Tension leg platform project execution

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\textbf{Abstract:} The first floating platform concept design work for South China Sea is undergoing in DMAR’s office now. This tension leg platform has potential to become the first advanced floating production platform project. Project execution is always a challenge for floating system. This paper focuses on the critical elements of project execution for tension leg platform, and studies potential implications to future oil and gas exploration in South China Sea. There are many factors affecting successful execution of floating system project, including technical issues, engineering management, interface management, etc. There are also failure examples of project execution in the industry. The author has participated 28 large detailed projects and has gained extensive experience on floating projects, with ample hands-on project experiences. A detailed tension leg platform project study example and discussions in depth are presented for future project execution in China deepwater development.

\textbf{Key words:} project execution; deepwater project; tension leg platform; floating system; project management

\section{Introduction}

Floating production has evolved to a mature technology that opens for development oil and gas reservoirs and would be otherwise impossible or uneconomic to tap. The technology enables production far beyond the depth constraints of fixed platforms, generally considered to be 350 m, and provides a flexible solution for developing short-lived fields with marginal reserves and fields in remote locations where installation of a fixed facility would be difficult. However successful execution of the project faces many challenges: demanding of new technologies and analysis scales, large structure with the increasing payload of deep water, high fabrication requirements due to the complexity of structure and loading, special installation equipment for long and complex offshore operation, increased interfaces with the complexity of structure and more vendors, and more importantly, short of experienced professionals\cite{1-3}.

Tension leg platform (TLP) is one of the most widely installed floating production systems (FPS) for the offshore deepwater oil and gas development\cite{4-9}. TLP is particularly suitable for water depths between 300 m and 1 600 m, and has been in use since the early 1980s. The first TLP was built for Conoco’s Hutton Field in the North Sea in 1984. As of 2012, there are 24 TLPs installed worldwide; 3 TLPs are under construction or installation, 6 under detailed or front end engineering design (FEED), and numerous under concept study. Among them, the shallowest TLP is Hutton TLP (147 m) and the deepest is big foot TLP (1 615 m). Fig.1 shows the photos of the 24 installed TLPs. The ultimate commercial viability of the selected production concept lies in strategic planning which strikes a balance among capital expenditure, size, geometry, complexity and uncertainty of reservoir and well performance requirements.

TLP normally consists of the following key components as shown in Fig.2.

1) Topsides-production and processing facilities, drilling facilities (dry tree only), wellbay (dry tree only), accommodations, helideck and utilities, deck structure.

2) Hull-marine system, ballast tanks, storage on hull, hull structure (columns and pontoons).

3) Tendon- tendon porches, tendon pipes, tendon foundations.

4) Riser-top tensioned risers (production and/or drilling), export risers (steel or flexible), tieback risers (steel or flexible).
actively work on the projects, including West Africa, Brazil, Asia and Australia. Most regions currently have TLP development projects ongoing [6, 7]. Projects in different regions usually have their own project execution styles, but there are many common project experiences which could be applied to the projects in all regions. These common challenges include advanced technical requirements of design and analysis engineering, high fabrication requirements, challenging installation condition, complicate project interfaces, high demanding engineering management and project management, and short of competent professionals.

2 TLP project technical challenges and engineering management

Most of TLP development projects have surface unit and subsea system. TLP structure is designed to bring oil and gas to the surface, and subsea development system functions as controlling the wells and transporting fluid. Early developments were mainly counting on the floating structures. Subsea development system is relatively new technology and have experienced significant advancement in recent years. There are many factors affecting the execution of a TLP project. Technical issues are always the most important ones. The key technical issues include the correct definition of reservoir characteristics, selection of wet tree or dry tree, field arrangement, design of riser system, performance of the global system, fabrication engineering, and installation engineering.

TLP is one of the two floaters which can support the dry tree production system. In comparison with the wet tree production system, dry tree system has the following advantages: a. higher production reliability and lower downtime; b. lower drilling and operating cost; c. less flow assurance risk and potentially higher recovery; d. direct vertical access for well intervention activities; e. minimal offshore construction. But there are challenges to the dry tree options too, such as safety concern due to well access at surface and stricter motion requirements for the host platform. Notwithstanding the challenges, the superior dynamic performance and the ability to support dry tree production has historically been a main reason for choosing TLP production system.

The design of TLP is the state of art technology. There are only very few companies which have TLP design experience. TLP sizing is a design optimization process. It takes both the knowledge of floating
structure and design experience. During design, each configuration considered the key objective is to minimize hull and mooring sizes for given payload, while meeting the following inter-related operational constraints; minimum and maximum allowable effective tendon tension, minimum air gap maintenance and horizontal offset.

TLP hull structure provides not only the buoyancy for the entire system, but also the ballast for operation. It provides links between the production risers and topsides facilities. Hull structure takes wave loads acting on the system and is under fatigue influence all the time. Fatigue design plays a very important role in TLP structure application. All major connection areas are governed by fatigue. Typically, these fatigue sensitive areas will use special materials and have special welding requirements and profiles. These connection areas include topsides to hull connections, pontoon to column connection, tendon to hull connection, and steel catenary riser (SCR)/riser to hull connection.

Tendon mooring system is another major component. Entire tendon length contains several tendon segments, which is linked together offshore through tendon connectors. Tendon top and bottom connectors are all specially designed. Tendon bottom connector is installed into the pile connector offshore and locked in position with pretension. The top connector is mechanically designed for offshore installation. Flex element is provided at connection to allow the physical rotation between tendon and hull support. Due to the high fatigue requirements of the system, TLP structure fabrication has some unique features and needs special attention. The material for the primary load path areas usually has high strength, high ductility and high sharp requirements. Good weldability and certain chemical contents limitation are also important.

Engineering management plays a very important role in floating system project. There are many failure projects initiated from poor engineering management. Engineering manager is the overall engineering lead of project and is responsible for all the design and analysis work of TLP. Since engineering is always the critical part of the TLP project, in order to execute a successful project, engineering manager needs to do well with the following: a. watch over critical issues in all disciplines; b. coordinate technical interfaces within disciplines; c. make sure the timely resolution on important discipline interfaces; d. help the technical compliance of vendors; e. perform site engineering and installation engineering support work; f. other duties as may be defined during the course of the project.

3 Project interfaces management

Floating project is a highly integrated system work. There are many disciplines and vendors participating in a TLP project. Communication between these disciplines is critical to execute the project. In a typical TLP project the following interfaces and responsibilities can be identified.

1) Geophysics & geology. Seismic surveys, processing and interpretation, log analysis, field mapping; hydrocarbon column analysis, oil/water and gas/oil contact determination.

2) Reservoir engineering. Well test interpretation, reservoir simulation, well profile, well production schedule.

3) Petroleum engineering. Production chemistry, completion design, tubing sizing, downhole measurements, field economics.

4) Filed layout. Well arrangement, pipeline layout, platform orientation.

5) Drilling engineering. Well design, drilling costs, extended reach drilling limitation, drilling equipment, wellhead and tieback equipment.

6) Production operations. Process equipment selection and operation, maintenance practices, operating procedures.

7) TLP hull. Configuration, in-place analysis, pre-service requirements, metocean data and compatibility, tendon and foundation system, hull structure, import riser, export options.

8) Topsides. Production facilities design and manufacture, accommodation, deck structure design and weight, installation.

9) Subsea. Pipelines, control systems, subsea trees, installation, operating procedures.

10) Safety/environmental/QA. Hazop evaluation, safety/environmental programs, quality control, safety case.


A lot of work needs to be done before a project can be sanctioned. These works will define some critical information for a platform, such as well numbers, production rate, etc. Once a TLP concept is selected, there are a lot of interfaces issues to take care
Taking West Seno as an example, the field was defined by two phase developments as shown in Fig.3. The approach of development adds a new interface between structures in phase I development and the tie-back and tender drilling in phase II development. The major interfaces between phases include the field layout for tie-back, attachment locations for SCRs, rig arrangement matching the previous platform, etc.

Field architecture of the system is one prime concern of the interface. Major general arrangement issues, which need to be addressed, include the following: individual structure field layout, jumpers arrangement, hawsers arrangement, TLP mooring, tender assisted drilling vessel mooring, flowline, pipeline and SCR arrangement. An overly cluttered field arrangement may include the effective use of tender vessel since there may not have suitable places to set mooring lines or not have enough safety clearance for the mooring system under the extreme design environmental conditions. The operations were to be as seamless with the shallow water operations as possible. With a high percentage of national staff, the additional crossover training and staffing for deepwater operations should be simplified. Tradeoffs were not elaborate or complicated. By getting the “right” people with sufficient experience in the early conversation, a thorough understanding about the operation was critical.

4 Project risk management

The offshore industry is moving into deepwater. New technology is continually being introduced. Most of offshore projects are executed internationally. These all make offshore projects increasingly complex, and require the use of more vendor and sub-vendors around the world. Large international offshore development projects entail many challenges including technology, regulation, finance schedule and commerce. Projects end up with the failure due to a combination of many factors. From participating in and reviewing many international offshore projects, we can identify some areas of the work that have a higher likelihood of causing problems. These areas include contracts, major technical issues, interfaces schedule impact and change orders.

Offshore projects are associated with various types of technical risks and uncertainties. Uncertainty in its nature can be an opportunity. The ratio of risk/reward explains this relationship better. The key is how to manage the project risk and eliminate the adverse risk, and create more opportunity. There was a survey conducted on offshore projects. According to the report, survey of 5 000 users in North America and Europe has found that 36 % of offshoring projects fail. Reasons cited for failure were poor communication, cultural differences, lack of expertise, performance and time differences. The main cause of offshoring failures is lack of preparation, poor execution by user organizations, management gaps and unrealistic cost saving expectations. Moving onto deeper water makes it more important to control the uncertainties, and to include the risk factor in the decision making process.

International offshore projects face may encounter the potential clashes of culture both in geography and discipline. Taking West Seno project for instance, it involved a US operator, a Korean contractor, an Indonesia field, and vendors from all over the world. With the wide spread of countries represented at the sub-contractor level, it’s pretty clear that the project is involved with quite different cultures. While the diversities can be strength, there are also some differences in practices between regions of the world that could lead to problems. Typically offshore involves the merging of topsides equipment designed and fabricated by process people, with a floating hull structure designed and fabricated by people with a marine background. The industry practices of these two cultures have some fundamental differences in approach, so communication becomes very important in order to avoid interface problems.

1) Contract management. One of the first thing to do in order to reduce the risk is to scrutinize the specifications included in the bid package. It is imperative that bidders ask questions regarding ambiguous
or conflicting requirements and object to overly stringent requirements prior to their submittal of the bid. The bidder must fully comprehend the development project they are bidding on with all of its requirements. Many projects are actually publicized prior to actual issuance of the invitation to bid package but the bidder is still required to review the entire package in close detail to ensure that all requirements are understood and included in their bid. Changes must be managed from the beginning of a project instead of from the end. It is important to have a dedicated group responsible for dealing with changes as they arise so that the actual scope of work is properly reflected in the budget and schedule.

2) Quality management. TLP structure is highly technical driving, and consistently under severe environmental loads. This is reflected in the governing design conditions; strength, fatigue and buckling. The risk associated with failure is extremely high. Many lessons have been learned during the course of offshore projects. It is important that the company make sure to retain the knowledge obtained by the staff and the expertise is utilized to better respond to future project questions. It is quite common that as project is complete, some employees, especially contract employees, find work elsewhere and the companies are forced to relearn many things when preparing for the next project, leading to higher cost and risks.

3) Schedule management. In order to ensure a successful project, keeping the work on schedule is very important. With modern computer programs the relationship of project tasks can be programmed, so the critical path is found and the impact of changing a task can be quickly evaluated. The engineering work on project schedule have an impact on project. When engineering work is pushed back, some construction work or installation work will not completed on time, unless other changes are implemented, such as resource allocation, earlier delivery time of equipment from vendor, etc. The reason for engineering delay could be many; change in design requested by owner or in order to comply with rules or regulations, or a change by another discipline, or simply that it took the engineers longer than planned, which again could be a result of many things. If these issues are caught up in the early project, there are ways to remedy the situation, but the remedy will likely cost more money. Still making a change in the design phase is easier than making the change in the construction phase, while implementing change after installation is even costlier.

4) Communication. The biggest key to success is communication. There are many differences which could arise during the project due to the presence of various players. By keeping an open dialog throughout, these differences can generally be resolved through discussion or negotiation, keep the end goal constantly in mind. The end goal is of course to complete a project on schedule and budget.

5 Fabrication and installation management

Due to the large scale and the involvement of many vendors, the management of fabrication and installation and associated interfaces of a TLP project is particularly challenging. The major components of fabrication activities involve the following: hull fabrication, topsides fabrication, mooring system fabrication, riser fabrication, subsea system fabrication, loadout and integration of major components. The major installation activities involve transportation of platform and mooring system, installations of subsea system, driving pile foundation, tendon, platform and riser.

Hull and topsides construction are usually on the critical pass. The fabrication design is site specific, taking into consideration the specific features of the shipyards. The topside and the hull are customarily fabricated in parallel in different yards. Normally, both the topside and the hull are modularized to fully utilize the yard capacity. The hull can be constructed either in a dry dock or on ground surfaces equipped with appropriate tools; the latter is more frequently. The full sized topside may consist of five modules: process, power, quarters, well bay and drilling. If each module can be fabricated in covered location of the yard, the fabrication process is much less subject to weather condition than that in an outdoor operation.

In order to mitigate the commercial risk inherent in the long duration of the project execution, efforts are usually made to compress the construction schedule. Effective communication between the parties involved in the manufacturing process is essential to the success of the project, as the number of equipment suppliers could well reach or exceed 50. Particularly, interfacing between the topside fabrication yard and the hull manufacturer is an intrinsic part of the fabrication process, as the topside will be mated to the hull.

As the offshore lifting process is more prone to adverse weather condition and costs significantly
more, recent projects have come in favor of quayside or onshore integration. Taking the West Seno as an example, is designed to have the topside integrated with the hull on land, then loadout onto transportation barge. The requirement of suitable topside lifting equipment varies. The topside for a wet tree platform usually takes different shapes from a dry tree platform. Topside with a close-end dry tree center well bay also differs from one with a dry tree open-end well bay as seen on the MOSES TLPs.

Considering the massive size of the TLP and the deepwater, early attention should be paid to the assembly and installation of TLP. This is necessary to attain schedule benefits from installation innovation and incorporate the installation-required modifications into the fast-trend construction process. The following activities are the highlight of what is normally required for a TLP offshore installation; pile installation, tendon guide cone installation, tendon installation, buoyancy can installation, TLP installation, and TTR/SCR/flowline installation.

Early planning allows a more stringent review of all details. Alternative approaches and innovative solutions can be reviewed, analyzed and generally incorporated. The planning needs to allow adequate time to level and optimize the use of various resources. The advantage of this approach allows different scenario plans to be quickly developed and reviewed. The participation by the complete team allows all members to become familiar with the different needs and capabilities of each discipline. Early planning also affords the team the time to impact equipment delivery dates to improve the fabrication, integration and installation schedule. Minimal planning may be sufficient when things are going well, but be inadequate under different circumstances. Even perfect plans lose their value if not maintained as the environment or process changes.

6 South China Sea development TLP project

To keep up with the increasing demand for energy in the economic development, China is moving rapidly into deepwater now. South China Sea is very rich in oil and gas distribution, and has been called “the second GoM”. The current TLP concept design undertaken by DMAR Engineering Inc., will be the first TLP project in China if the concept has proven to be valid. It could pioneer deepwater platform project in China. There are many good examples of field developments and project histories around the world, which can be used in the development of China deepwater fields. Most of these developments have represented the current advanced industry technologies, and have a proven history of both technical viability and economic benefits.

TLP concept is well developed and proven technology, and it also has many advantages. There are more than 30 TLPs around the world which have been installed or under construction/installation, or in detailed design. These projects has provided valuable insight and experiences. In order to efficiently develop our own TLP project, we will need to capture the lessons learned from various executions of floating projects, utilizing the technologies accumulated in the advancement of TLP concept, and incorporating the experience from the same type of project. The following areas are particularly important and deserve special attention.

1) Technologies and expertise. Deepwater development is high-tech driving. The success of development is largely relying on the technologies and experienced technical experts who master the technologies. It’s very important to establish a competent team. This team should not only include experts in China, but also include experts internationally, especially people who have worked on TLP projects before.

2) Project execution and expertise. Floating project execution is always international scale. It will involve many vendors around the world. To be effective and successfully executes the TLP project, the project management team needs to include experts from different areas who have extensive previous project experience, and can transfer the knowledge to help streamline the execution.

3) Fabrication and installation. The massive scale of TLP structure constitutes challenges to some of our current facilities and associated procedures. Early planning and investigation is the key to overcome the weakness. Procedures need to be setup early, and be reviewed by all relevant parties, and investigation is to be done with the planned equipment. In some cases, early studies will be needed for verifying the applicability and improvement of the equipment. For the case of insufficient equipment, either modification needs to be performed or outsourcing to be planned. The risk associated with operation needs to be fully assessed. The difficulty of some special requirements for TLP projects needs to be fully understood. Some of the areas include high welding require-
4) Schedule planning. Detailed planning needs to be conducted at the beginning of the project, kept monitored and updated during the whole implementation duration. Issues emerging needs to be addressed and resolved at its early stage. If issues are caught up in the early stage of the project, it will be easier to find ways to remedy the problem, and the cost would be much less. Due to the fast track nature for deepwater projects, schedule is always very tight. To plan the TLP project, it would be wise to leave some floating range for potential needs, at least for the tasks on critical pass.

5) Risk management. A through risk analysis needs to be performed to identify any potential problems. Risk plan needs to be in-place before the project starts. For the identified major risks, a mitigation plan will need to be formed. At some critical cases, if the risk can’t be reduced to the acceptable level, a backup plan will be implemented.

7 Conclusions

South China Sea deepwater field development will continue to face technical challenges in various areas as the exploration gets deeper. This paper studied the execution of TLP development project, reviewed the key issues to be encountered, and discussed some potential development problems for the execution of TLP project in South China Sea.

There are many advantages to have a fully integrated team to achieve common goals and optimum efficiencies. A completely integrated project management system should be considered essential, especially for TLP project. Staffing the integrated team with experienced, positive, open-minded, problem-oriented individuals who strive to continuously improve themselves is a critical key to the success of the project. Empowering the field personnel, who are aligned with and committed to the project objectives, will have a tremendous impact on the project success. Interface management and internal and external communications to the project, are critical factors in the successful execution.

References

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