



Girassol buoy under tension

In early 2004, the Girassol offloading buoy, installed offshore Angola, was equipped with a new mooring arrangement. TOTAL E&P Angola awarded the contract for the Tension Measurement System (TMS) to MARIN T&M. Here is a brief outline of the work involved.

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The Girassol offloading buoy is located in the Girassol Field Block 17, off the Angolan Coast, in 1,350 m-deep water. Weighing 715 tonnes, the buoy measures 19 m in diameter and is 10 m high.

Located one nautical mile from the Girassol FPSO, the buoy is anchored with nine composite lines made of polyester and steel chain, connected to suction piles. These anchoring lines are gathered in three clusters of three lines each. Early last year the buoy was equipped with Rod Connecting Arms (RCA) which were used for connecting the new anchoring legs to the loading buoy. To make sure the correct pre-tension was achieved during the installation and to check the tension periodically afterwards, TOTAL E&P Angola requested MARIN to design, engineer, assemble, commission and start-up a TMS to measure the tension in all nine RCAs.

Instrumentation

In order to determine the roll and pitch bending moment and the axial load in the RCA, four

amplified waterproofed weldable strain gauges were installed - two on both sides of the rod. In total, 36 encapsulated strain gauges were installed. These strain gauges were chosen because of their robustness, accuracy and because of the perfect location the mooring arrangement presented to install the strain gauges. Of two strain gauges, one reinforced cable runs upwards to the TMS junction box located in the central well of the buoy. A sub sea connector installed near two strain gauges enabled the connection of the cables after the installation of the RCAs. Polyester ropes and magnets were installed at the bottom of the buoy and along the central well upwards to guide the signal cables by providing sufficient attachment points. To ensure a waterproof encapsulation and reliable protection, a dedicated epoxy cover was purposely designed and installed over the strain gauge and filled with resin. The TMS also has a portable battery pack to feed the system and a laptop computer



with dedicated measurement software, allowing the crew to conduct measurements when needed.

Calibration

In December 2003, the strain gauges were installed on the RCAs in Saint Etienne in France. They were subjected to a calibration procedure in order to increase the accuracy of the TMS by removing uncertainties from strain gauge fabrication, installation, structure shape and material properties. Therefore, a calibration frame was designed and setup in the workshop allowing a calibration load equal to the designed pre-tension load.

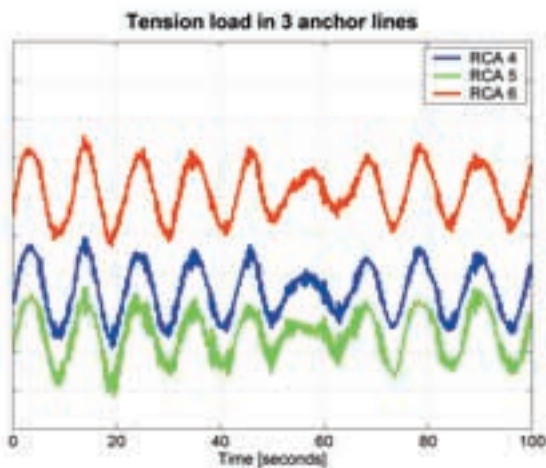
During the installation of the RCAs offshore Angola, in March and April 2004, a MARIN Instrumentation Engineer supervised the TMS inside the central well, determined the calibration offset values, commissioned the TMS and trained the crew onboard the FPSO.

Data analyses

After successful commissioning on April 23, 2004, MARIN was contracted by TOTAL E&P Angola to evaluate, analyse and report on the TMS data obtained from the commissioning and onwards. The adjacent figure shows time traces of the axial loads in one cluster of lines.

The results are also being used, in combination with the recorded wave and wind conditions, to validate computational hydrodynamic models.

Reference was made to the presentation entitled 'Operational experience with the Girassol CALM Buoy' by Alajouanine, R. and l'Hostis, D. at the 14th FPSO Research Forum, held in Paris on October 27, 2004 (www.fpssoforum.com). [MARIN](#)



TMS results.