D.I.6 PLETs and Pipelines installation 2 x 8".

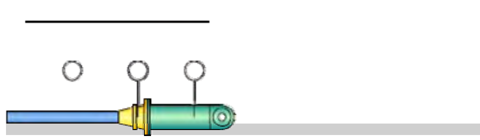
Pipelines are installed in at least 4 different methods, J-Lay, S-lay, Reel-Lay and Normal-lay (towed pipelines), of them the most suitable for the depth of the Lakach field would be a J-lay with flexibility to use a S-lay system also. A description of the advantages and disadvantages of the J lay given by Nogeira is reproduced in the table 3 (Nogeira, P.p. 931, 2005).

A PLET (Pipeline End termination) is a structural-transportation element in the subsea pipelines, as indicated in its name it is located at the end of the pipeline and is usually installed in the installation vessel and then lowered and positioned in the sea floor. Antani et. al. documented the installation of PLETS in the Neptune project in 2008, below it is a excerpt of their work that explain the procedure of installation of a PLET.

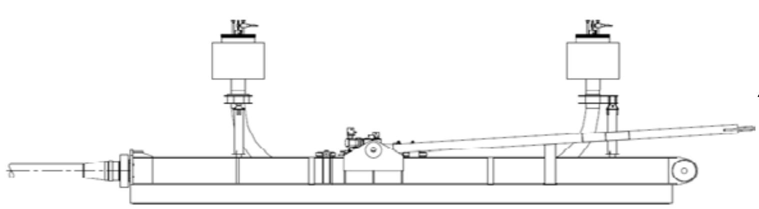
Advantages	***Disadvantages***
Best suited for ultra deep water pipeline installation.	*Some vessels require the use of j lay collars to hold the pipe.*
Suited for all the diameters.	*If shallower water pipeline installation is required in the same route, the J-lay tower must be lowered to a less steep angle. Even then, depending on the water depth, it may not be feasible to J-lay the shallow end with a particular vessel and a dual (J-lay/S-lay) installation may be required. Such as the case of the Canyon Express project.*
Smallest bottom tension of all methods, which leads to the smallest route radius, and allows more flexibility for route layout. This may be important in congested areas.	
Can tipically handle in-line appurtenances with relative ease, with respect to landing on the seafloor but within the constrains of the J-lay tower.	

Table 3 Advantages and disadvantages of the J lay construction method for pipelines (Nogeira, P.p. 931, 2005).

> ***PLET Installation***
>
> *…Although PLET installation in S-mode is well feasible, the PLETs for the Neptune project were designed to be installed using a J-mode installation method. The following section describes the standard J-mode PLET installation procedure for Solitaire before discussing the project-specific challenges and the solutions that led to the successful installation of the Neptune export PLETs.*
>
> *Standard J-mode PLET installation*
>
> *Starting point of this operation is that both flowlines have been laid down on the seabed (in S mode) with a (temporary) laydown head (see Figure 4.13).*



Before PLET Installation



After PLET Installation

Figure 13: Schematic lay out of before and after PLET installation on seabed.

In general, for a J-mode PLET installation the following steps can be distinguished:

1. J-mode pipeline recovery

Before the start of the operation, the PLET has been transported and offloaded to Solitaire where it is stored on the main deck in the vicinity of the 300 mT special purpose crane (SPC). The abandonment & recovery (A&R) cable, routed over a sheave in the A-frame, is lowered to the pipeline recovery sling on the seabed and hooked in, assisted by a remotely operated vehicle (ROV). Solitaire then moves to stand-off position, the pipeline is recovered to the surface and hung off in the hang-off frame using Solitaire's SPC (Figure 14).

2. PLET Installation

Upon removal of the temporary laydown head, the pipeline end is prepared for the installation of the PLET. The SPC is used to upend the PLET using a two-point lift with the SPC main hoist and the SPC whip hoist. The PLET is then upended by lowering the whip hoist whilst the PLET load is gradually taken over by the main hoist. The rigging configuration is chosen such that the PLET angle after upending is equal to the pipeline hang-off angle. Figure 15 illustrates the up-end scheme.

After stabbing of the PLET onto the pipeline, the swivel flange on the transition forging is bolted to the PLET bulkhead ensuring the structural connection between the pipeline and the PLET. Thereafter, the PLET piping is welded to the pipeline and the weld is inspected before field joint coating is applied.

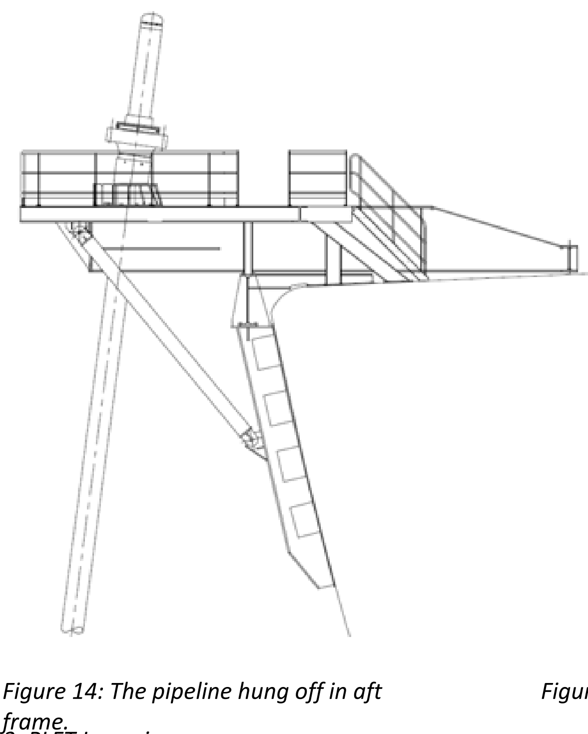


Figure 14: The pipeline hung off in aft frame.

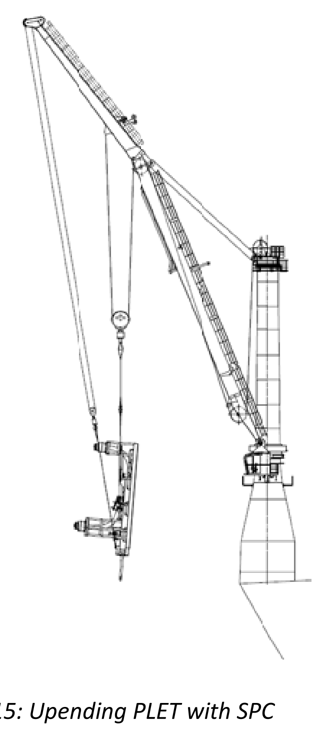


Figure 15: Upending PLET with SPC

3. PLET Lowering

The PLET will be lifted off the hang-off frame and positioned in line with the sheave of the A-frame. Once in line, the SPC will lower the PLET pipeline assembly until the tension is transferred from SPC to A&R cable, as illustrated in Figure 16. From this point onwards, the A&R winch will lower the PLET onto the seabed.

The yoke stabilizes the PLET during lowering and ensures that the PLET is positioned on the seabed in an upright position within the installation tolerances. Once position and location have been confirmed to be within specifications, the A&R cable is disconnected and recovered onboard. [Antani, P.p. 5-6, 2008].

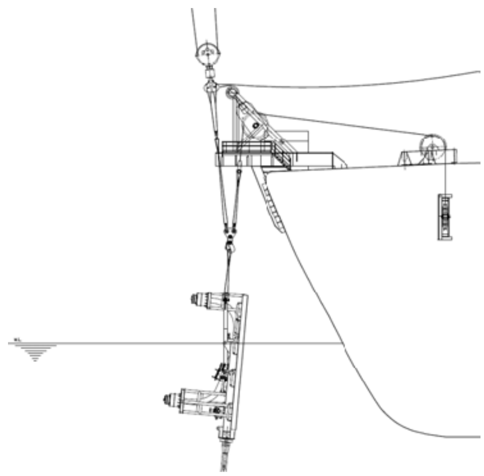


Figure 4.16: Hand over PLET pipeline assembly from SPC to A-frame

D.I.7 Workover and well intervention

Nergaard (Nergaard, 2009) give a definition of the two terms and explains its purposes as:

Workover: The term is used for a full overhaul of a well. It reflects the full capacity to change production equipment (tubing etc) in the well as well as the Xmas tree itself. This implies the use of a rig with fullbore BOP and marine riser. This means the we have to apply the same capacity systems as used during initial completion of the well. Full overhaul/workover might imply a full recompletion of the well. Using a full capacity drilling/completion rig offers the full capacity for redrilling, branch drilling and recompletion. In some cases we see the full capacity WOI system referred to as Category C intervention: heavy well intervention.

Well intervention: This term is used commonly for all vertical interventions that is done during the wells production life, ie after initial completion. The term is most commonly used for the lighter interventions; those implying that operations take place inside and through the Xmas tree and the tubing.

These are:

Category B intervention: medium well intervention, with smaller bore riser

Category A intervention: light well intervention – LWI, through water wireline operations..

The purpose of the interventions is increase the recovery rate and also as required:

- Survey – mapping status-data gathering.
- Change status (ex open/close zones – smart wells)
- Repair
- Measures for production stimulation.

D.I.8 Abandonment

At the end of the production life of the oilfield, the facilities must be decommissioned and abandoned according to the environmental and health requirements of the home country and any other applicable laws. The site must be restored to a condition that minimizes residual environmental impact and permits reinstatement of alternative industries in the area and unimpeded navigation through it.

• Floating production facilities will be removed from the field.
• Subsea infrastructure must be removed or abandoned and the wells will be plugged and abandoned.
• Buried flow lines must be abandoned at the place of the installation after be flushed.

D.II. Marine operations for a SPAR.

The SPAR is a floating structure that typically involves complex marine operations; Reeg (Reeg et. al., 2000) provides a review of the installation process of the hull of the SPAR that is reproduced next:

> *Installation is performed in stages similar to those of other deepwater production systems, where one component is installed while another is being fabricated. Installation schedules heavily depend upon the completion status of the hull and topsides.*
>
> *Listed below are the order of events for a typical spar installation:*
>
> - *Well predrilling (drilling vessel)*
> - *Export pipelines laying*
> - *Presite survey; transponder array deployment; anchor pile target buoys set*
> - *Anchor pile and mooring line settings*
> - *Hull delivery and upending*
> - *Temporary work deck setting*
> - *Mooring and pipeline attachment*
> - *Mooring lines pretensioning*
> - *Hull ballasting and removal of temporary work deck*
> - *Topsides delivery, installation, hookup, and integration*
> - *Buoyancy can installation*
>
> *Prior to the delivery of the hull to location, a drilling rig might predrill one or more wells. (See figure 17)*
>
> *During this time, export pipelines are laid that will carry production either to another platform (host) or to shore after processing.*

A presite survey is performed and includes the following: onbottom acoustic array installed for the mooring system, identified obstructions removed, anchor pile target buoys preset, and a final survey of the mooring lay down area performed.

Once on location, a derrick barge installs the anchor piles and mooring system. The installation of the anchor piles is performed using a deck-mounted lowering system designed for deepwater installations and an underwater free-riding hydraulic hammer with power pack. Remotely operated vehicles (ROV's) observe the hammer and umbilical as the pile is lowered and stabbed into the seafloor.

In conjunction with pile installation, the mooring system is laid out and temporarily abandoned. A wire deployment winch with reels specifically designed for this type of work handles each wire. An ROV monitors the wire lay-down path as the derrick barge follows a predetermined route until it reaches the wire end on the deployment reel. The end of the mooring wire is then connected to an abandonment/recovery line and marked for later use in attaching the mooring system to the hull.

To date, all GOM spar hulls have been built in Finland. Upon completion of the hull, it is shipped to the Gulf of Mexico on a heavy-lift vessel such as the Mighty Servant III. See figure 18.

Because of its size and length it is necessary to divide the spar hull into two sections. (NANSEN/BOMVANG were delivered in only one section) *Upon arrival at an onshore facility, the sections are connected together using a wet mating technique, which allows for lower cost and ease of handling and positioning, and eliminates the need for special equipment. The hull is then ready for delivery to location.*
Depending on the proximity of the onshore assembly location to the open sea, smaller tugs (2,000 to 4,000 hp) may be used first to maneuver the hull into deeper water, and then larger oceangoing tugs (7,000 hp) tow the spar to its final destination. See figure 19.

A derrick barge and a pump boat await arrival of the hull on site. The barge and boat up-end the hull. While the hull is being held loosely in place, the pump boat fills the hull's lower ballast tank and floods the centerwell.

The hull self-up-ends in less than two minutes once it is flooded. Next, the derrick barge lifts into place a temporary work deck brought to the site on a material barge. Tasks performed using the temporary work deck are basic utility hook up, mooring line attachment, and riser installation. (Figure 20).

The hull is positioned on location by a tug and positioning system assistance. Then the mooring system is connected to the hull. After the mooring system is connected, the lines are pretensioned. (Figure 21)

Then the hull is ballasted to prepare for the topsides installation and removal of the temporary work deck.

Topsides are transported offshore on a material barge and lifted into place by the derrick barge. An important characteristic is that the derrick barge can perform the lift in dynamic positioning mode.

The topsides consist of production facilities, drilling/workover rigs, crew living quarters, and utility decks. Installation of miscellaneous structures such as walkways, stairways, and landings are also set in place by the derrick barge. The last pieces of equipment to be installed are buoyancy cans and the associated stems. The cans are simply lifted off the material barge and placed into slots inside the centerwell bay. (Figure 22)

Next, the stems are stabbed onto the cans. To prepare for riser installation, the cans are ballasted until the stem is at production deck level (figure 23) [Reeg et. al., P.p. 26-27, 2000].

A schedule of the installation of the Nansen SPAR is reproduced in the Chart 1.

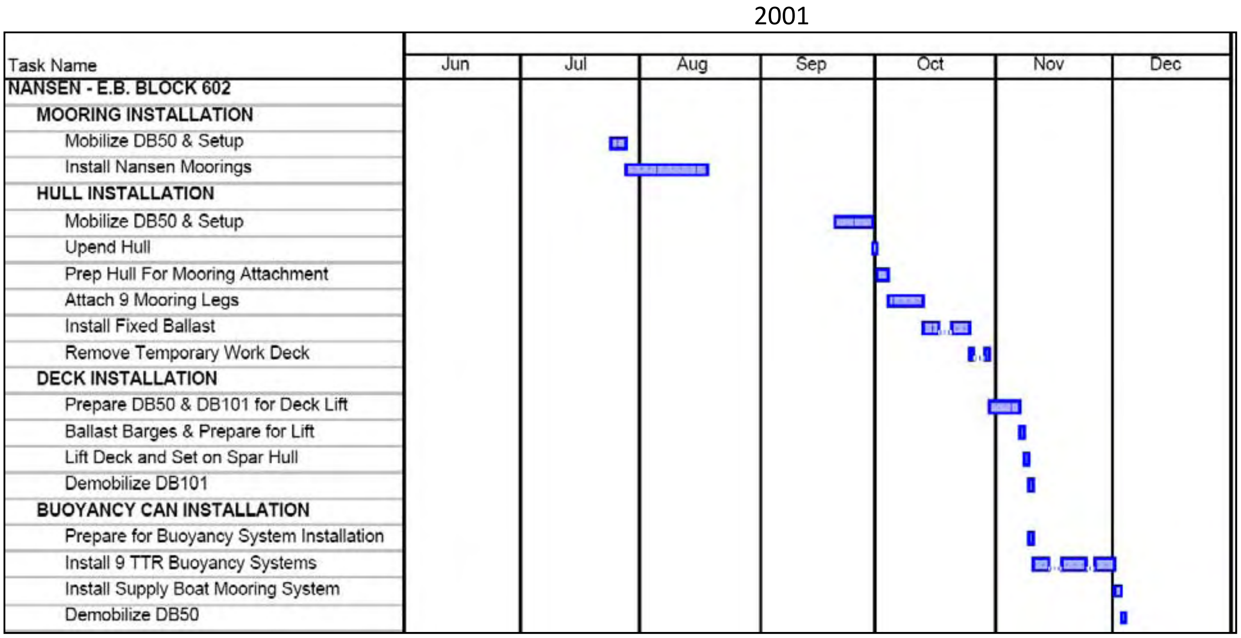


Chart 1: Project Installation time line [Beattie, P.p. 10, 2002]

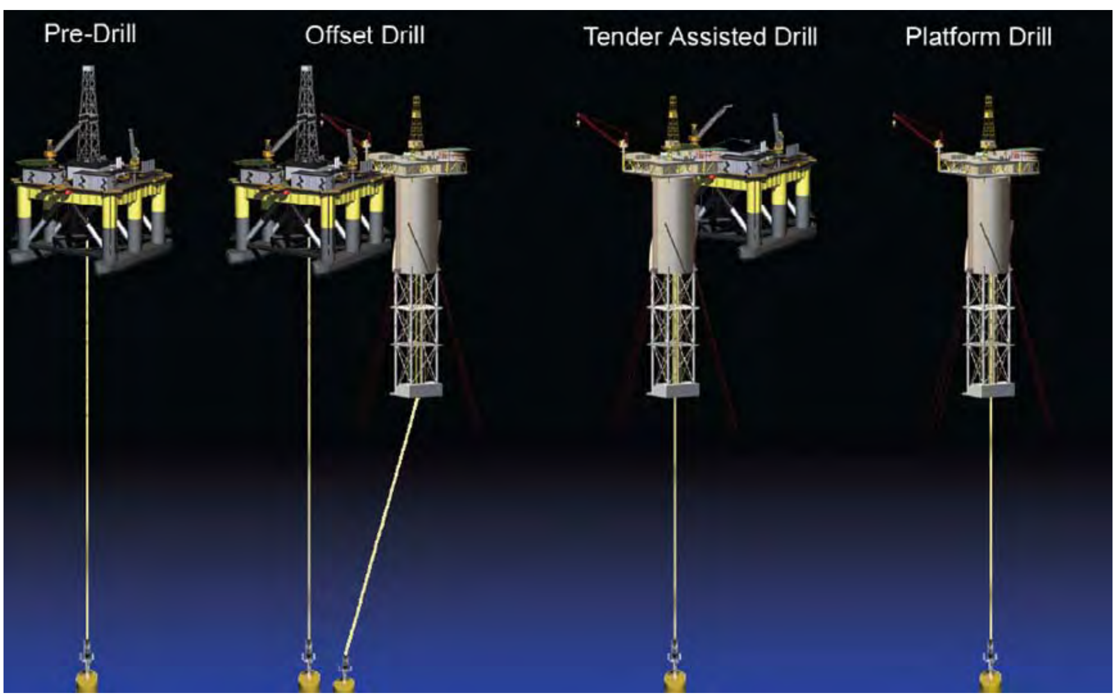


*Figure 17: SPAR drilling options (*Wilhoit*, 2009)*

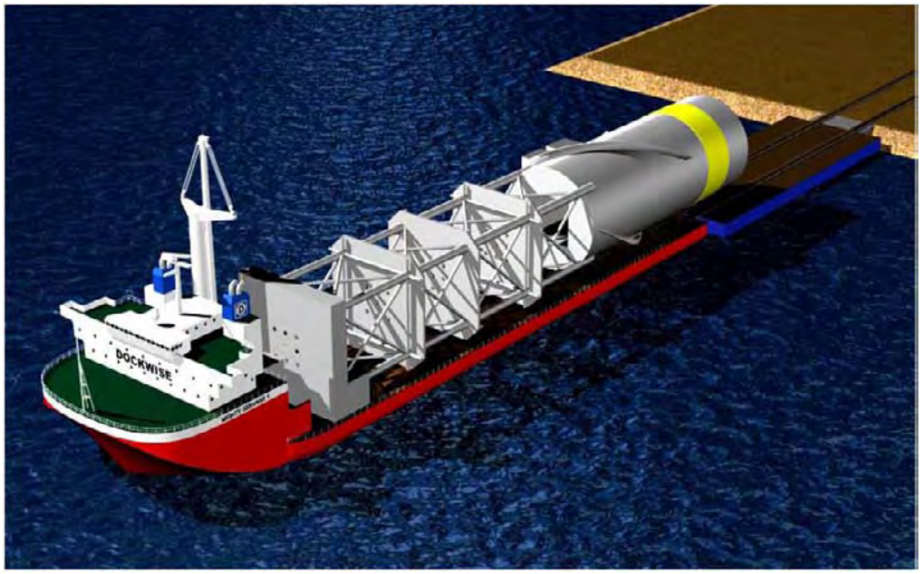


Figure 18: SPAR hull loadout [Beattie, P.p. 11, 2002]

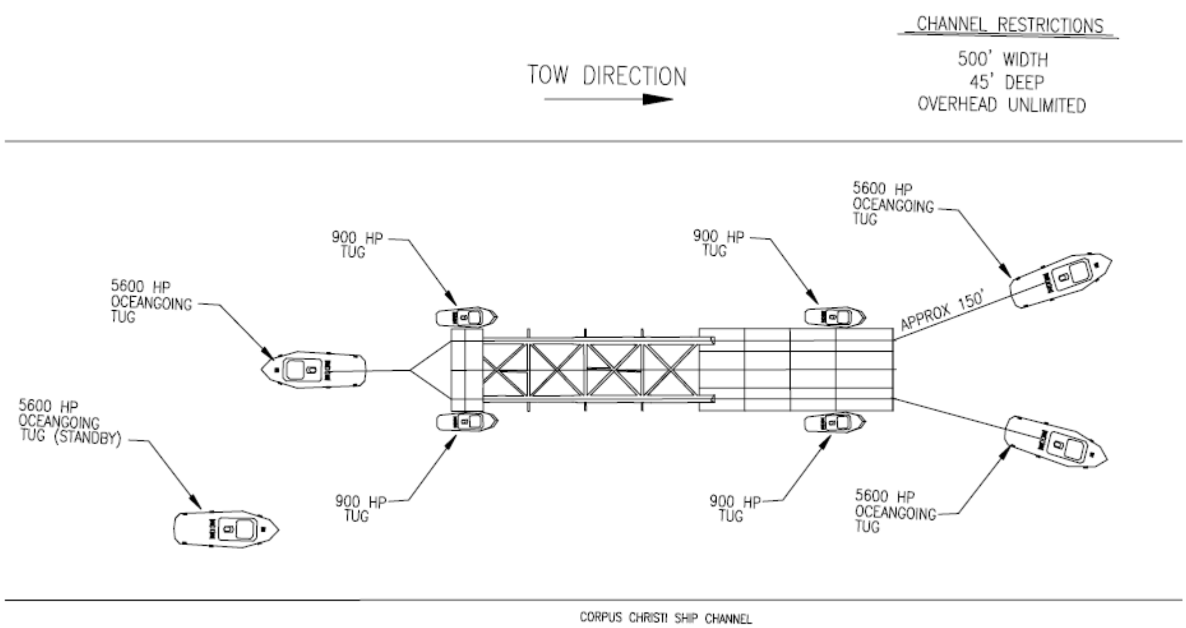


Figure 19: SPAR hull wet tow configuration [Beattie, P.p. 13, 2002]

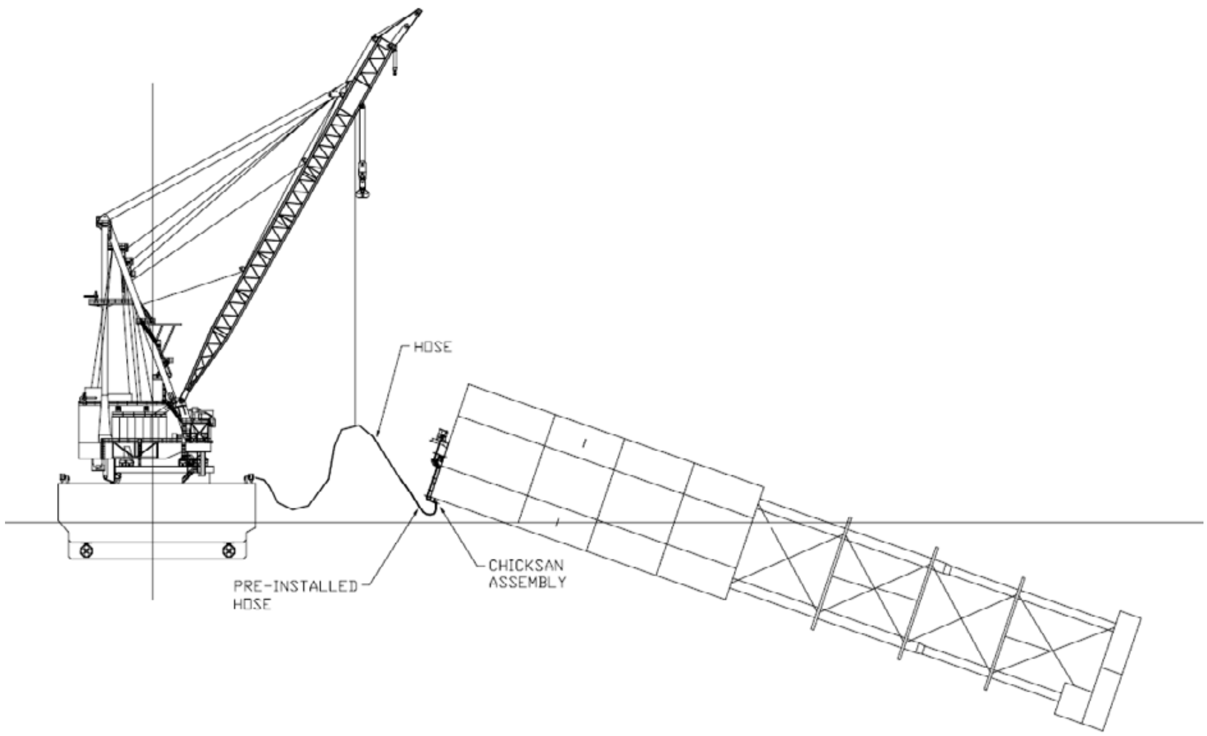
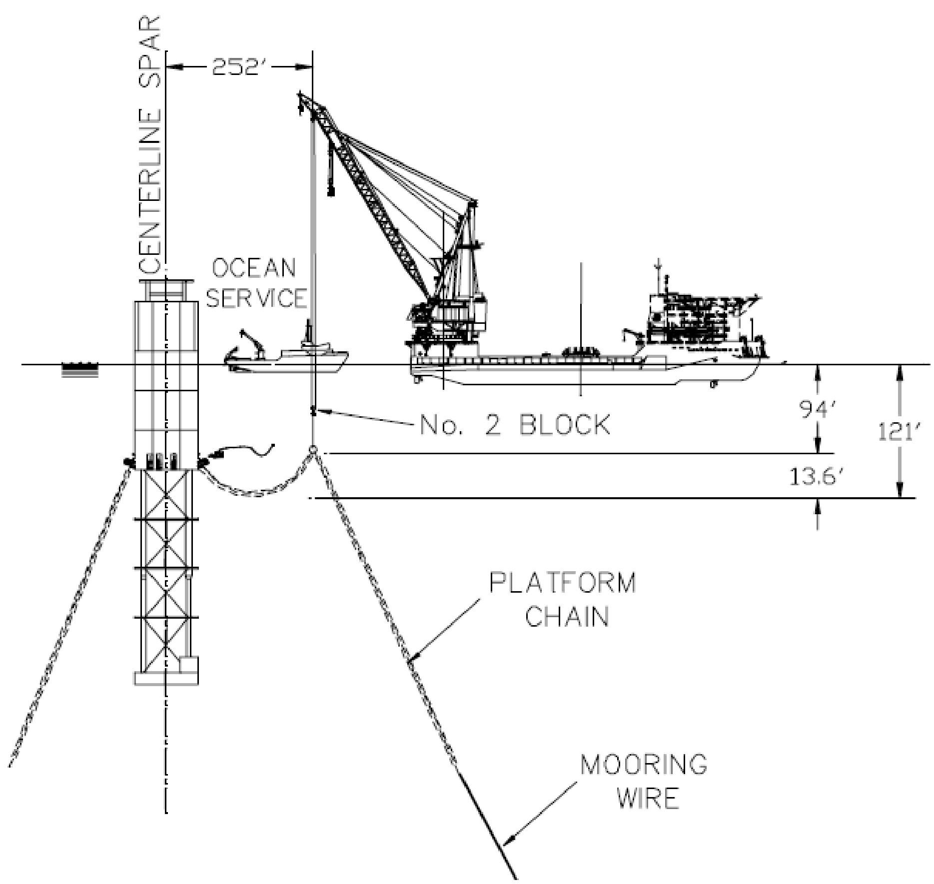


Figure 20: SPAR hard tank flooding operations [Beattie, P.p. 13, 2002]



gure 21: SPAR mooring line installation [Beattie, P.p. 14, 2002]

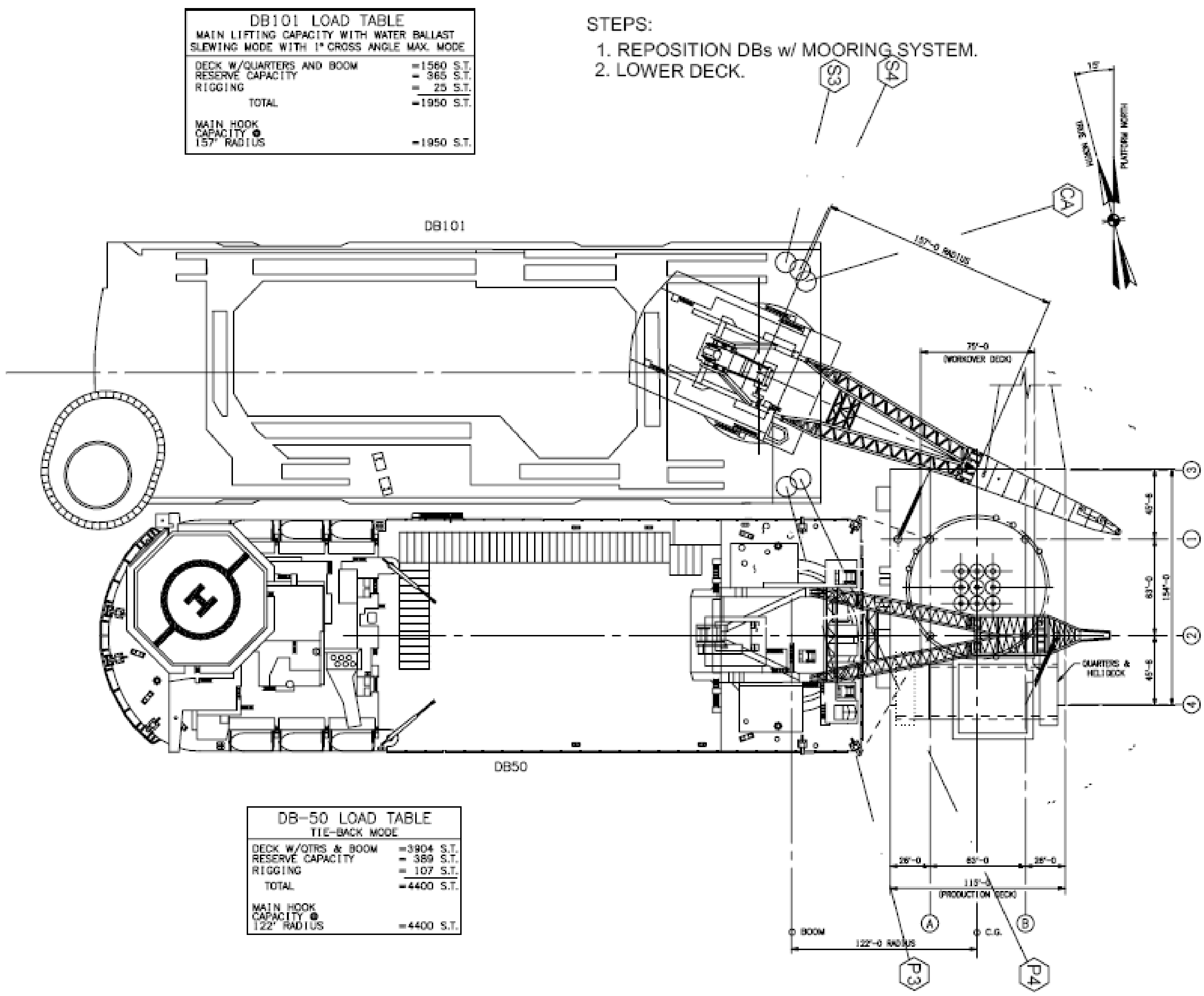


Figure 22. Deck installation arrangement [Beattie, P.p. 15, 2002]

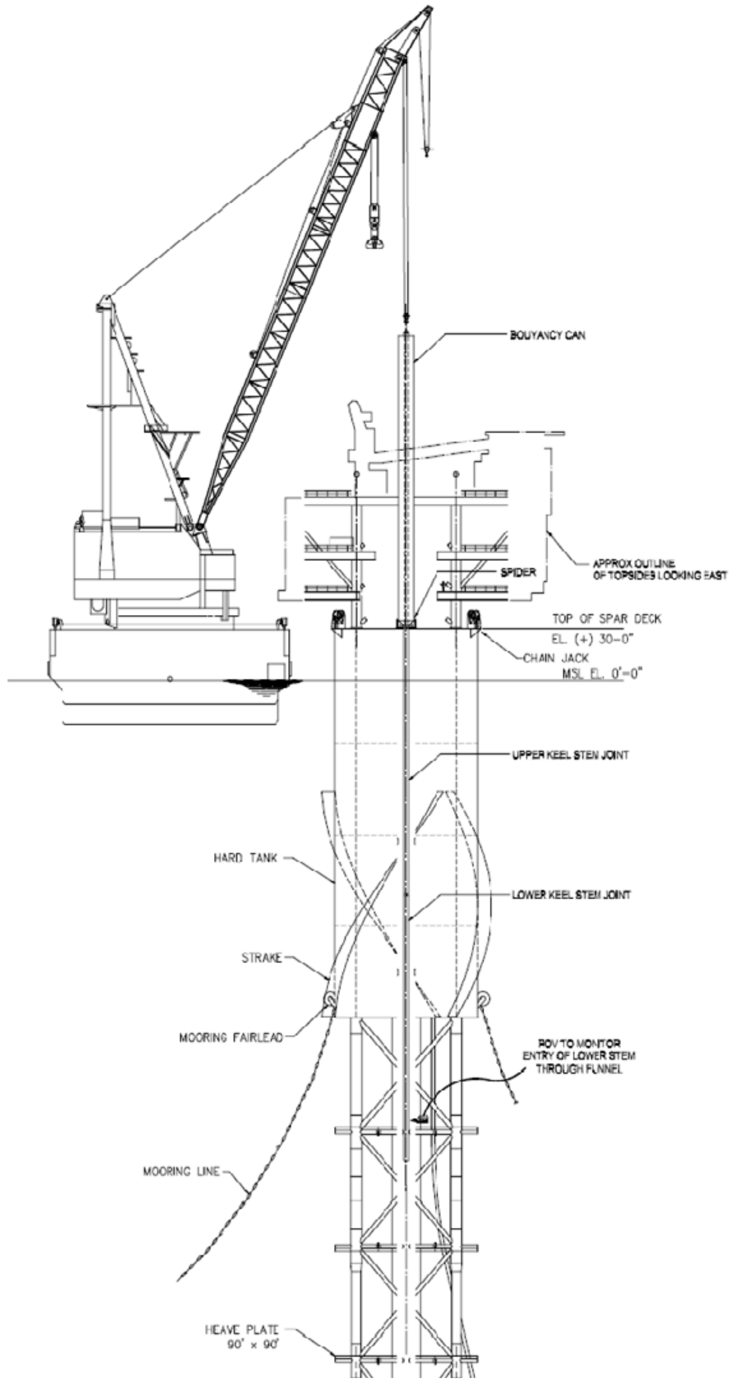


Figure 23: Buoyancy can installation [Beattie, P.p. 15, 2002]

D.III MARINE OPERATIONS FOR A TLP.

Reeg et. al. resume the installation process of the TLP concepts that is reproduced next:

INSTALLATION OVERVIEW.

Installation of a TLP is done in stages; often the design work on one section of the TLP is being done while another part is being installed. For example, the wells will often be predrilled while the TLP is being designed and constructed.

Installation of a typical TLP is done in the following order:

1. Template for wells or foundation for TLP
2. Export pipelines
3. Flexible risers and mooring lines
4. Platform/Tendons
5. Hull and Surface Facility

Template and Foundations

Templates. *Templates provide the layout for well locations and/or for the foundation, if needed. The wells may be drilled to their total depth, or partially drilled and the conductor casing set. Additional well drilling and completion operations can be done from the TLP. Template installation for drilling and foundation templates is similar, except some of the equipment used may be different. The template is built onshore and towed to location for installation.*

A drilling rig (mobile offshore drilling unit [MODU]) is preferred for installation because it eliminates the need for additional vessels. However, drilling rigs cannot lift large payloads and have limited lowering capacity. Large templates may need a crane for installation; they will also require costly handling systems and rigging.

Foundations. *Foundations secure the TLP to the seafloor by use of buried piles, which can be concrete or steel. Tendons are attached to the foundation and the platform is attached to the tendons. The piles can either be driven or drilled and grouted. Driven piles are expensive to install, but the holding power of drilled and grouted piles may not be as strong because of changes to the sole-pile interface during the jetting and drilling operations. A typical vessel used for foundation installation would be one of the several available semisubmersible construction/crane vessels. A hydraulic hammer is used to drive the piles into the seafloor.*

Export Pipelines. *Pipelines for the TLP are the same as pipelines used for conventional platforms. A steel catenary riser may be used to connect the subsea pipeline to the TLP. Various methods of installation can be used. The most common method used for installing pipelines is the J-lay method. Pipelines for TLP's range in size up to 18 inches in diameter for oil and approximately 14 inches for gas. Often the pipeline will join another system for transport to shore. Oil can be transported by tanker as an alternative to pipelines.*

Platform/Tendons. *The TLP's use tendons to secure the platform to the foundations. There is no set order for installation of the platform and tendons. In some cases the tendons will be connected to the foundations, and then the platform will be moved into place and the tendons secured to the platform. Other operations will move the platform in place first, secure the tendons to the platform, and then attach the tendons to the foundation. Another option is to secure some of the tendons to the foundations, move the platform in place, attach the secured tendons, and attach the remaining tendons to the TLP and then to the foundation.*

Hull and Surface Facility. *The upper section of a TLP consists of the hull, the deck, and the surface facilities. The surface facility modules are built onshore and typically assembled at a* *shallow-water location near shore, then towed to the site. The modules may be attached to the hull either inshore or at the site. Economics are the determining factor for where the modules and hull are assembled.*

The hull provides the buoyancy for the TLP to float in the water and supports the platform. The hull contains several of the mechanical systems needed for platform operation. Topsides-related equipment includes firewater, seawater, diesel storage, low toxic oil storage, and completion fluid storage systems. Hull-related equipment includes ballasting and trim, drain and bilge 12 hours.

• The platform was then transported to the site using four ocean-going tugboats, traveling at three miles per hour, taking seven days for the 400-mile transport.
• Because the installation took place inshore there was no need for extra helicopters, supply boats, and marine equipment, and offshore operations, quartering, and weather delays were greatly reduced. Peak manpower used during installation was 350 people.

***Drilling Information.** Well drilling for the TLP often begins after well template installation. A TLP can have 50 well slots with provisions for satellite subsea well tiebacks.*

Predrilling involves using a mobile offshore drilling unit (drillship or semisubmersible) to batch drill and case the wells to a convenient depth, normally through the shallow water flow zone or other potential hazard. Predrilling may also be suspended just above the production zone. Some wells may be drilled to total depth and completed. The Sonat George Richardson semisubmersible drilling vessel is an example of the type of vessel used to predrill.

The Typhoon project was extensively documented in various OTC papers and other publication, chart 2 shows the project Schedule, pay particular attention to the points 47 to 57 in that chart.

Figure 24 shows the concept of the Typhoon field, note that this field is entirely a subsea development, while the most of the operations will not be so different as the one applied for the subsea tiebacks to shore, the availability of facilities close to the wells in this way increase the capability of processing and distribution of oil and gas which increase at the end the recovery factor.

D.IV. Marine operations for a semisubmersible.

From the tree concepts of floating structures shown in this report, the semisubmersible is the less demanding on complexity and number of marine operations since the topsides can be preinstalled before the final emplacement. The onshore operation to place the topsides over the hull is called “superlift”.

The mooring of the hull and the installation of risers and umbilicals to the main host are however operations that need to be carefully planned and is not less complex the translation from the construction yards to the field.

The Na kika project was documented in those aspects in several papers:

- OTC 16701 Na Kika – Host Construction for Record Water Depth Platform.
- OTC 16702 Na Kika – Deepwater Mooring and Host Installation.
- OTC 16704 Na Kika Umbilical Transport & Installation Challenges.
- OTC 16703 Design and Installation of the Na Kika Export Pipelines, Flowlines and Risers.

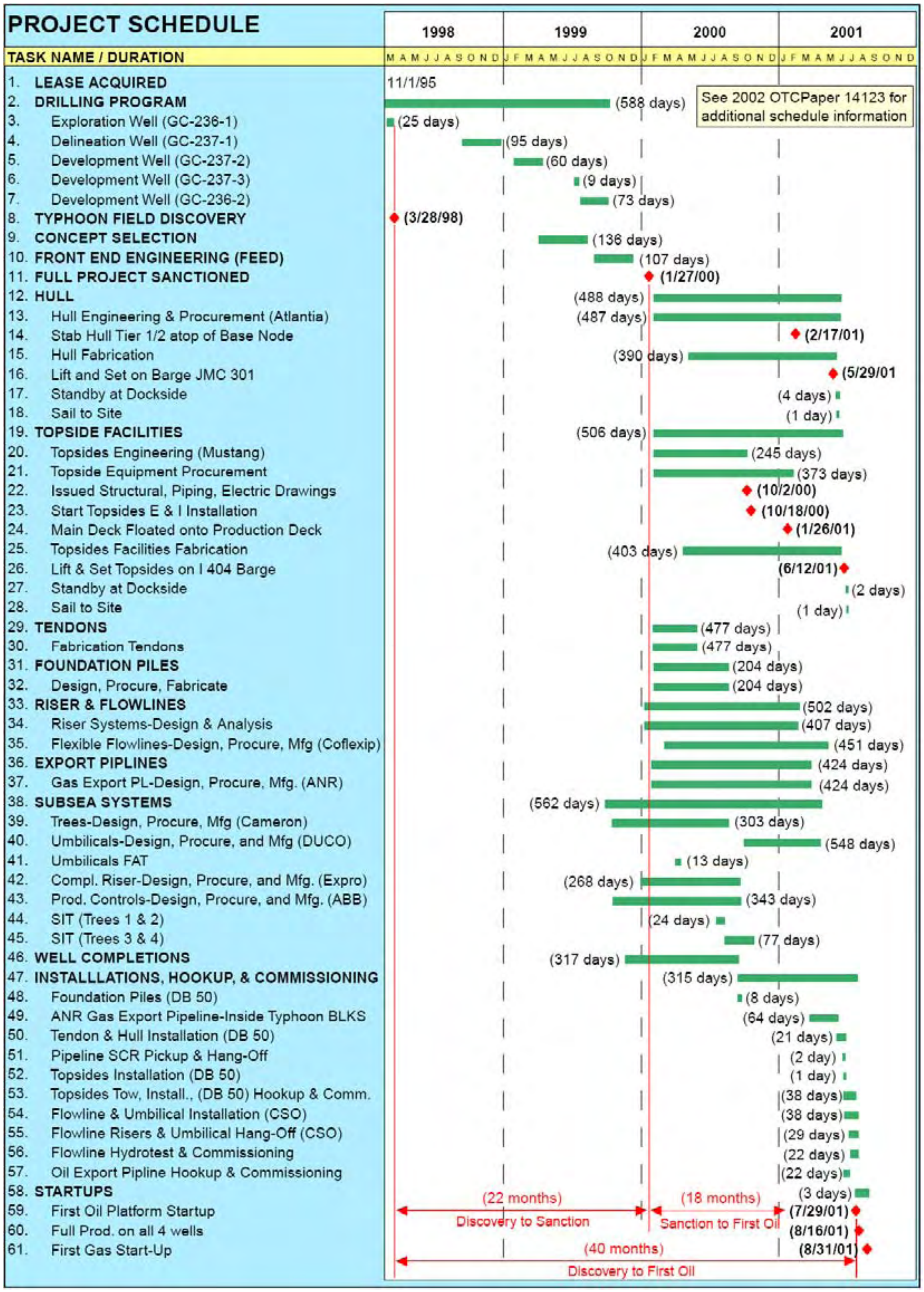


Chart 2 Project Schedule for the field development of the Typhoon project (Albaugh, 2003)

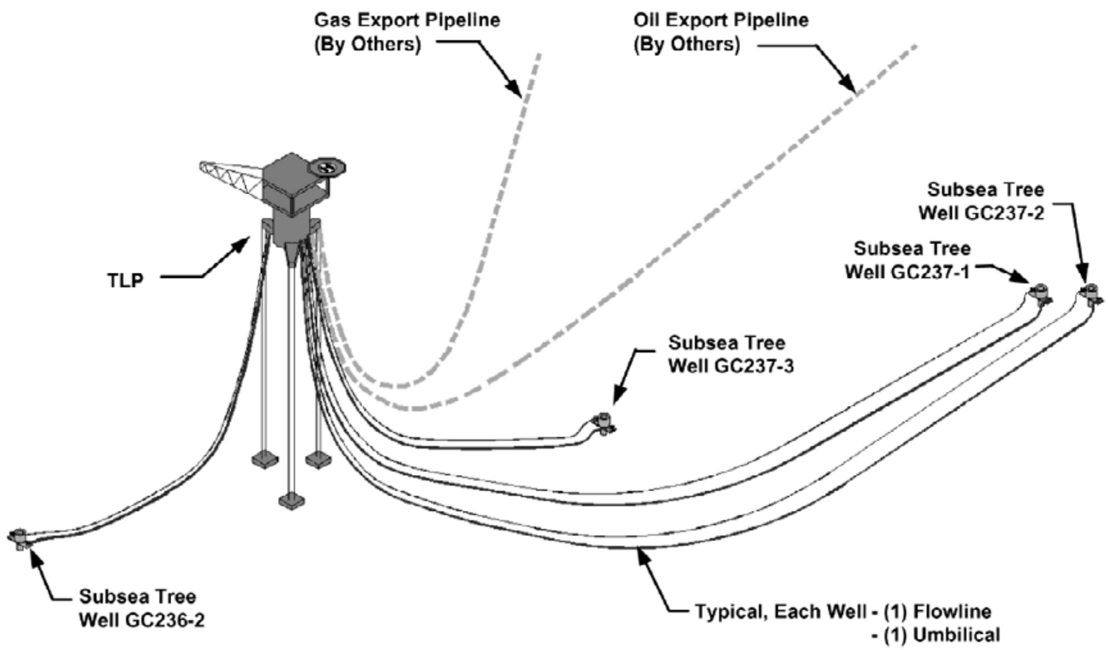


Figure 24 Conceptual visualization of the field development Typhoon (Reeg et. al, 2004).

The placement of the structure is made in a tow operation that can be wet or dry since the FPS is not entitled to have powerful motion systems.

Installation of Risers, export pipelines and flowlines once the main host is moored is not so much different than the ones performed for other floating units as SPAR or TLPs.

The mooring system is however of major importance since the design of the structure particularly for the weight that this system add to all the structure.

CONCLUSIONS:

The subsea tieback to shore is usually the concept that represents less complexity in terms of marine operations.

The technology and knowledge for the construction and installation of floating structures in deep water have been already tested and were successfully installed in comparative projects reviewed in this Annex.

Even though the subsea tieback represent a clear saving in term of capital costs, the selection of alternative concepts using floating structures would represent an increased recovery rate with respect to the subsea tieback concept and cannot be excluded under the exclusive consideration of the complexity of Marine Operations and Marine technology.

Floating structures represent an ample competence challenge but the investment in enhance the competence in this aspect would be necessary when the distances to shore or the size of the field make the concept more favorable to deploy.

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ship.php&h=384&w=550&sz=59&tbnid=2QMzAT-amilOsM:&tbnh=93&tbnw=133&prev=/images%3Fq%3Ddrilling%2Bship&hl=en&usg=__Snm0NIuSZLuDWdDNEeVbbvxTt2E=&ei=ukf5SqGnBI744AbM6c2_Cw&sa=X&oi=image_result&resnum=1&ct=image&ved=0CAcQ9QEwAA

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