Mooring Line Monitoring to Reduce Risk of Line Failure

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ABSTRACT
The past decade has seen 21 mooring incidents reported on Floating Production Systems (FPS), with 8 classed as system failures. This paper highlights the requirement for monitoring of mooring lines and provides a case study of a non intrusive, retrofittable, anchor leg load monitoring system (ALLMS) installed on an FPSO off the coast of China. The paper describes the technical challenges with designing, installing and commissioning such a system and also details how the line tension is derived. This type of mooring line monitoring system has applications in both turret and spread moored FPSO's as well as other types of moored vessels, whether located in shallow or deep water.

The proposed system uses inclinometers to measure the mooring system condition and inform on the effective loading of each anchor leg, and rapidly alert the FPSO operator in case of line failure and over-tension situations. Additionally, the system determines average mooring line tension to deduce the fatigue life of the mooring lines. The statistical data is transmitted acoustically to the control room on a daily basis. The proposed monitoring system answers the operators’ need for more accuracy and more reliability in the data obtained, as well as little and easy maintainability of the monitoring equipment. It provides a clear understanding of the state of each mooring line as well as tools to accurately evaluate what it takes to restore the mooring to its original stiffness.

KEY WORDS: Mooring; monitoring; integrity; reliability; FPSO; fatigue; failure; tension;

INTRODUCTION

The number of FPSs in operation has continued to rise over recent years, reaching around 400 installed facilities in 2013. With Exploration and Production (E&P) activities continuing to move into more isolated locations this number is expected to grow by a further 50% over the next 5 years.

Floating installations are subject to a variety of extreme weather conditions. In Southeast Asia this includes the regular typhoon season between May and October. Storms, cyclones and other severe environmental conditions offshore can lead to deterioration of mooring lines over time and increase the likelihood of failures. Five mooring incidents were reported in the Asia Pacific region between 2006 and early 2014. The details of these incidents are found in Figure 1 and summarized below:

- Liuhua FPSO: Seven legs parted from FPSO mooring turret;
- FPSO Kikeh: One line parted in shackle on anchor;
- Nan Hai Fa Xian FPSO: Four lines parted in bottom end of upper wire segments;
- Hai Yang Shi You 113: Collapse of yoke tower;
- Rubicon Vantage FPSO: Mooring failure still being investigated

Mooring systems on FPSOs are category 1 safety critical systems (Noble Denton Europe Limited, 2006) and there are a number of potentially severe human, environmental and economic consequences of a mooring system failure. These include:

- Vessel drift;
- Riser rupture or damage;
- Production shutdown;
- Hydrocarbon release;
- Repairing of damaged lines.

It is estimated that the financial cost of a single mooring failure could be anywhere between $3 million and $17 million depending on size of facility and location (Noble Denton Europe Limited, 2006). However, the cost of a system failure could be many times this. For example, the Gryphon Alpha has only recently resumed production in the North Sea 27 months after breaking free from some of its mooring chains and causing significant damage to subsea infrastructures (Rigzone, 2013). The cost of this is expected to reach an estimated $1.8 billion (Maslin, 2013), reinforcing the importance of understanding the integrity of the mooring system.

In recent years greater attention has been placed on mooring line integrity management systems as a means to maintain system condition and operational integrity, particularly since FPUs are increasingly expected to remain on location for longer periods.