

# PETROJARL FOINAVEN





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PETROJARL FOINAVEN IS AN OFFSHORE PRODUCTION SYSTEM SPECIALLY DESIGNED FOR OIL PRODUCTION IN THE ULTRA HARSH ENVIRONMENT OF THE NORTH SEA AND NORTH ATLANTIC MARGIN. IT IS DESIGNED TO STAY CONNECTED TO THE PRODUCTION WELLS IN THE 100 YEAR WEST OF SHETLAND ENVIRONMENTAL CONDITION (33,5 M MAX WAVE HEIGHT, 40 M/S WIND AND 2 M/S CURRENT).

The ship's production facilities comprise two parallel two stage separation trains separating crude, gas and produced water. The stabilized crude is temporarily stored onboard for subsequent offloading to shuttle tankers. The produced gas is used for generation of electricity, fuel to boilers, gas lift and the remainder is exported to the Magnus Field for enhanced recovery purposes. The reservoir pressure is maintained by a water injection system.

The normal operation of the ship requires a crew of 45 persons including catering, although PETROJARL FOINAVEN can accommodate up to 70 persons.

PETROJARL FOINAVEN is a Golar-Nor Offshore design, delivered by Astano of Spain in 1996. The ship is equipped with proprietary equipment securing high operational regularity.



Petrojarl Foinaven - Location of the Field



## OPERATING EXPERIENCE

PETROJARL FOINAVEN was the first FPSO to enter the harsh frontier waters West of Shetland. The Foinaven Field is located in UK Licence Block 204 approximately 125 miles West of Shetland. The Foinaven Field is owned by Britoil Plc., BP Exploration Operating Company Ltd., Marathon Petroleum Ltd. and Marubeni Oil and Gas Ltd. The licence holder of the Foinaven Field is Britoil Plc., which is a wholly owned subsidiary of BP. The contract was signed in 1994 for the provision and operation services of the FPSO and shuttle tankers. In addition, the operation of the subsea system is part of the contract. First oil started to flow in November 1997. The FPSO and shuttle tankers have obtained an overall production regularity of 98%. Despite the extreme conditions experienced during the winter seasons, the FPSO and the crew onboard has demonstrated a superior ability to overcome the challenging conditions and maintain a stable and safe production.

## MAIN PARTICULARS

Type: Floating Production, Storage and Offloading vessel (FPSO)

Length overall:	250.2 m
Breadth:	34.0 m
Draught:	12.8 m
Deadweight:	43,2769 tonnes
Oil storage:	260,000 bbls
Slop tank:	10,610 bbls

## PRODUCTION CAPACITIES

The process system is skid mounted in open air on a platform elevated above the ship main deck and constitutes of two parallel trains. It is characterized by the following throughput capacities:

Crude:	140,000 bopd	
Produced water:	120,000 bwpd	
Water injection:	165,000 bwpd	Note 1
Gas injection:	100 mmscfd	
Ground flare capacity:	114 mmscfd	
Riser/umbilicals:	12 slots in use, 15 slots totally	

The given capacities are nominal and based on Foinaven crude. The actual capacities will depend on specific gravity, GOR, pressure etc. Furthermore, the process plant is designed with flexibility for modifications. Increased throughput and improved product specification can be achieved to meet the specific field requirements.

Note 1: Both produced water re-injection and de-oxygenated seawater injection is possible.





## LAYOUT

The ship is arranged, from forward to aft, in the following sequential order:

- Helicopter deck
- Accommodation area
- Turret area including derrick
- Process area
- General facilities including power generation
- Offloading area including ground flare

## CLASSIFICATION

The ship with equipment is built for, and operating under the special survey and classification of Det Norske Veritas (DNV).

PETROJARL FOINAVEN complies with the following class and notations:

+ 1A1 Oil Production and Storage Ship, HELDK, EO, F-AMC, POSMOOR ATA, DYNPOS AUT, COW, INERT\_GAS, CRANE

## REGULATIONS

The ship complies with the following rules and regulations:

- British continental shelf regulations
- International convention for safety of life at sea (SOLAS)
- International convention for prevention of pollution from ship, MARPOL 73/78. Annex 1.

## SUBSEA SYSTEM

PETROJARL FOINAVEN is equipped for connecting up to 15 flexible risers/ umbilicals through the turret. Presently there are 12 risers and umbilicals tied back to the FPSO. The subsea system is arranged in two riser bases separated approximately 3.5 km away from the FPSO. In addition, water and gas re-injection wells are distributed at three separate locations. The total subsea comprises:

- Two drilling centers with production wells, manifold and flowline tie-ins.
- Steel flowlines connecting the manifolds with the individual riser bases under the production ship.
- Flexible risers configured in a "pliant wave" configuration from riser base to the turret.
- Dedicated gas re-injection well located 10 km away from the FPSO.
- Water injection wells located at both drilling centers and at separate locations.
- The Foinaven East Field was tied back in 2001 with two production and water injection wells.



Picture showing main layout of the FPSO

## MANIFOLD AND SWIVEL SYSTEMS

The turret manifold system consists of the valves and piping for commingling of production fluid (production/test manifold), injection of re-injection gas and wellbore gas lift (gas injection manifold) and for the distribution of treated sea water and produced water injection/re-injection respectively (water injection manifold). The manifold system includes pig launchers and receivers for compact scraper pigs. Space and connections are provided for intelligent pigging systems.

The multipath swivel provides safe and reliable means of transferring fluids, gas and electrical power between the geostationary turret and the weathervaning ship. The swivel comprises of the following elements:

- One axial in-line swivel for injection gas
- One electrical slip ring for turret power
- One semi-toroid assembly for turret air and water injection
- One integrated toroid assembly for production fluid, test and hot oil circulation

## PROCESS SYSTEM

The process plant comprises parallel separator and gas compressor trains that are designed to handle 50% of the design flows.

The separation plant has a common slug catcher followed by two parallel trains consisting of two stages of separation and coalescers. A test separator is installed to handle single well flows.

The gas compression system consists of two centrifugal, three stage compressors and supplies gas for gas lift, gas re-injection and fuel gas purposes. The gas is dried in a glycol dehydration system.

As the wellfluid arrives at a relatively low temperature, a considerable amount of heat is required in the separation process. Heat supplied is recovered in the process by exchanging hot and cold process streams.

The process consists of the following systems:

- Slug catcher
- Test separator
- Separation plant with electric coalescers
- Gas recompression (ejector)
- Gas compression (centrifugal)
- Gas dehydration
- Seawater deaeration
- Seawater injection/produced water re-injection
- Produced water treatment system (hydrocyclones)
- Produced water pre-treatment system for re-injection (sandcyclones)
- Cooling and heating medium system
- High- and low-pressure fuel system
- Hot oil circulation
- Sand cleaning system
- Flare and relief systems (ground flare)
- Open and closed drains

## FLARING SYSTEM

The main function of the ground flare, located at the stern of the vessel, is to collect and dispose safely hydrocarbon vapors and liquids during operational, emergency and maintenance events. The ground flare is designed to dispose the following maximum flow rates:

HP flare gas – 120 mmscfd

LP flare gas – 11.8 mmscfd

The gas is combusted completely within the flare drum. The risks of exposing the shuttle tanker to “burning rain” are therefore eliminated.

## OFFLOADING SYSTEM

The produced crude is shipped to shore by shuttle tankers. The crude is transferred to the shuttle tankers via a flexible hose suspended in a catenary from the stern of the FPSO to the shuttle tanker bow. The hose is retrieved and stored on a hydraulically powered reel on completion of cargo transfer. The cargo transfer is controlled from a dedicated control centers located on port side aft.

The distance between the FPSO and the shuttle tanker is approximately 75 m when the shuttle tanker is in DP-mode (with slack hawser), and approximately 85 m when the shuttle tanker is in manual position mode (with tight hawser).

The design capacity of the offloading system is 5,000 m<sup>3</sup> crude per hour. The shuttle tanker will connect in sea states up to 5.5 m significant wave height, and stay connected up to 6 m significant wave height.

## STATIONKEEPING SYSTEM

The stationkeeping system of **PETROJARL FOINAVEN** is approved for the one hundred year storm condition. The mooring lines are terminated at the turret. The turret is located in the forward part of the ship so as to allow for natural weathervaning. This means that the combined forces from wind, waves and current to be restrained by the mooring system are minimized, resulting in optimal safety against mooring line break. The FPSO is moored in 450 meters water depth.

The main elements of the stationkeeping system are:

- 10 mooring lines with anchors. Each mooring line consists of a 135 mm diameter steel rope and a 111 mm diameter studless chain connected to a 35 tonnes drag embedded anchor. A buoy with 35 tonnes net buoyancy is arranged in the catenary part of the mooring line dividing the steel rope into two segments.
- 10 winches with a pull-in capacity of 320 tonnes.
- One transverse nozzle thruster rated for 2,400 kW
- A Simrad Albatross Position Mooring (APM) system for automatic heading control and/or longitudinal position control.

## UTILITIES

The majority of the machinery and utility systems are arranged in the aft section. In addition, some machinery and utility systems are located in the forward section. All hull penetrations are confined to the aft and forward sections. The main utility capacities are:

### ELECTRIC POWER:

- 4 x 5.76 MW (dual fuel Wärtsila 32 V reciprocating generators).
- 4 x 6.48 MW (dual fuel Wärtsila 32 V reciprocating generators).
- 1 diesel emergency generator 1000 kW

### STEAM:

2 x 45 tonnes/hour at 16 bars. The steam is generated by dual fuel (diesel/gas) boilers.

### SERVICE AIR:

2 x 1000 m<sup>3</sup>/h, delivered by air cooled compressors.

### COOLING WATER:

6 x 1000m<sup>3</sup>/h at 2 bar capacity for cooling of diesel engines and general engine room cooling.

### FIRE WATER:

Fire water is delivered from two independent fire pump rooms, one located forward and one aft. Each room can deliver 3,500 m<sup>3</sup>/hour at 12 bar.

## PROPULSION SYSTEM

The main propulsion system consists of two electrically driven ducted propellers, 6000 kW rating each. In order to provide maximum side force in case of weathervaning assistance, one Shilling rudder is located in each of the propeller races.

## CRANES

Three main pedestal cranes are installed on the FPSO. They are located forward, midship and aft. The cranes are designed and built according to Norwegian Petroleum Directorate and DNV rules for lifting appliances.

The forward crane is mainly used for loading/offloading supply vessels. This crane is powered via the emergency switchboard and can be used for emergency evacuation.

The crane capacities are 10 tonnes at the extreme reach of 36,2-42 m. At 20-30 m reach the capacities are 30 tonnes.





## ACCOMMODATION

The normal manning of the FPSO is 45 persons. Provisions are made for accommodation of 70 persons. The accommodation is located in the front part of the vessel. The main controls of the vessels are in the NCC room in the accommodation quarters. Emphasis is laid on easy access to NCC room.

Risk analyses have shown that the weathervaning feature, and the forward location of the accommodation, has reduced the risk to personnel on **PETROJARL FOINAVEN** to a minimum.

## SHUTTLE TANKERS

PETRONORDIC and PETROATLANTIC are dedicated to service **PETROJARL FOINAVEN**.

Teekay Petrojarl is currently operating two shuttle tankers specially equipped for operations with FPSOs. The shuttle tankers are PETRONORDIC (92.995 tdw) and PETROATLANTIC (92.995 tdw).

In addition Teekay Petrojarl owns the shuttle tanker RITA KNUTSEN (124.472 tdw) which presently is on bareboat charter to Knutsen OAS Shipping.

## COMPANY BACKGROUND

Teekay Petrojarl is the largest operator of Floating Production, Storage and Off-loading (FPSO) vessels in the North Sea. With a combined production capacity of 350,000 barrels of oil per day and a crude storage capacity of more than one million barrels, we have a long, proven track record in safely operating FPSO vessels in one of the harshest environments in the world.

Teekay Petrojarl owns and operates five FPSOs of which two are on each of the Norwegian and UK Continental shelves and one offshore Brazil. The company currently has another FPSO under construction in Singapore for the production of oil for Petrobras in 2012. All production units are under contracts producing for oil and gas companies. Our operating fleet also includes two shuttle tankers, one storage tanker and a 40% ownership in the FPSO Ikdam, operating offshore Tunisia.

With our head office in Trondheim Norway and operations offices in Aberdeen and Macaé, Brazil as well as a site office in Singapore, our 700 employees offshore and onshore possesses a unique blend of operational, engineering and professional expertise.

