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## Deepwater Oil Export Systems: Past, Present, and Future

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### Abstract

To date, nine deepwater export systems have been installed by Oil Companies, or are under construction. The first deepwater export system, on the GIRASSOL field (Angola), was installed in 2001. Since then, a further three systems are now in place, one on the BONGA field (Nigeria) and two on the KIZOMBA field (Angola). A further five are under design or construction (ERHA, DALIA, GREATER PLUTONIO, AGBAMI and AKPO).

All these export systems are based on the concept of a large surface buoy, shaped, in most cases, like a flat cylinder. These buoys are anchored to the sea bed by an array of semi-taut composite anchor lines and support several – generally two – mid-water export lines.

Although these systems show clear differences in anchor line arrangement and composition, and also in export line diameter and configuration, they indicate that the design of deep water export systems has reached maturity.

In its first part, the paper gives a general outline description of the nine export systems mentioned above. It explains what the key design drivers are and describes the design process, addressing successively the following issues:

- a. derivation of mooring force and definition of the anchoring system;
- b. buoyancy requirements and hydrostatic stability;
- c. coupled motion response in waves;
- d. fatigue in anchor lines and export lines.

In the second part, the paper highlights the major limitations of the present systems. It describes the various concepts recently developed in the Industry and discusses their relative merits and drawbacks.

In conclusion the paper will propose a way forward, facing the challenge of deeper water and harsher environments.

### Introduction

At the beginning of 2006, there were four deepwater export systems installed and operating offshore West Africa. The first one, on the GIRASSOL field, offshore Angola, was installed in 2001. The GIRASSOL export system was followed by two terminals on the KIZOMBA field, also offshore Angola (KIZOMBA A, installed in 2004 and KIZOMBA B, installed in 2005) and by one terminal on the BONGA field, offshore Nigeria, installed in 2004 and delivering oil to export tankers since December 2005.

These terminals are connected to large new built FPSO's, with production rates in excess of 200,000 bpd associated with storage capacity greater than 2 million barrels. All these FPSO's are spread moored.

The GIRASSOL terminal experienced severe problems after the successive failures of five of its anchor legs, due to a new fatigue phenomenon (see Ref. [1] and Ref. [2]). However, it was successfully repaired in May 2004 and has been operating normally since then. The three other terminals also operate to the satisfaction of their respective owners.

There are five other deepwater export systems, presently under design or construction ERHA, AGBAMI and AKPO offshore Nigeria; DALIA and GREATER PLUTONIO, offshore Angola.

Eight of the nine systems are or will be designed and supplied by SBM and one (DALIA) by APL.

ERHA is hooked up to its anchor legs, but not yet connected to the export lines.

Seen from some distance and from the surface, these deepwater systems, most of them at least, look very similar to the popular shallow water CALM buoys. One may recognize the familiar flat cylindrical buoy body, topped by a rotating turntable, to which the mooring hawsers and the floating hoses are connected. The buoy body diameter just appears a bit larger than usual (see Figure 1).