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CASE STUDY ON FPSO VESSELS AND STRUCTURES

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ABSTRACT

This case study is part of an ampler research project regarding FPSO vessels. The aim of the paper is to try to exploit some major information based on the existing data in the literature in order to be latter used for a deeper analysis regarding the behaviour and the induced loads necessary for a better evaluation of the structural analysis. As known, among the large diversity of floating structures, a Floating Production, Storage and Offloading (FPSO) vessel is quite a familiar solution in oil and gas offshore industry in order to ensure the storage, processing and transfer of hydrocarbons. In fact, an FPSO vessel is part of a larger family carrying out different types of activities which are practically dependent on the characteristics of the location where the unit is going to be installed (waves, wind, currents). Such aspects are briefly presented in the paper.

Keywords: FPSO, floating production, oil, oil industry, trends, new builds conversions.

1. GENERAL DESCRIPTION OF FPSO TYPE VESSELS

Historically, the first FPSO vessel was the Shell Castellon. It was built in Spain in 1977. Today, there are over 300 FPSOs operating worldwide.

Floating production, storage and offloading vessels are practically more effective in deep water locations, where some other technical solutions are more expensive due to the particularities of the locations. The utilisation of an FPSO, which is working in tandem with a shuttle tanker, eliminates the need to transfer the product to an onshore terminal. This possibility becomes an adequate and economic solution for installing a pipeline. Moreover, the possibility to use the FPSO on a new location is another advantage which ensures more flexibility.

The major differences between an FPSO and an oil tanker are:

- Operations and safety requirements;
- Layout and arrangement;
- Specified service/location;
- Rules and regulations;
- Design/construction/commissioning
- On-site inspection/maintenance.

Photo 1. Overhead view of FPSO Cuulong MV9

Table 1. FPSO Capabilities - typical requirements

Storage	200.000	2.000.000 barrels
Production	30.000	300.000 bopd
Vessel	100.000	300.000 tonnes
Water depth	70	2.500 m
Topsides	2.000	35.000 tonnes
Risers	1	30+
Wave height	0	30+ m
Air temperature	-20	30 degrees celsius

Photo 2. Side view of FPSO Anadarko Jubilee

Photo 3. 3D rendering of Apollo FPSO

2. FPSO HISTORY AND DEVELOPMENT

Table 2. FPSO history table

Years	1985-1996	1996-2006	2007-2012
FPSO application	Marginal reservoirs, Early production testing	Moderate size reservoirs	Large and major reservoirs
BOPD	20-40.000	50-75.000	100-250.000
DWT	80.000	150.000	320.000 +
Design life on site	1-5 years	5-10 years	15-25 years
Water depth	Less than 100 m	Less than 300 m	Up to 2500 m
Offload frequency	40-60 days	15-30 days	5-10 days

3. NEW BUILDINGS AND CONVERSIONS

The advantages of tanker-based conversions are:

- The shipbuilding boom is over; conventional shipyards need new contracts and require work;
- Shipyard engineering is no longer a limited resource;
- Attractive for smaller operators;
- Commercial flexibility;
- Smaller costs.

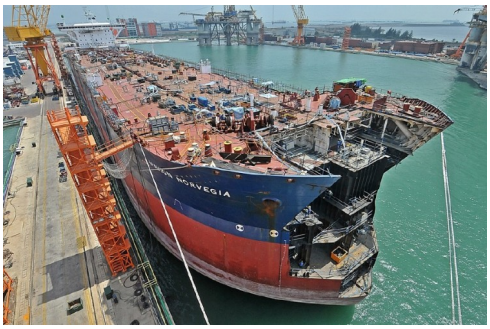

Photo 4. Conversion of Navion Norway

The advantages of new builds are:

- ❖ All the advantages of the conversion;
- ❖ Higher production capacity;
- ❖ Higher quality, reliability and maintainability;
- ❖ Health, security and environment regulations are easier to comply with;
- ❖ Extended life on site;
- ❖ Attractive to major oil companies.

Table 3: Newbuilds and conversions fleet

Year	2002	2005	2013	Predictions
Number of operating FPSOs	90	99	147	More, unless new technologies emerge
Conversions	62%	62%	70%	Probably fewer
Newbuilds	38%	8%	30%	Probably more

4. HULL SHAPE AND GENERAL ARRANGEMENT

Photo 5. FPSO technicals

1. Turret and swivel stack;
2. Flare tower;
3. Gas compression;
4. Process plant;
5. Heating medium;
6. Power generation;
7. Switchgear room;
8. Accommodation;
9. Helideck;
10. Mooring lines;
11. Risers and umbilicals;
12. Storage tanks;
13. Fiscal metering;
14. Offloading hose;
15. Central control room.

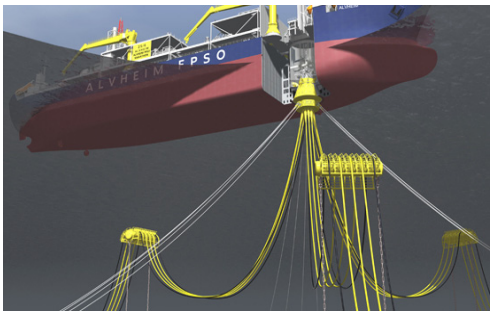

Photo 6. Turret system inside the hull

Photo 7. Modified hull with turret

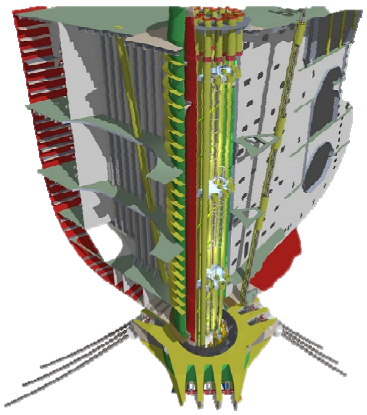

Photo 8. Turret mooring system (detail)

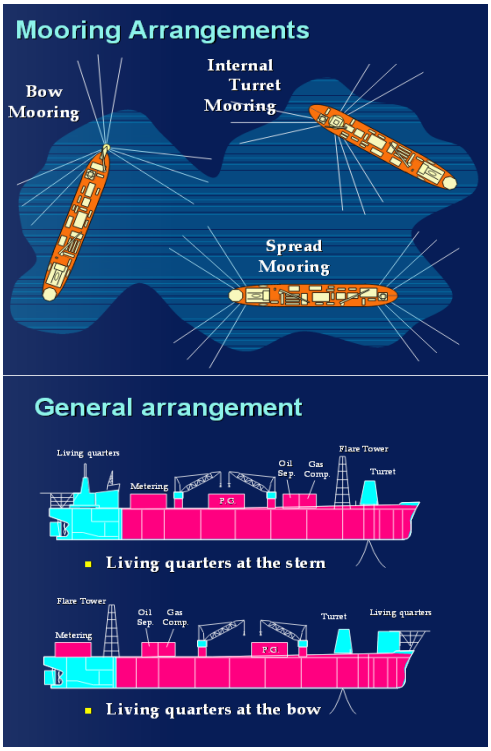

Photo 9. Mooring arrangements

5. HULL SELECTION CRITERIA

Table 4: Criteria table for hull selection

Action	Conversion	New build
Builder/ Age/ Project life	Yes	Project life
Desired storage capacity	Yes	Yes
Deck space	Yes	Yes
Environmental constraints	Yes	Yes
Displacement and Hull dimensions	Yes	Yes
Tanker trading history	Yes	No
Accomodations	Yes	Yes
Propulsion	Yes	Barge or self-propelled
Physical inspection	Yes	No
Site-specific analysis	Yes	Yes
Class records for cracking history	Yes	No

6. HULL DESIGN CONSIDERATIONS

- Hull strength, arrangement and materials;
- 100-year site specific criteria;
- Local connection details and fatigue life (min 20 years);
- Range of loading conditions;
- Vessel motions and accelerations;
- Mooring system & hull integration;
- Process support structure;
- Slamming and green seas;
- Sloshing;
- Helideck, cranes and cargo offloading system;
- Accommodation;
- Corrosion control;
- Construction tolerances and fabrication quality;
- Philosophy for in-service periodic survey;
- Interfaces.

7. THE CONVERSION PROCESS

Before making the decision to convert a vessel to an FPSO, a series of investigations need to be carried out. These will be made according to class rules, company specifications and other applicable rules, regulations and standards. Prior to inspections, a detailed plan is developed by the owner and approved by the class society. The first major inspections carried out are the internal and external structural survey of the ship, and the steel thickness gauging. These are required to produce the specifications for the steel renewal process, where the case demands it. All damaged areas, cracks, fissures and defective structural, known from previous experience to have sustained damage or fatigue, are extensively NDT tested to prevent accidents. Surveys and inspections are carried out by company and owner representatives, yard and class inspectors. The steel renewal criteria for the vessel being converted to FPSO will be based on the goal that after the steel renewal no part of the hull or decks will reach substantial corrosion levels during the service life.

8. MAJOR WORKS ON EXISTING HULLS

- Removals / modifications
  - hull steelwork, coatings etc.;
  - propulsion and other machinery
  - rudder / steering gear;
  - accommodation, deckhouses and helideck;
  - helideck;
  - piping systems.
- Upgrades
  - marine and topsides control system integration;
  - fire protection systems and their integration;
  - power generation systems and their integration;
  - cargo tank venting arrangement;
  - ballast and cargo oil pumps and valves;
  - inert gas system;
  - utility systems (water, steam, heating).

9. MAJOR WORKS – HULL ADDITIONS

- Turret or spread mooring system, equipment, etc;
- Riser porches or fluid transfer system and piping;
- Provision of thrusters;
- Installation of process deck supports;
- Process systems;
- PAUs, flare and piping;
- Blast walls;
- Life saving equipment;
- Fire and gas equipment and systems;
- Evacuation measures;
- Bulwark and breakwater;
- Lifting equipment;
- Loading instrument (computer);
- Offloading system.

10. LOOKING AHEAD

The economic uncertainties correlated with the drop of the oil price are now creating important distortion related to the future trend in the FPSO sector. The growth of the capital expenditures is now questionable and future massive investments in offshore industry are not expected anymore as predicted some time ago when spectacular evolution of this specific market was expected.

Some previous studies, carried out by the important players in the FPSO market, revealed significant positive trends as well as some specific problems in the floating, production, storage and offloading vessels as follows:

- About $100 bn to be spent between 2013 and 2017, meaning an increase by 100% as compared to the last 5 years.
- It appears that most of operators prefer lease FPSOs instead of owning a unit;
- Subcontractor management could be a real bottleneck in FPSO business;
- It is believed that continuous growth in the field will continue.

Some of actual trends are creating serious difficulties in a credible forecast in the area.

11. CONCLUDING REMARKS

General remarks regarding FPSO-type vessels were done. The operating limits of the structures and their timely variation are presented, while creating a comparison between standard hull shapes and FPSO structures. The main differences between them are highlighted. The general arrangements and mooring systems are also highlighted. From a naval architect's point of view, the ship's data combined with metocean data will impose a calculation model and method to establish the vessel's operating conditions and response to exterior forces. Computations for a vessel of this type will be carried out using the strip theory for predicting heave, pitch, sway, roll and yaw motions as well as wave-induced shear forces, bending moments and torsional moments.

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Table 1. FPSO capabilities typical requirements, credits to Tom Koster and http://www.fpsoforum.com .

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Table 4. FPSO Hulls: New-builds and conversions, credits to Tom Koster and http://www.fpsoforum.com.

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