INSTALLATION PROCEDURE OF THE PROTOTYPE BUOY IN CONGRO FIELD IN CAMPOS BASIN

Ricardo Franciss, franciss@petrobras.com.br
Jairo Bastos de Araujo, jairoba@petrobras.com.br
José Carlos Lima de Almeida, jcalmeida@petrobras.com.br
Marcos de Oliveira Rangel, morangel@petrobras.com.br
Petrobras – Av. Horácio de Macedo, 950 - Rio de Janeiro
Antonio Carlos Fernandes, acfernandes@peno.coppe.ufrj.br
Universidade Federal do Rio de Janeiro, Cidade Universitária, Rio de janeiro
Same format for other authors, if any
Abstract. *The steel catenary riser usually has high dynamic movements, due to the first order movements of the Floating Production Storage Offloafing (FPSO). These movements induce high fatigue damage close to the Touch Down Point (TDP). In ultra-deep waters, this phenomenon is more critical.*
To make this type of riser feasible, one possible option is to use flotation elements in any point of the riser. Part of the line, rigid, comes from the seabed to a buoy and then, to the platform, lines should be flexible. The use of rigid lines is due to the lower costs and the flexible lines to absorb the movements of the production vessel.
This paper describes the installation procedure of a prototype buoy, 1/3 of the size of the buoy designed for P-52 platform in Roncador Field. Petrobras manufactured this buoy in Rio de Janeiro, Brazil, and at the end of 2009, this technology will be tested in Congro Field, in Campos Basi, in 500 m water depth. The numerical analysis were done using Orcaflex program and some changes of the equipment were necessary to facilitate the installation.

Keywords*: Rigid Riser, Subsurface buoy, Installation Procedure*

1. INTRODUCTION

The Steel Catenary Riser (SCR) usually has high dynamic movements, due to the first order movements of the Floating Production Storage Offloading (FPSO). These movements induce high fatigue damage close to the Touch Down Point (TDP). In ultra-deep waters, this phenomenon is more critical. Particularly in Campos Basin, the fatigue damage is so high that it is not technically feasible to hang a SCR on a FPSO.

To make this type of riser feasible, one possible option is to use a subsurface buoy as an intermediate element. The subsurface buoy supports the weight of all rigid risers while flexible jumpers connect the buoy to the FPSO. The use of rigid lines is due to the lower costs compared to flexible lines, and the jumpers absorb the movements of the production vessel.

This concept will be tested following the installation procedures developed by Petrobras. Then, a reduced model test was performed to test its feasibility and some adjustments were made to minimize loads on the intermediate buoys, used to facilitate the installation of the Subsurface Riser Buoy (SRB). The procedure chosen uses pre-installed tendons and posterior connection to the subsurface buoy when it reaches the operational depth.

This paper describes the installation procedure of the SRB, in scale 1:31.5 with respect to the buoy designed for this test. Petrobras manufactured this buoy in Rio de Janeiro, Brazil, and at the end of year 2009, this technology will be tested in Congro Field, in Campos Basin, in 500 m water depth. The numerical analysis were done using Orcaflex program and some changes in the equipment were necessary to facilitate the installation.

2. THE SUBSURFACE RISER BUOY (SRB)

The subsurface riser buoy is a system composed of a submersible buoy, anchored at the sea bottom by a certain number of tendons. The buoy is an intermediate floating element which connects the flexible lines, called jumpers, to the SCRs, which are in catenary shape toward the sea bottom. The Figure 1 shows the general schematic of this system.

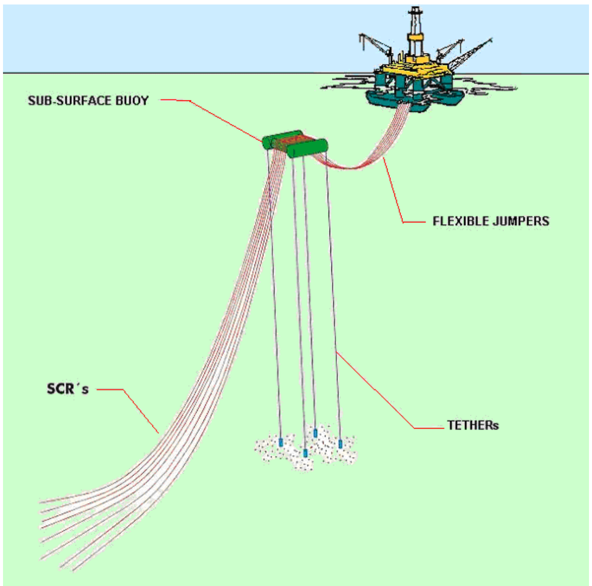

Figure 1 – General schematic of the system

This system was firstly developed in Deepstar JIP, coordinated by Texaco in 1996/1997. The buoy had an H shape, where the risers were installed in the central bracing of the structure. Petrobras performed several structural analyses and concluded that this solution was not feasible for deep water fields. Due to the fact that H shape using 4 SCR had interference with the tendons, a new shape was designed and the rectangular ring (model) was chosen to be the best solution, in 1998. During the period 2000/2001, a new buoy was designed for 12 SCR for Albacora Field. Finally, in 2002/2003, this concept was extended to 1800 m water depth, sustaining 19 risers.

The advantages of this option are:

- Uncouple the movements of the riser system, giving independence to choose the best production platform (FPSO or semi-submersible);
- Reduction of the top loads due to the risers in the platform stability design;
- It is possible to install almost 90 % of the total SCR independently of the arrival of the platform, anticipating the production;
- Reduction of the complexibility and the capacity of the pull-in and pull-out systems for the jumpers at the production vessel, reducing time and risk of these operations;
- Increase significantly the technical feasibility window of the SCR in free hanging configuration – fatigue analysis – because the jumpers will absorb the movements of the production vessel;
- Less constraints of the stiffness of the mooring system of the production vessel;
- Increase significantly the technical feasibility of the flexible risers eliminating the dynamic movements at the touch down point, if the option is to use only flexible lines with a buoy;
- The buoy can be manufactured in Brazil and anchored with the same installation spread mobilized and available in Campos Basin for all units;
- The system is composed by field proven technologies, i.e., buoy + SCR + jumpers separately;
- The jumpers can be installed or replaced using conventional vessels due to smaller loads.

2. DESCRIPTION OF THE SYSTEM

The SRB will get down up to 110 m water depth using ballast in most of the tanks and one dead weight. After the adjustment of the tendons and disconnection of the dead weight the SRB will move upward up to 97 m of water depth. The installation system will use lines in two parts, higher and lower lines, which will be connected to the auxiliary buoys, to avoid large horizontal displacements. These auxiliary buoys are initially at 34 m deep and after the descent of the SRB, they reach 56 m deep. The figure 2 shows the configuration of the system in the final phase of the descent of the SRB, at 100 m water depth. The tendons of the SRB (in red and black) and the auxiliary system (in blue) will be pre-installed in 500 m water depth. The torpedo piles for the SRB and the auxiliary buoys will be also pre-installed.

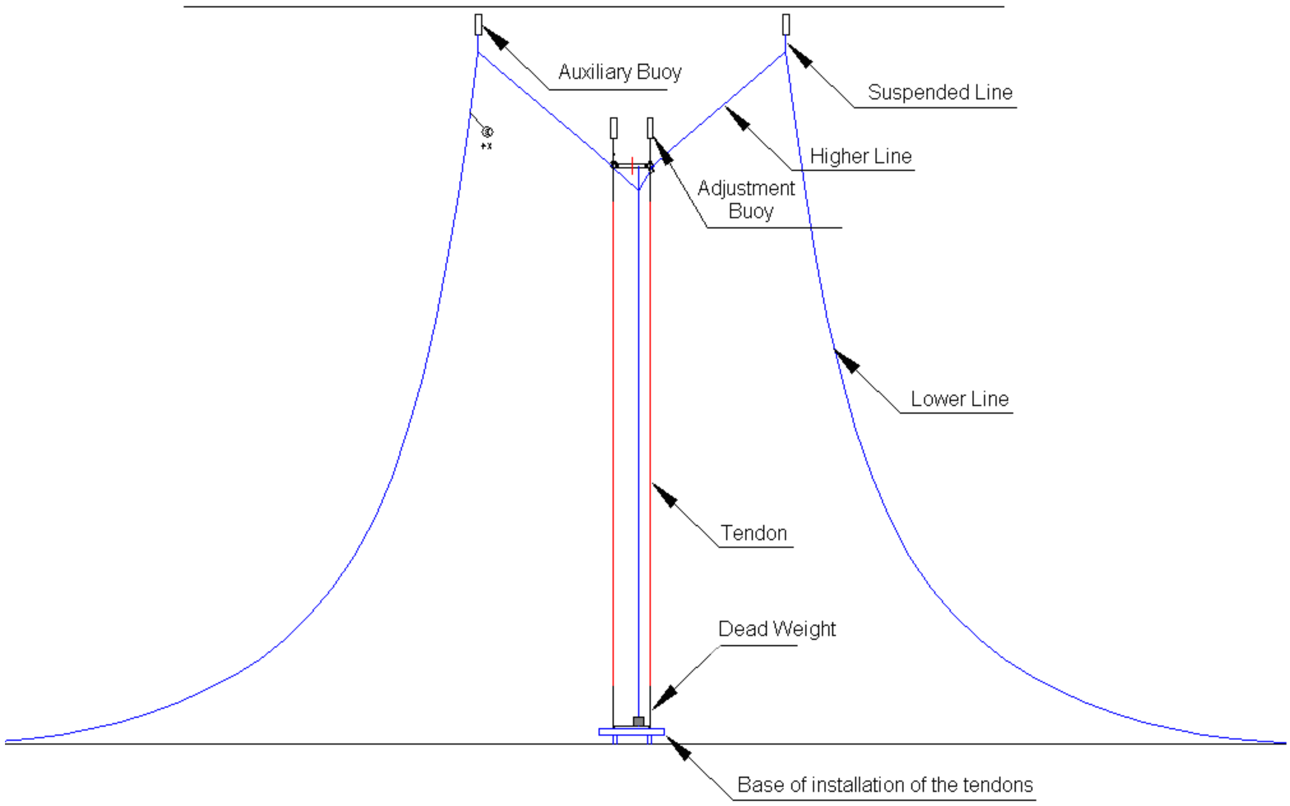

Figure 2 – Final arrangement of the descent of the SRB

The tendons are planned to be fixed at the chain-stoppers and the final position of the buoy to be reached by changing its buoyancy. At this moment the dead weight will be disconnected and the SRB gets up. At 97 m water depth the auxiliary system, composed by the auxiliary buoys and the higher and lower lines will be disconnected remaining only the SRB connected to the four tendons. Finally, the buoy will be depleted.

This procedure was developed to be installed in Congro Field. Reduced model tests were done to confirm the feasibility of this procedure.

3. THE MODEL TEST

The Ocean Basin called LabOceano at Federal University of Rio de Janeiro has been designed to carry out model tests of ocean structures in a tank with 40 m long, 30 m wide and 15 m depth with a central pitch of 5 m diameter and 10 m deep, giving a total depth of 25 m. There are glass windows at 4 m and 5 m deep where it is possible to see the tests and 3D wave generators with 75 wet-back hinged flaps give several height and directions depending on the considered sea state. Parabolic beaches made by wood absorb the waves generated for the tests.

The main goal of the tests was to verify the installation procedure of the SRB, measuring the tension of the tendons and trim and heel angles during the installation. Three alternatives were tested by changing the order of the installation of the tendons without application of wave and current and the worst case was repeated with wave and current. The simulation of the current force was done through application of equivalent horizontal loads in the SRB and it was done using lines, sheave and weights.

The considered wave was Hs = 2,0 m and Tp = 8 s. The value of the "equivalent current" was 1 m/s in the same direction of the waves. For this purpose a equivalent force of 230 kN was imposed in the SRB giving a displacement of 27,37 m towards stern.

The reduced model used was 0,863 m long, 8,35 kg weight and 19,30 dm^3 in volume, giving a net buoyancy of 4,70 kg when all ballast tanks were full of water. The scale used in these tests was 1:31.5 and the model is shown in Figure 3.

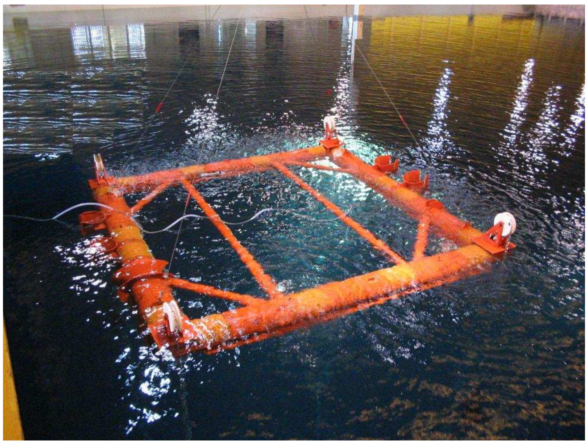

Figure 3 – The SRB model

The instrumentation used in the tests was:

- Wave-probe, to measure the wave amplitudes;
- 04 tension cells for the superior and inferior lines;
- 04 tension cells for the tendons;
- 02 inclinometers to measure the trim and heel angles during the installation of the SRB;

The auxiliary buoys have in real scale 27 t buoyancy (863 g in scale) and the positions of them – also in scale - are shown in Figure 4.

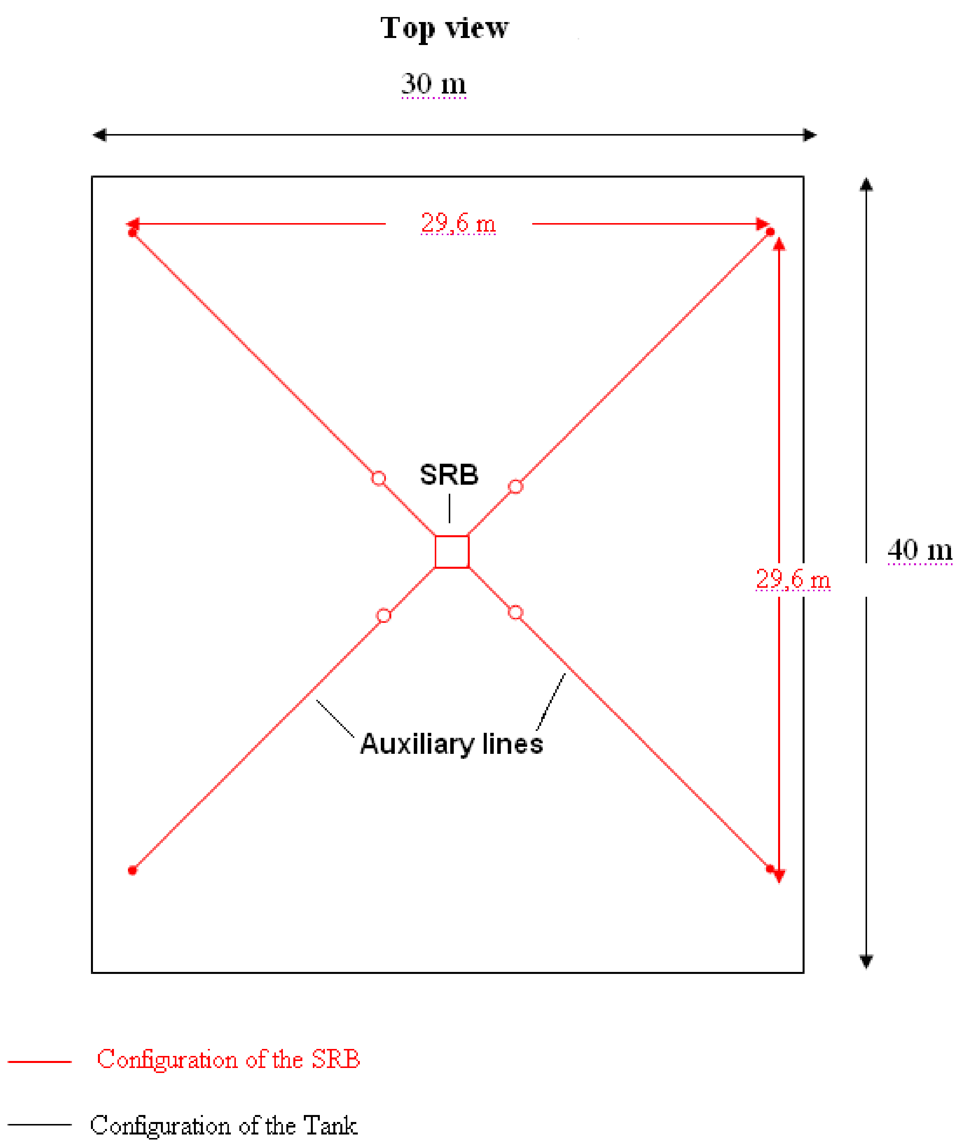

Figure 4 – Initial arrangement in Conof the tests

4. RESULTS

The dead weight tensioned the only cable that was fixed at the SRB. This fixture was responsible for bending the SRB and the buoy had a great offset, as shown in Figure 5. Furthermore, the dead weight did not reach the correct point at the sea bottom creating a trim and heel angles greater than the limits of the design premises. Therefore a new procedure was developed considering four dead weights independently and the tendons will be installed after the SRB reaches 110 m water depth.

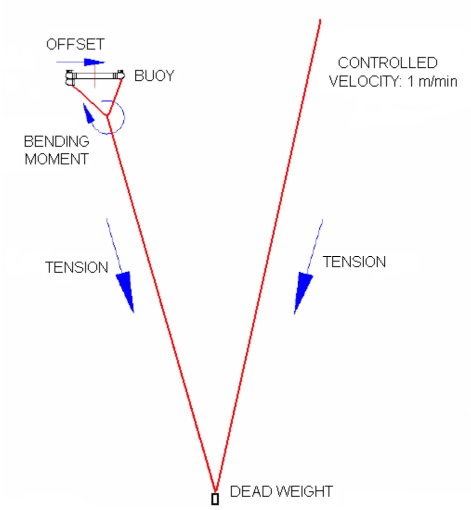

Figure 5 – Bending moment due to the descent of the dead weight

The results of the variation of the trim and heel angles of the buoy are the most important in this test. The tests of the setting down of the SRB with four auxiliary buoys without waves and current showed an angle variation of 4º maximum, as shown in Figure 6. The setting down began after 85 seconds of the beginning of the measurements.

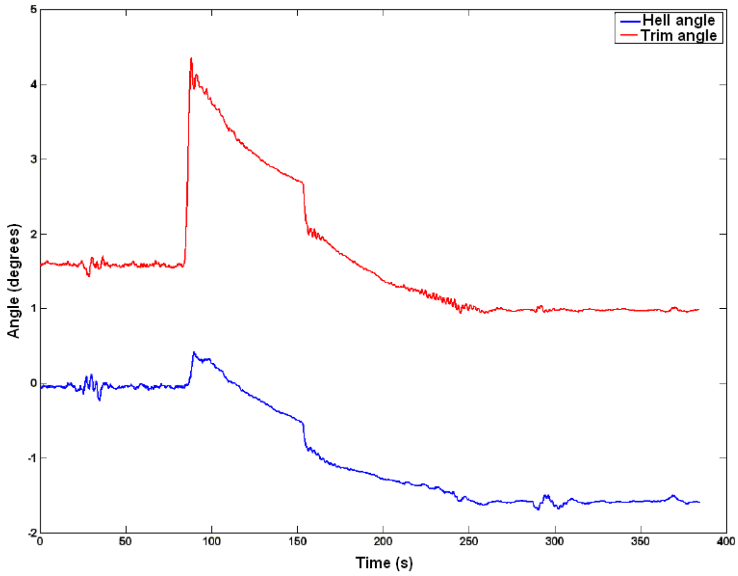

Figure 6 – Angular variation of the SRB during the set down without wave and current

The results of the setting down of the SRB with the same number of auxiliary buoys with wave and equivalent current had a more regular behavior, without great variations of the angles, as shown in Figure 7. In this test the setting down began in 130 s after the beginning of the measurements.

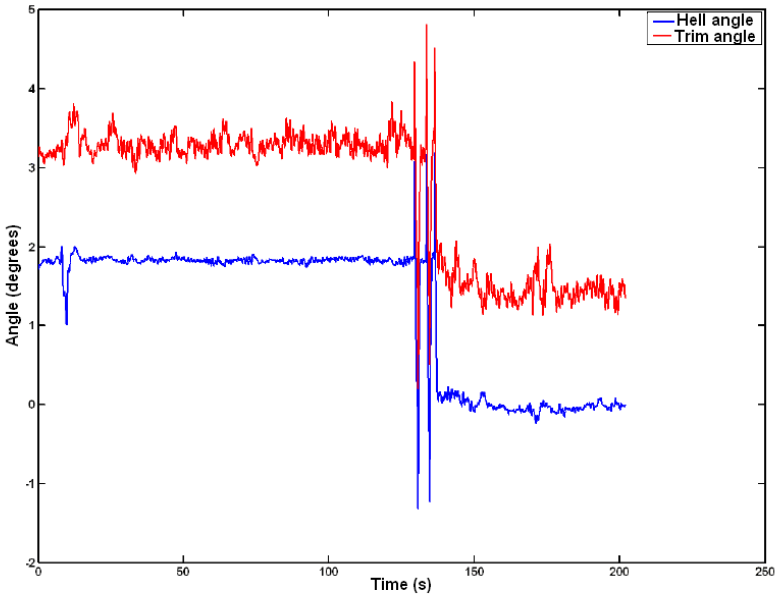

Figure 7 – Angular variation of the SRB during the set down with wave and current

The variation of the trim and heel angles of the SRB in this case showed that these angles were stable because the wave direction helps the buoy in keeping the horizontal position and in the final process, the variation of the trim and heel angles are minimum, because the SRB is not symmetric.

According to the measurements, the disconnection of the dead weights gives acceleration in the SRB and therefore, a variation of the tension in the tendons. Beyond this fact the tension of the cable of the dead weight was too high.

5. CONCLUSIONS

The set down of the SRB had a variation of the trim and heel angles below 2º at the final position. Angles grater then 2º turn this installation not feasible. To reduce the angles of the buoy, 4 ships can be used. After the buoy was in its final position, the tendons can be installed beginning at the stern of the buoy.

An equivalent current used in the tests helps the SRB to reduce the trim and heel angles, helping the SRB in the installation. The value chosen for the tests was the maximum velocity that can be occur at 100 m water depth.

The installation of the buoy using only one dead weight showed that a bending moment was generated and the tension was too high. The procedure was reviewed now considering 4 dead weights one in each corner of the buoy. Beyond this fact, it is more easy transport and handle smaller dead weights instead of a great one.

After the SRB was in its final position the tendons could be installed in the chain-stopper in any order because the trim and heel angles remained at the same value after the first tendon be installed.

6. REFERENCES

LabOceano, "Ensaios para Avaliação do Método de Instalação da BSR", Relatório Técnico. Abril/2008.

Petrobras/Cenpes, "Especificação Técnica dos Ensaios em Escala Reduzida da Instalação da Bóia de Sustentação de Risers (BSR)", Fev/2008.

MCS, “Sub-Surface Buoy Installation Analysis”, Study Report, Fev/2009.