

STEVMANA VLA INSTALLATION, A CASE HISTORY.

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INTRODUCTION.

Catenary mooring systems using drag embedment anchors have successfully been used for the anchoring of mobile offshore drilling units (MODUs) in water depths of up to 1800 m. The use of catenary mooring systems in deep and ultra deep water requires long and heavy mooring lines or synthetic fibre rope inserts. The tendency for deep water MODU systems is to go from the self deployed catenary mooring systems to pre-laid taut-leg mooring systems (Fig. 1).

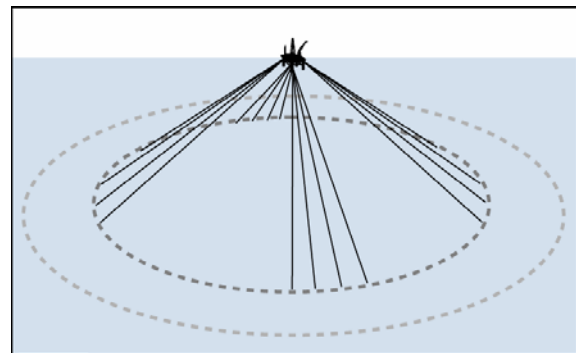


Fig. 1 - taut leg mooring system

The use of the taut-leg mooring systems allows for a considerable reduction in the required length and weight of the mooring lines and reduces the footprint of the mooring system. For use in these taut-leg mooring systems the Stevmanta Vertical Loaded Anchors (VLA) is the ideal anchor, being able to withstand the large horizontal and vertical loads that are applied to the mooring system. This paper will discuss the development of the Stevmanta VLA and focus and the lessons learnt from a recent Stevmanta VLA installation.

STEVMANA DEVELOPMENT.

To meet industry demands for an anchor suitable for taut leg mooring systems, an extensive testing program has been completed which has led to a new type of anchor, the Stevmanta VLA (Fig. 2), where a traditionally rigid shank has been replaced by a system of wires connected to a plate. The anchor is designed to accept vertical (or normal) loads and is installed as a conventional drag embedment anchor with a horizontal load at the mudline to obtain the deepest penetration possible. By changing the point of pulling at the anchor, vertical (or normal) loading of the fluke is obtained thus mobilising the maximum possible soil resistance.

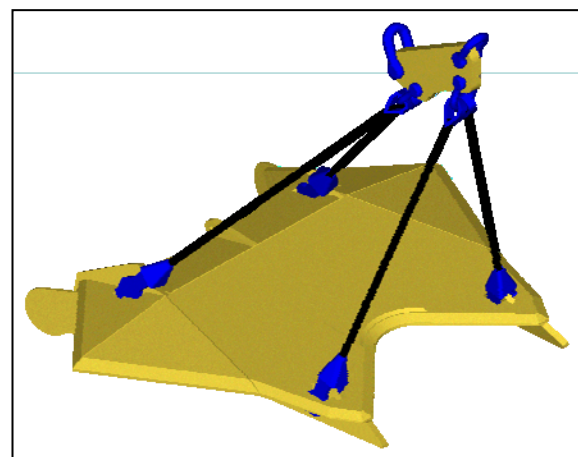
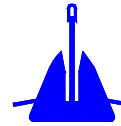


Fig. 2 - Stevmanta VLA

As the Stevmanta VLA is deeply embedded and always loaded in a direction normal to the fluke, the load can be applied in any direction, i.e. between 0° and 90°. Generally the anchor is used for taut-leg mooring systems, where the load angle varies from 25°



to 45°. The angle adjuster changes the mode of the anchor from pull-in mode to vertical (or normal) mode.

Currently six sets of Stevmanta VLAs have been supplied to Brazil, for use on 3 semi-submersible production units and 3 FPSOs. The water depths for these units varies between 500 m and 1500 m. For use on MODUs, Stevmanta's have been tested offshore Norway, Indonesia and in the Gulf of Mexico.

STEVMANA VLA INSTALLATION.

The permanent mooring systems in which Stevmanta VLAs have been applied, have consisted of chain – polyester - chain mooring lines with a wire rope forerunner connecting the bottom chain to the anchor. Generally the Stevmanta VLAs have been installed using the single line installation method with the polyester rope as part of the installation (mooring) line.

This procedure requires only one AHV for deployment of the Stevmanta VLA. The Stevmanta VLA is deployed with the shearpin angle adjuster. The mode of the anchor changes when the shearpin breaks at a load equal to the required installation load. When the shearpin breaks, the Stevmanta VLA changes from the installation mode (figure 3a) to the normal (vertical) loading mode (figure 3b). A drogue tail is connected to the rear of the Stevmanta VLA. The tail assures correct orientation of the Stevmanta VLA on the seabed.

A general outline of the one line installation procedure is presented below.

- Connect the installation / mooring line to the angle adjuster of the Stevmanta VLA on the AHV.
- Lower the Stevmanta VLA overboard. The Stevmanta VLA will be going downwards tail first, i.e. the tail will be the first part that reaches the seabed (figure 3c).
- When the Stevmanta VLA is on the seabed, a ROV can optionally inspect the anchor (position and orientation). The AHV starts paying out the installation / mooring line while slowly sailing away from the Stevmanta VLA.
- When enough of the installation / mooring line has been paid out, the AHV starts increasing the tension in the installation line. The Stevmanta VLA will start to embed into the seabed (figure 3d).
- When the predetermined installation load has been reached using the AHV's bollard pull, the shearpin in the angle adjuster fails, triggering the Stevmanta VLA into the normal (vertical) loading mode. This can be clearly noticed onboard the AHV, as the AHV will stop moving forward due to the sudden increase in holding capacity.
- As the Stevmanta VLA is now in the normal (vertical) loading mode, the AHV can now continue to increase the tension in the (taut-leg) installation / mooring line up to the required proof tension load (figure 3e).
- After the Stevmanta VLA has been proof tensioned to the required load, the installation / mooring line can be buoyed off or attached to the floater.

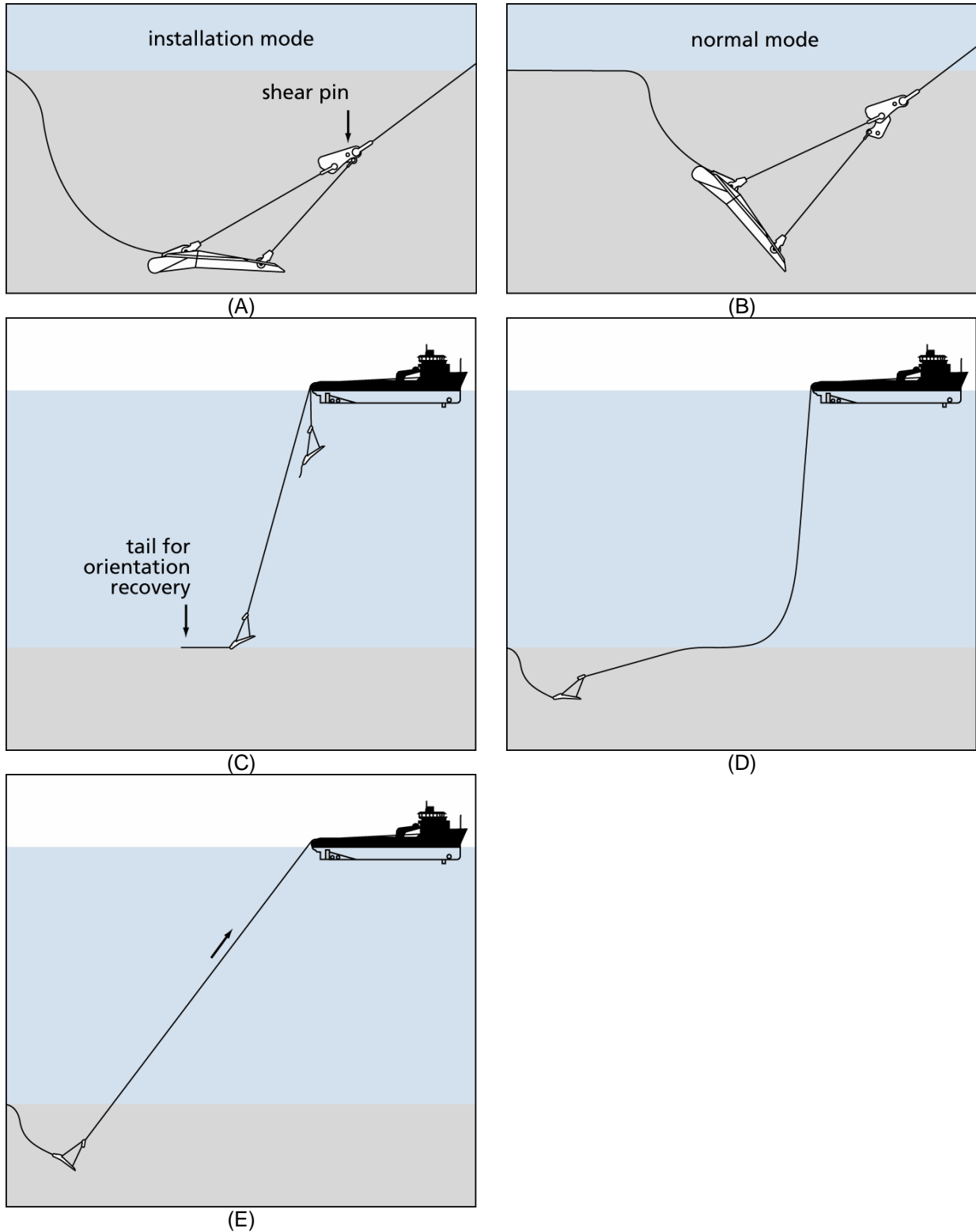
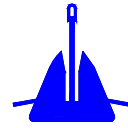
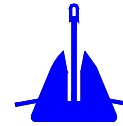


Fig. 3 – single line installation procedure



PROJECT DESCRIPTION.

FPSO Fluminense is located in the Bijupira and Salema fields, offshore Brazil. The water depth at the intended mooring location is approximately 700 m. Soil conditions are normally consolidated clays, typical for the Campos Basin.

During the design stage various mooring line configurations have been evaluated, chain or wire rope forerunners on the anchor. The final configuration selected consisted of spiral strand forerunners on the anchor. In combination with the required ultimate pull-out capacity of the anchors of 759 ton, this resulted in 11 m² Stevmanta VLAs being selected for the anchoring of the FPSO.

In previous projects, the Stevmanta anchors had been installed with the polyester mooring lines connected to the anchor. For this project the polyester mooring lines would be connected to the anchor after installation using a subsea connector (figure 4). The subsea connector was connected to a seabed frame at the end of the spiral strand forerunner.

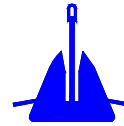


Fig. 4 – deployment of subsea connector and seabed frame

Use of a subsea connector for the

installation of the Stevmanta VLAs has a number of advantages, being:

- Use of a dedicated installation line.
When polyester is included a relatively long installation line is required due to the low submerged weight of the polyester. With a dedicated installation line, chain and wire rope can be used which reduces the scope required.
- Less chance of the polyester being damaged during the installation. As the polyester rope is not loaded during anchor installation, there is less chance of damage due to high loads on the anchor.
- Reduction in the time that the mooring lines need to be buoyed off. When buoys are used to keep the polyester off the seabed, there is always a chance that a buoy comes lose and the polyester is dropped on the seabed. With the subsea connector, the polyester can be attached to the anchor just before the floater arrives at the location, thus significantly reducing the risk.
- Easy replacement of the polyester mooring lines. If one of the mooring lines needs to be replaced in the future, this can be easily disconnected using the subsea connector and thus not requiring the anchor to be removed from the seabed.



ANCHOR INSTALLATION.

The Stevmanta anchors for FPSO Fluminense were installed in May 2003. For the installation of the anchors the single line installation procedure was used with some modifications, resulting in the following procedure.

- Two AHVs lower the Stevmanta anchor to the seabed. One AHV (Maersk Assister – figure 5) is connected to the forerunner / subsea connector and the other AHV (Havila Surf – figure 6) is connected to the anchor recovery system (on the rear of the fluke).
- Once the anchor is placed on the seabed, the Havila Surf is disconnected from the anchor.
- Maersk Assister embeds the anchor to the required installation load (225 ton at the anchor) and applied the proof tension load.
- The installation line is disconnected from the anchor forerunner using the subsea connector.

Using the above mentioned deployment method, the anchor could be accurately placed on the seabed and the fluke partly embedded directly into the seabed with the fluke at a 45 degree angle to the horizontal. With fluke already at a penetration angle, the anchor embedded immediately when tension was applied to the installation line. This resulted in relatively short drag lengths, typically the measured drag length of the anchor was equal to 1.0 to 1.5 times the penetration depth of the anchor (between 22 m and 32 m below seabed).

Using the subsea connectors the installation of the anchors (figure 7) was successful with 2 to 3 anchors being installed per day. Of the 9 anchors, 6 were installed with an all steel installation line and 3 with the polyester mooring line connected to allow quick connection of the FPSO.



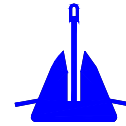
Fig. 5 – AHV Maersk Assister



Fig. 6 – AHV Havila Surf



Fig. 7 – anchor deployment of the stern roller



CONCLUSION.

For FPSO Fluminense offshore Brazil, 11 m² Stevmanta VLAs have successfully been installed using subsea connectors in a chain – polyester mooring system. The use of the subsea connectors allowed the anchors and polyester to be installed separately of each other with the result that the installation can be optimised. In addition the polyester mooring lines can be replaced without requiring the anchor to be recovered from the seabed. With the installation method, anchor drag lengths in the order of 1 to 1.5 times the penetration depth have been recorded.



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