

World Petroleum Congress

Early Production in Deep Water

Mats Rosengren

Abstract:

The presentation would be based on production in deep waters, test and early production to determine reservoir characteristics for designing Life Of Field production systems, particularly important for discoveries with certain crude properties such as low API grade and high viscosity, to declare field commercial and obtain wellstream evidence etc. During this phase of early production, attractive cash flow is generated to finance field development in addition to collecting data.

The presentation would present proven technologies applied in Brazil with regards to riser and subsea solutions for deep waters, processing facilities to meet challenging crude properties, experiences gained from 5 years of proven Brazilian operations in deep waters with a FPSO dynamically positioned (the only of its kind in the world);, with proposals how the same technology can be applied in Africa on a second FPSO built on the experience from the existing FPSO. The proposed FPSO for Africa would be dynamically positioned for production operations in ultra deep waters, 2.500 meter water depth, capable to set production deep water world records.

Our proven concept technology for power generation is to use produced gas for all power requirements onboard the FPSO, and would be part of the description of the floating facility.

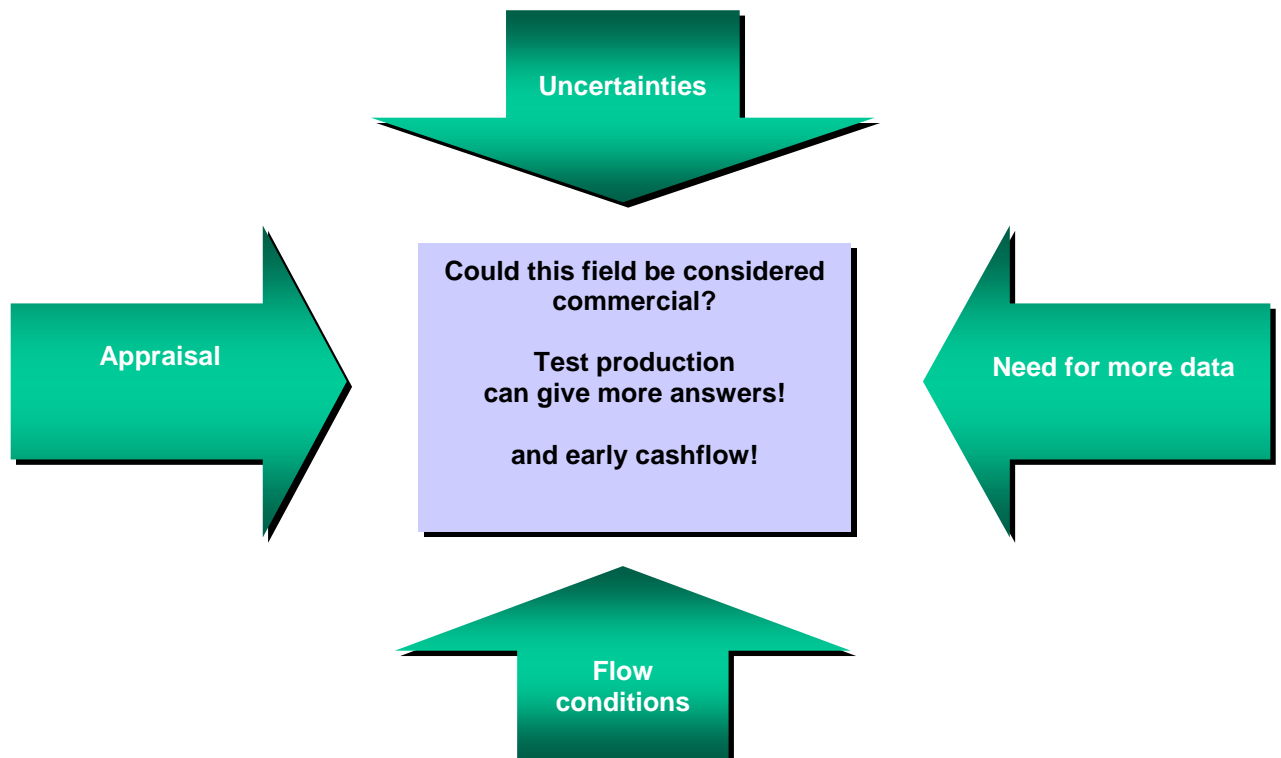
Introduction

Discoveries in deep and ultra deep waters historically take several years from discovery to first production. By utilizing an early production system, the time frame from discovery and well completion to producing oil can significantly be reduced, pending time for regulatory approval in the host country of operations and an available early production system. Converting an existing tanker vessel to a DP FPSO can provide the operator with a fast track solution to early production in deep waters.

The discoveries of heavy crude in deep waters in recent years are demanding solutions to handle low API grade crude, high viscosities and contents as sulfur and acids. Uncertainties of well stream evidence and reservoir characteristics makes it difficult to design and optimize a life of field production system without first deploying a test and early production phase to obtain the required data. Experience from Brazil has since 2002 proven that heavy crude can be produced in deep waters and new ventures are under way to make it viable to efficiently produce difficult crude properties in deep waters.

Uncertainties related to the reservoir performance and production process of heavy crude

- Oil volume connected to the well;
- Aquifer strength;
- Effectiveness of the internal shale barriers;
- Oil-water relative permeabilities;
- Sealing capacity of the main reservoir fault;
- Damage mechanisms along the well;
- Performance of artificial lift with an Electrical Submerged Pump (ESP)
- Calibration of the multiphase flow correlations (pressure and temperature);
- Flow assurance in low temperatures, inclusive during production shutdowns;
- Oil-water and gas-oil separation performance
- Oil storage
- Offloading operations



The Seillean DP FPSO - Concept

The Seillean is a DP class 2 redundant FPSO equipped for test and early production operations in up to 2.000 meters water depth. The FPSO is highly self contained with a full size derrick to handle the rigid production riser and subsea equipment, resulting in very fast mobilization and demobilization times, experienced to two days mobilization time in 1.000 meter water depth from arriving on the well location until the production riser has been connected to the well and production has started.

Offloading of produced crude is carried out to a shuttle tanker with a flexible hose connected between the two vessels.

The FPSO can with a few modifications be upgraded from 2.000 meters of water depth capability to operate in 2.500 meters by increasing the tensioning system capacity to support the additional 500 meter of rigid production riser, and to upgrade the DP system by installing a hydro acoustic reference system capable of operating in 3.000 meter of water depth.

Seillean DP FPSO - Particulars

- Length Over All: 249.7 meter
- Breadth: 37.0 meter
- Crude Production Capacity: 22.500 bpd at API 17 with higher capacity for lighter crude
- Crude Storage Capacity: 300.000 bbls
- DP System: Class 2
- Main Power: Total 22 MW, diesel generator sets and dual fuel gas/diesel turbines
- Thrusters: Total 21 MW



The Seillean 2 DP FPSO – Concept

The Seillean 2 concept is built on operating experience from the in Brazil operating DP FPSO Seillean and is based on a conversion of an Aframax size tanker with 1.000.000 bbls crude oil storage capacity when trading as a tanker.

To convert a tanker to a FPSO with capacities for test and early production in deep and ultra deep water operations, a DP system has been preferred for station keeping in favor of a conventional mooring system. The DP system will give a very high flexibility to quickly relocate the FPSO between wells and is a proven and reliable concept developed for deep waters. The demand for power to the propulsion system consisting of thrusters are met by dual fuel generating sets, operating on produced gas whilst producing from a well, thereby reducing the need for diesel fuel consumption to a minimum keeping down operating costs.

The concept Seillean 2 has also taken into consideration the ability for the FPSO to be equipped to perform other services than test and early production, to increase the flexibility of usage by adding light well intervention and work over capabilities.

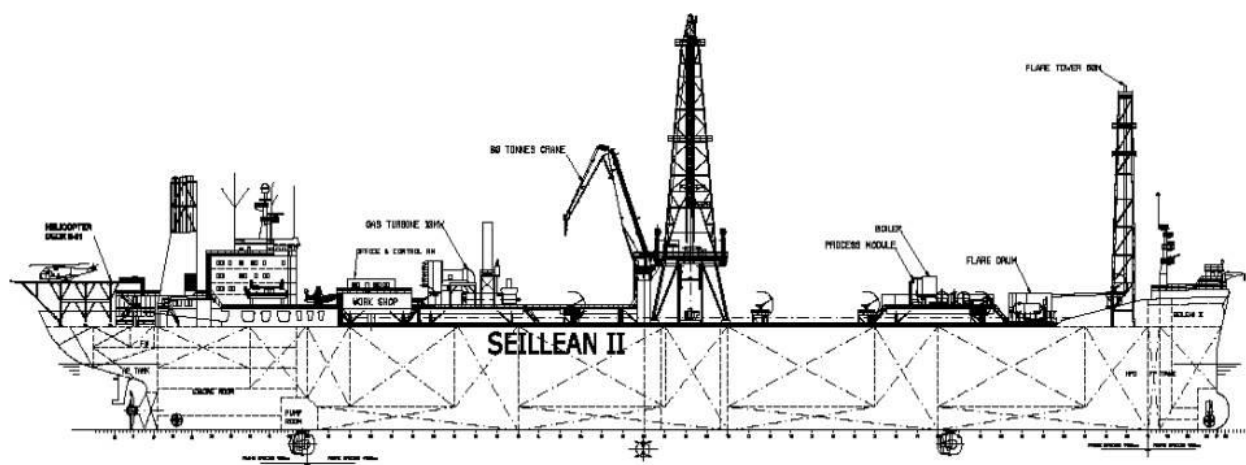


Seillean 2 DP FPSO – Conversion

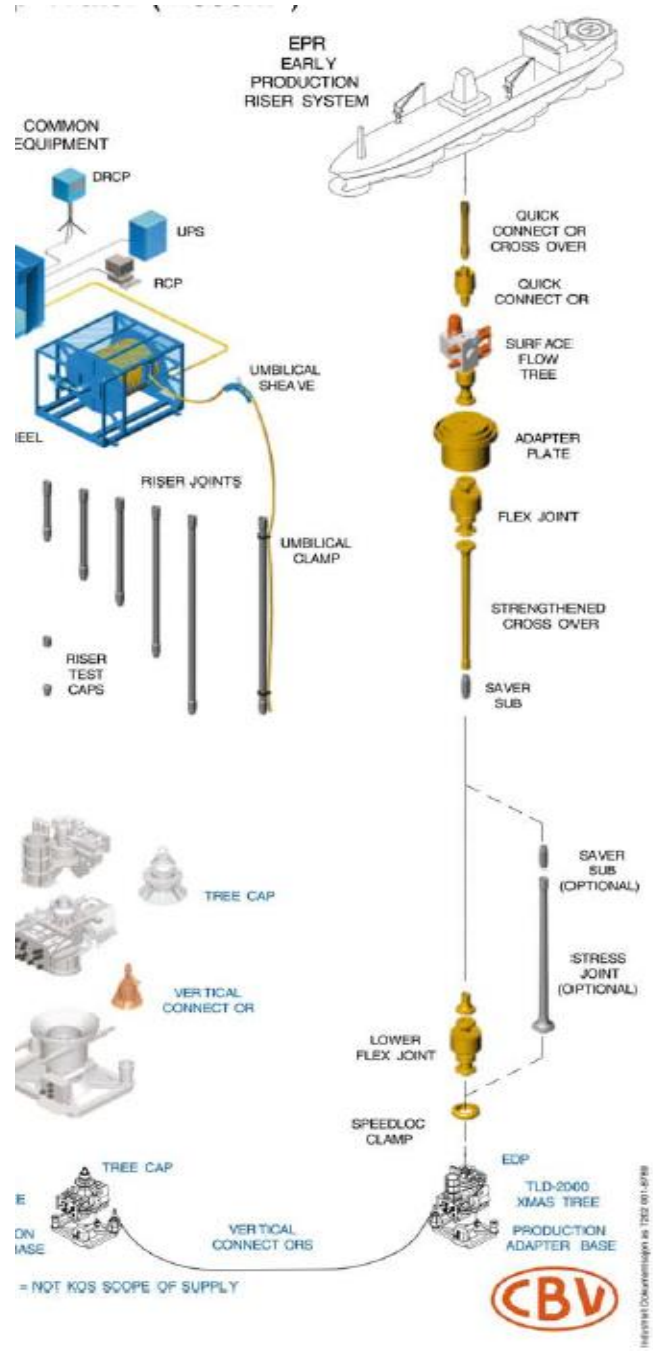
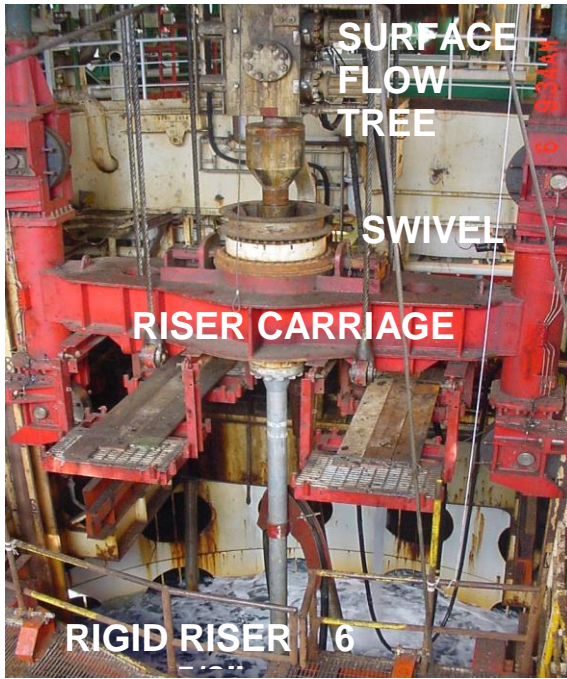
A project to convert a tanker to a DP FPSO includes feasibility studies to define technical solutions, fatigue assessment and definition of structural integrity, establishment of an execution plan with detailed engineering, safety plans and layouts, procurement, pre-fabrication, vessel modification, installation of new equipment, with test and commissioning of the finished DP FPSO before the unit is ready to produce first oil.

With feasibility studies and identified equipment for the conversion completed, the estimated conversion time is approx. 18 - 24 months to build the DP FPSO. Main systems to be addressed at the conversion includes:

- **Structural Hull Modifications – General**
 - Derrick with substructure for handling of the rigid production riser system
 - Moon pool to deploy the rigid production riser system
 - Hull reinforcements to support top side equipment
 - Process plant supporting elements
 - New power generation and control plant supporting elements
 - Flare tower supporting elements
 - Heli deck supporting elements
 - New accommodation module supporting elements
 - New thruster supporting elements
 - Crane and handling equipment supporting elements
 - General structural hull reinforcements



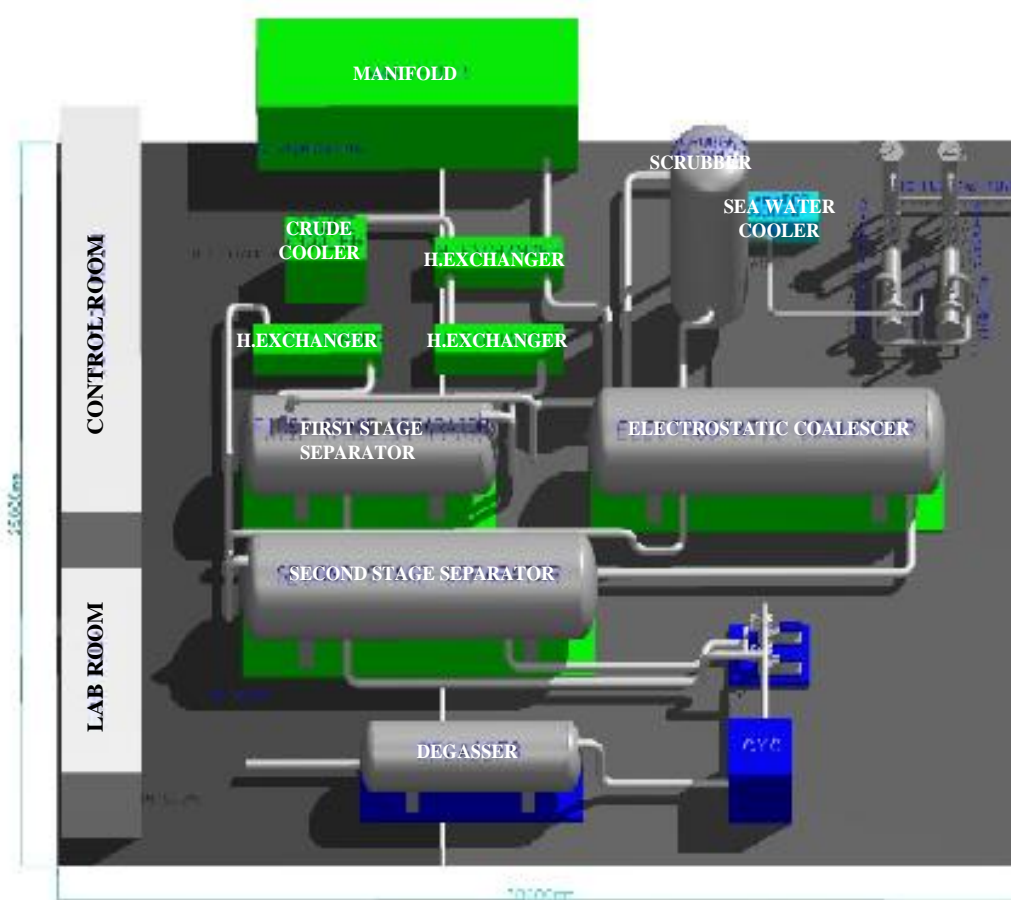
- **Dynamic Positioning System with sub systems - General**
 - Power system with new dual fuel (diesel/ gas) generating sets, new power management system, integration of existing diesel generating sets
 - Thruster system with new thrusters and a new control system, integration of existing thrusters
 - DP class 2 control system with position reference systems
- **Production Riser System - General**
 - Riser handling system on rig floor and in the derrick
 - Rigid riser, size 6 5/8"
 - Multi functional control system
 - Lower Riser Assembly with an Emergency Disconnect Package (EDP)
 - Riser carriage and swivel suspended by a tensioning system
 - Designed to handle heavy crude



• **Production Riser System – Design Parameters**

- Dimensions of the subsea wellhead, vertical or horizontal tree
- Interface between the tree and the LWRP
- Tree production bore, ID
- H₂S expected?
- CO₂ corrosion, expected?
- Umbilical annulus access line
- Electrical Submerged Pump (ESP) requirement

- **Production Process Plant - General**
 - Crude production capacity: 30.000 bpd
 - Designed to handle heavy crude



- **Crude Storage System - General**
 - 600.000 bbl, storage capacity
 - Designed to handle heavy crude by controlled storage temperature
- **Offloading System - General**
 - DP class 1 shuttle tanker required in Brazilian waters for export of crude for operations in environments with significant wave heights up to 5.5 meters.
 - Mooring hawser connected between the DP FPSO and the DP Shuttle tanker
 - Flexible hose system to offload crude to a shuttle tanker
 - Designed to handle heavy crude



- **Optional Systems**
 - Flexible multiple riser system
 - Gas re-injection or export
 - Light Well Intervention, wire line and coiled tubing
 - Work Over capability

Conclusions

The Seillean 2 DP FPSO concept for test and early production in deep and ultra deep waters is based on a proven concept from Frontier Drilling do Brasil's operations in Brazil in deep waters since 1998, and can be also be deployed in Africa and world wide to accelerate field development and first production in already made deep water discoveries. Simulations have been made with a DP capacity analysis to prove that the DP FPSO Seillean 2 can withstand extreme weather conditions in a 100 year return period in Brazil.

The concepts proven experience of 6 years of operations in Brazil with an average uptime of 98% whilst in production mode, with more than 130 offshore offloading operations without any incidents to the environment. Production has been carried out in water depths to 1.860 meters, with less than 4 days of rigid riser deployment time before starting producing crude oil at this water depth. An Electrical Submerged Pump has been installed in the production riser system to boost production of heavy crude oil in deep waters, a proven technology contributing to make it feasible to produce heavy crude oil discoveries in Brazil and world wide.