including aircan and flexible

jumpers, can be quickly installed from a drilling platform, construction vessel or from the production platform itself, giving a high degree of installation flexibility. In addition freestanding risers can be used for export, enabling a fast development installation schedule by pre-installing all risers prior to arrival of the host facility.

An umbilical is needed, installed in either a simple or wave catenary configuration and distributed on the seabed, to control the subsea wells.

Ten SLORs and CORs have been installed in West Africa for the ExxonMobil, Kizomba A and B field developments, for production/gas lift, water injection and gas injection. An 18 in. SLOR has been installed on Petrobras P52 field in 6,000ft water depth with the function of exporting oil to shore. More SLORs are being constructed for the first FPSO project in the Gulf of Mexico by Petrobras for the Cascade and Chinook developments in 8,200ft water depth.

The flexible jumper between the riser and platform offers two key advantages: firstly they can accommodate large platform motions allowing lower cost non-motion optimised platforms to be considered, and secondly they can be connected to the platform at a location to best suit the platform layout. Normally this would be away from the central drilling moonpool area, providing segregation of drilling and production activities.

The reduction in riser numbers is critical, particularly as water depth increases, in the contribution to cost reduction of the production system. It is important to note that some 80% of the dry tree system hardware is sensitive to water depth, as opposed to only about 20% for the SPS arrangement. Consequently, as water depth increases the cost difference between the dry tree and SPS well system will increase, with SPS showing to be much less expensive.

It should be noted that the SPS is neither a classic subsea system nor a dry tree system but it offers the best features of each and avoids many of the disadvantages. The arrangement is suited to a wide range of field development types and environments. The SPS is particularly suited to developments where reserves are uncertain as the system configuration allows the addition of future wells without pre-investment of additional wellbay space or platform buoyancy requirements. SPS is effectively a 'self contained' system that can develop the reservoir in a phased execution without the requirement for an additional installation vessel to be mobilised to install risers or flowlines.

A somewhat close idea, but different in riser type, is the drilling and production semi-submersible located over subsea wells for BP's Thunder Horse development in the Gulf of Mexico where steel catenary risers are used. Another relative is the world's first FDPSO (FPSO with added drilling facility) unit installed by Murphy over subsea wells at the Azurite field offshore Congo, but flexible risers are used in this case. It should be noted, however, that both these production systems are designed to station for the life of field, and the concepts are not suitable for extension to ultra deep water depths because of the chosen riser types.

APPLICABILITY TO ASIA REGION

A successful field development can start with an arrangement that minimizes CAPEX through eliminating the use of high cost installation and construction vessels. This is particularly important in Asia whereby the mobilization of large capacity derrick barge will have a significant economic impact on the development. The SPS field development solution is designed around the ability to use the lowest cost production facilities that do not require heavy lift vessels to install topsides, and

riser systems that can be installed using vessels readily available in the Asian region, or even from the drilling rig on the production facility itself.

SPS is configured with a riser system to operate without a highly specified heavy optimised vessel. A vessel of convenience can therefore be converted to serve as the production platform, as long as it has the capacity to carry the drilling rig and suitable processing facilities on the topsides. A conversion offers improved schedule to first oil and is significantly less costly than a new build, and more likely to be within the capability of local shipyards. However, as the SPS platform is re-usable and, unlike a dry tree unit, is independent of well count, investment on a new build vessel may be justified if longer term multi-field applications are envisaged. Even then, the type of vessel to build is entirely the operator's choice, and it can be non-proprietary and chosen to suit the local capabilities. A locally built and commissioned production platform will have only a short distance to travel to the field thereby shortening the lead time to first oil.

Furthermore, the SLOR and COR systems utilise riser components, such as large diameter steel buoyancy cans and suction anchors, that are well suited for local fabrication. Placing the orders with local fabricators will create business and employment opportunities for the regional economy.

Finally, SPS lends itself to be used as an early production system. The ability to increase the well count and install additional risers at minimal costs will prove to be a very flexible development tool to initiate production from a large number of fields. This will significantly cut down the normal time spent evaluating and optimising development options for sanction, and lead to earlier return of oil revenues which must help meet the economic targets for the emerging oil producing countries.

CONCLUSIONS

It can be seen that conventional dry tree solutions with the use of spar and TLP technology is proving to be 'hamstrung' by increasing water depths and the trend is observed that operators are defaulting to subsea developments for field developments in excess of 6,000ft water depth, and accepting the higher drilling and workover costs associated with subsea developments.

The SPS concept has been developed with a riser and well systems focus with the intent to take the beneficial features from both subsea and dry tree developments, whilst providing flexibility to enable efficient contract strategies to be implemented.

Compared to a dry tree system, the SPS arrangement offers improved technical performance, higher levels of safety, reduced interface complexity, improved development flexibility and lower cost. It also enables the step into deep and ultra deep water developments to be made with confidence, using proven components and technologies.

Table 2 – Summary of SPS Features

Feature	SLOR Production System	
Drilling Cost	From facility	
OPEX Costs	From facility	
Facilities CAPEX Cost		Choose least cost hull
Offshore Construction		Minimal required
Development Flexibility		Minimal vessel impact
Riser/Vessel Interfaces		Simpler interaction
Vessel Flexibility		Full range
Shut in location		Seabed Isolation and Offset
Flow Assurance	Shortest Flow Path	

Finally, the SPS solution provides opportunities for Asia's emerging deep water oil producing countries to convert or build the production platforms in their own shipyards, benefiting their own economies; to become less reliant on mobilisation of large offshore construction vessels, saving significant installation costs and schedule; and to have early production systems that can later be expanded to be life-of-field facilities, bringing faster revenue returns and achieving production targets. In summary, a logical solution to any aspiring deepwater operators in the region.