A New Proposal for Float-over Installation in Fixed Platforms

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Abstract. In view of the increase in drilling activities, resulting in the growth of offshore production facilities, the oil industry should use more efficient and secure ways of installing their equipment. In recent years, the offshore company projects developed many ways to overcome the challenges of carrying and lifting heavy loads. The installation step of a heavy equipment has always been one of the most critical phases of an offshore structure design because of the risks inherent to the operation, the availability of heavy-lift ships and costs of mobilization of such vessels. Fixed platform topsides are installed nowadays considering two different methods: the conventional heavy lift crane barge and the float-over method. The latter requires that the jacket is designed such a way that the barge carrying the deck is able of floating in the space between the legs of the jacket, upon which it is lowered (see Fig.1, 2, 3 and 4). There is no question that the float-over technique is cheaper, but unfortunately it is not always possible due to the limitations associated with the environmental conditions. Such limitations have a negative impact on the project cost due to the high crane barge rental prices. This paper proposes an alternative procedure aiming to allow float-over installations under environmental conditions that were unacceptable, thus extending the range of applicability of this type of operation. As a result of this procedure, the float-over method can even justify disadvantageous projects and become more popular in the Brazilian market where specific environmental conditions hindered its use. This procedure presented herein considers an existing fixed platform that was installed using the traditional lifting method precisely because of the environmental limitations. It was considered suitable for this study because its dimensions are compatible with a float-over operation.

Index Terms - Method; Float-over; Installation; Topside; Lift; Barge; Jacket and transport.

1 INTRODUCTION

In view of the increase in drilling activities, resulting in the growth of offshore production facilities, the oil industry should improve their abilities to use more efficient and secure ways to install their equipment. In recent years, offshore companies have developed many ways to overcome the challenges of carrying and lifting heavy loads.

The installation step of heavy equipment was always one of the most critical phases of an offshore structural design due to the risks inherent in the operation, availability of heavy-lift crane ships and the rental costs of such vessels around US$ 1 million daily, what can hinder the traditional method of running frequently.

To troubleshooting the aforementioned problems, new methods have been studied for the installation of "topsides" aiming the economy in the operation process, without sacrificing safety. The float-over method, created about 30 years, has generated great interest to engineering companies due to the advantages it offers.

Figure 1. ACG Topsides Float-Over (Topside with 16000 t – Wilson and Munro-Kidd, 2008)

The float-over method allows the installation of heavy weight topsides without the use of cranes ships, offering benefits in terms of economy, layout and allowing faster the installation process, as can be seen in Figure 1. This method minimizes costs nothing and rarely get to make the operation for low production fields. In this method, the topside is fixed on the barge transport, directed to the place of installation, where is finally supported by a system of hydraulic jacks. At the time of installation will be used for its accommodation on the legs of the jacket. Figure 2 details the layout and components necessary for carrying out the method.

Considering the advantages presented for the float-over installation method, it should be expected that its use becomes a common practice. Indeed, it does occur in a state of mild sea and regions where it is hard to get large-capacity vessels. Nevertheless, the float-over method has restrictions imposed by environmental conditions, because the barge movements, mainly caused by the waves, may reach unacceptable values for the topside installation.

This paper aims to present an engineering solution which allows to carry out the float-over installation method in areas with adverse environmental conditions. The solution for this issue consists in the adaptation of the existing method in order to ensure system stability, both vertically and horizontally at
the time of installation in adverse sea conditions (Hs < 2.0 m and T > 5.0 s).

This study will be carried out using the example an existing production platform, located in the Brazilian coast, where the irregular sea state predominant (southeast waves) has joined to a regular sea state of waves coming from east, whose overlay has prevented the use of the traditional method of work-over and has not yet used the float-over method. The analysis and the solutions are described in Section 4.

Figure 2. Location of system components (Tan et al., 2008)

2 “FLOAT-OVER” INSTALLATION

The idea of "float-over" is very simple and is expressed as follows: a deck structure to be installed is transported by barge to the place where the jacket it is located, being further positioned on it through jacking system and ballast control, then releasing the barge. It is a choice of excellent value for money, through which reaches enable some marine installations, such a reduction in associated costs.

The above definition is given generically because the float-over method applies to many different types of structures. However, what all these have in common, the conditions are practically "static" with which the operation is carried out to accomplish.

This fact alone answers the main question that could be done here, which is: why not always use the float-over methods? It is obvious that the installation conditions are not always associated with an appropriate environment condition which could be classified as "sheltered waters", i.e. static conditions. In practice, it is important to recognize that the majority of facilities do not comply with that condition.

Nevertheless, despite its limitations, the float-over method has achieved great applicability. The first float-over installation occurred on the Maureen platform, a fixed platform with a topside of 18600 t, installed in 1983 by the company KBR (Kellogg Brown & Root) in the North Sea. After the success of Maureen project, some companies as TECHNIP, ODL (DOCKWISE), EMAS AMEC, etc. have used the concept of float-over method.

3 NEW PROPOSAL FOR FLOAT-OVER INSTALLATION

Aiming to carry out a float-over operation in adverse sea conditions (Hs < 2.0 m and T > 5.0 s, and a cross swell 2 m), the proposal developed here should be a viable ingenious solution that maintains the stability of the vessel and ensure the safety of the procedure.

The main challenge of this new proposal is to eliminate the displacements caused by the resulting movements of environmental action. The movements in question have a direct impact on the support structure so that they can determine the failure of the installation procedure.

The procedure presented herein concerns the installation of fixed platforms decks, where it seeks to take advantage of the difference between the loads acting on the jacket during installation and those that will be on it during the operation phase.

Another important point of this method is in trying to eliminate the barge movements making it to "stranding" literally, in the jacket. This is only possible thanks to the difference between loads for installation and operation, as mentioned above.

Knowing that the platform jacket has at this stage large cargo reserve, the studied solution is to design a rigid beam (see Fig. 5) supported on the legs of the jacket to serve as a ramp to the barge at the time of installation, making with which it rises out of the water progressively reducing their movements until cease altogether.

The slope of the beam-ramp is calculated according to the height the barge needs to be raised to stop movements. When the barge to contact the beam is undesirable that the vessel produces horizontal forces overturning the jacket (except the wave of actions that are unavoidable). For this, the barge
should be pulled up through a self-balanced system that causes friction, and this is overcome by pulling the barge through a winch system.

**Figure 5.** Sloping beam designed for jacket (schematic)

It was considered conservative in the model coefficient of friction of 0.3.

The analysis developed in this work show that the barge movements are canceled as the barge up the "ramp jacket." This rise will be simulated by a winch system modeled on the analysis type "time history" for an irregular sea with a cross swell.

Figures 6, 7 and 8 show the orcaflex model developed for this analysis.

**Figure 6.** Top view of the barge at the time of installation

**Figure 7.** Jacket of the beam in contact with the beam of the barge at the time of installation

**Figure 8.** Front view of the barge at the time of installation

### 4 Analysis To Be Held

For the design of a system for a project "float-over" it is necessary to take into account the following steps / analysis:

- Layout equipment on the deck
- Weight control and center of gravity of the deck
- Geometric verification for deck installation (height, width, etc.)
- Stability for transport barge
- Spacing legs jacket / deck support
- Deck transportation (RAOs)
- Platform orientation for alignment with the waves directions
- Sea conditions (transport and float-over operations)
- Systems to guide and absorb the impacts barge (guiding / fendering)
- Loading transfer

For this study will be used an existing platform in the Campos Basin which is located in an area where the installation of the deck using the "float-over" was discarded because it is a rough sea state region beyond the incidence of a state additional sea "swell" coming from almost perpendicular direction to the head sea state.

For the transportation and installation of the deck was chosen a barge, which has sufficient capacity and which is suitable to the geometric conditions of the jacket.

#### 4.1 Basic Data

The severe wave parameters for the corresponding transport conditions in the Campos Basin, where it was installed the jacket in question, are listed in Table 1.
The sea state provided above was modeled using the ISSC spectrum (known as modified Bretscher-Auer or Pierson-Moskowitz) to irregular waves which operate at 180° (longitudinal direction) and Dean Stream spectrum of 5° order for the regular waves that occur 90° (transverse direction).

### 4.2 Deck Weights

Deck weights in Table 2 highlight the difference between the weight of the light structure (the time of installation) and weight of operating.

<table>
<thead>
<tr>
<th>Item</th>
<th>Mass (mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giant barge</td>
<td>5408.00</td>
</tr>
<tr>
<td>Tanks</td>
<td>754.57</td>
</tr>
<tr>
<td>Topside</td>
<td>13571.00</td>
</tr>
</tbody>
</table>

### 4.3 Stability Condition

The data of the barge used for deck transport is described in Table 3.

<table>
<thead>
<tr>
<th>Item</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length extreme</td>
<td>140.00 m</td>
</tr>
<tr>
<td>Breadth extreme</td>
<td>36.04 m</td>
</tr>
<tr>
<td>Depth extreme</td>
<td>8.54 m</td>
</tr>
<tr>
<td>Summer draft extreme</td>
<td>6.68 m</td>
</tr>
<tr>
<td>Light draft</td>
<td>1.39 m</td>
</tr>
<tr>
<td>Length moulded</td>
<td>139.97 m</td>
</tr>
<tr>
<td>Breadth moulded</td>
<td>6.00 m</td>
</tr>
<tr>
<td>Depth moulded</td>
<td>8.5 m</td>
</tr>
<tr>
<td>Deck area</td>
<td>120 x 36 = 4320 m2</td>
</tr>
<tr>
<td>Deadweight summer draft</td>
<td>24000 tonnes</td>
</tr>
<tr>
<td>Lightweight</td>
<td>5408 tonnes</td>
</tr>
<tr>
<td>Deck load maximum</td>
<td>15 tonnes/m2</td>
</tr>
<tr>
<td>Capacity high range</td>
<td>15 tonnes – 13 m/min</td>
</tr>
<tr>
<td></td>
<td>10 tonnes – 20 m/min</td>
</tr>
<tr>
<td></td>
<td>3.5 tonnes – 36 m/min</td>
</tr>
<tr>
<td>Capacity low range</td>
<td>30 tonnes – 6.5 m/min</td>
</tr>
<tr>
<td></td>
<td>20 tonnes – 10 m/min</td>
</tr>
<tr>
<td></td>
<td>11 tonnes – 18 m/min</td>
</tr>
</tbody>
</table>

### 4.4 Transfer Functions

For the proposed article, it is very important to get and know the transfer functions per unit wave amplitude, which are generated for a variation of period that wave can have.

Then one should know such transfer functions of the barge movements, which are known in naval terminology as RAOs (Response Amplitude Operators). In this work, however, required RAOs need to be expressed as a function of the forces and not the movement, so that one can take into account the effect that removal of the barge out of the water produced on the movement at the time that it climbs the ramp gently sloping jacket.

To obtain the barge strength RAOs, it was used WAMIT program (WAMIT, 2016) that analyzed the stability and generated the RAOs. The data used for this analysis were the same with which it performed the analysis of stability.

The strength RAO not completely define the ship’s movement as does the displacement RAO; it simply defines the strength and bending that a wave exerts on the vessel. The OrcaFlex program (Orcina, 2016) uses these forces and moments, along with any other loads on the vessel and the data on the mass and inertia of the vessel, to determine the ship’s movement from its equation of motion.

Figure 10 shows a typical example of RAO obtained in WAMIT in terms of Amplitude and Period:

*Figure 9. General arrangement of Barge (mm)*
4.5 Motion Analysis – Installation

The software used for motion analysis of the barge was OrcaFlex (Orcina, 2016) as can be seen in Fig. 11 and 12.

Analysis description

The interest of analysis for the particular problem is focused to the displacement of the barge originally near the jacket, during its trajectory as this enters and starts up the ramp installed for the purpose of "beaching" barge in the jacket beams as Fig. 14 shows. The total distance to be overcome by barge is approximately 130 m.

Throughout this phase will be evaluated buoyancy forces, contact forces generated between the vessel and the ramp contained in the jacket, the movements of the set and the forces on the winches. Subsequently, the contact reactions can be extracted from the model (OrcaFlex) and applied in another model for a structural verification of the jacket.
Analysis results

The results are presented through graphs generated by OrcaFlex program (Orcina, 2016).

The graph of Fig. 16 shows the main reaction expected to be determined in this analysis. These reactions are generated from the moment it starts to transport \((t = 0\ s\) in Fig. 16) remains zero until the time at which the barge touches the ramp \((t = 300\ s)\) and advances to the final installation time \((t = 900\ s)\). The high barge reactions affecting the ramp in relation to their pitch motion are undesirable, but these can be greatly reduced through a fender system at the end of the beam. The seek here is that only the ability of vertical movement is eliminated in that the barge up the ramp. The same figure shows that initial reactions are high and need to be damped, but from 700 s what you see is a variation of 40000 kN reaction, which corresponds only to the variation of buoyancy.

Figure 15. Wave amplitudes and vertical reactions (wave direction 180°)

The graphs show the forces generated by a model element; they may be the beam of the jacket or the winch, and there is no need to present the other side, due to system symmetry.

The graph of Fig. 17 and 18 shows the horizontal contact reaction that is desired and values that this force affects one of the beams (it is assumed here that these reactions are the same in both the transverse beams by friction being equal).

Figure 16. Vertical contact forces

Figure 17. Horizontal reactions

Figure 18. Horizontal contact forces

Considering that impacts are absorbed by dampers will be considered again only the forces generated from the instant 700 s.

The tension force applied to the winches to pull the barge throughout the procedure is displayed by the graphic in Fig. 19. The same problem explained in the previous graphs is seen here, so will be considered in Fig. 20 only the reactions from the moment 700 s when impact forces are fairly small.

Figure 19. Traction force on cables (winches)

Figure 20 reports the forces applied by the winch from the time \(t = 700\ s\). Looking at this graph, it is noted that the pulling system should have approximately a total load capacity of 4000 t, which implies to have two winches 50 t and hoists 5 pulleys, which will pull at a speed approximately 3 cm/s. The operation to pull 130 m thus it would take about one hour. The analysis of 900 s (15 min) implies a greater pulling speed.

The following graphs represent the displacements of CoG barge along the way covered during the proposed time for the operation (see CoG position in Fig. 21). The both horizontal and vertical displacement vessel, from the moment it touches the ramp \((t = 400\ s)\) to its peak \((t = 900\ s)\) are provided in Fig. 22 (lateral direction), 23 (longitudinal direction) and 24 (vertical).
Looking at the graphics of displacements it is noteworthy that at the point $t = 900$ s the barge affects the "docking point" and stop completely, demonstrating the accuracy and effectiveness of the proposed solution.

The center of the barge, which has a molded depth of 8.5 m, is positioned at $z = -0.52$ m, and therefore has an initial draft of 4.77 m (4.25 + 0.52) which decreases as the vessel rises to ramp up "beaching" with a draft of 3.77 m (4.77 - 0.52 to 0.48). Figure 25 shows the vertical displacement (Z) of the barge from the moment it meets the ramp jacket.

It is emphasized in the graphics in the Y and Z direction that they describe the gradual elimination of barge movements as it ascends the sloping beam jacket up to the "docking point", meeting virtually complete rest.
The results of motion analysis of installation proposed in this paper were satisfactory and therefore "attractive", given the enticing advantages of float-over method.

5 CONCLUSIONS

The purpose of this paper was to show, through a new proposal that the "float-over" installation method can be applied in the most adverse sea conditions than those currently applied, included here, mainly the Campos Basin, which has a swell crossed very damaging to the installation procedures available today.

From the new proposal, a configuration was developed for float-over installation that followed the confirmatory analyses. These analyses were performed through the previously mentioned programs, based on the recommendations of standards such as RP 2A-WSD (API, 2000), Guidelines for Marine Transportations (GL Noble Denton, 2015a) and Guidelines for Float-Over Installations (GL Noble Denton, 2015b).

The analyses showed satisfactory results for the purpose it was intended, but it should be noted that a more comprehensive study of the fenders system is required for the practical application of this method. Further, a structural analysis of the barge and jacket must be made in order to contemplate the possible reinforcements structural analysis indicate, however, it is known that these studies have extremely low value compared to the costs of the traditional method of installation.

The motion analysis presented vertical and horizontal displacements that practically were suppressed as the barge went up to beam jacket and came to deck installation point.

Based on the presented results, it can say that the new proposal exposed in this work for float-over installation is possible to sea conditions considered.

REFERENCES


