Dynamic Response of Semisubmersibles with Damaged Mooring Lines

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ABSTRACT

For the final design of moored floating structures, the design regulations require a complete assessment of the damaged mooring conditions. In this study, a twin hulled six column semi-submersible has been modeled using Froude’s law of similitude with a scale of 1:100. In order to investigate the effects of single line failure of the restraining system on the motion and the intact line responses, four sea-keeping tests have been conducted in head and beam random seas. Results indicate that the platform migrates to new mean position with a remarkable transient response directly following the line failure.

KEYWORDS: Mooring line loss; Physical modelling; Damage conditions; Dynamic response; Semi-submersible model; Wave basin testing.

INTRODUCTION

About 40% of the floating structures available worldwide up to 2005 are semisubmersibles serving primarily as drilling and production systems (S. K. Chakrabarti, 2005). Semisubmersibles are multi-legged floating structures with large deck. These legs are interconnected at the bottom with horizontal buoyant members called pontoons or underwater hulls. Some of the earlier semisubmersibles resemble the ship form with twin pontoons having a bow and a stern. This configuration was considered desirable for relocating the unit from one location to another either under its own power or towed by tugs. Early semisubmersibles also included significant diagonal cross bracing to resist the prying and racking loads induced by waves (M. Patel and J. Witz, 1991). Fig. 1 shows typical conventional semisubmersible. The station-keeping system for semisubmersible platforms can be achieved by spread mooring or dynamic positioning system. The spread mooring consists of multiple legs connected to the platform by fairleads and to seabed by the anchors. They are normally arranged in symmetrical pattern. On the other hand, the dynamic positioning system consists of a position reference system, usually acoustic, coupled with computer-controlled thrusters around the platform to compensate current, wave and wind forces in a dynamic controlled mode to keep the platform on predetermined location and heading at sea. The dynamic positioning can be used as the sole source of station keeping or for assisting catenary mooring. Although dynamic positioning system offers greater mobility, conventional mooring has the advantage of being able to retain station-keeping ability in extreme weather conditions and requires substantially less capital and running cost. Therefore, conventional mooring continues to be adopted as an effective station-keeping means for the majority of floating structures and provides a more reliable deepwater mooring solution. Mooring lines for deepwater operations may be made up of chain, wire rope, synthetic rope, or a combination of them. There are many possible combinations of line type, size, location and size of the clump weight or buoys that can be used to achieve the given mooring performance requirements. Chain and wire are the most popular mooring line materials currently in use. Of the two, chain is more popular with about 85% of all semisubmersibles using it for station keeping due to its durability and contribution to the anchor holding capacity. The wire is much lighter and provides a greater restoring force than chain and requires lower pretension. This becomes increasingly important as the water depth increases. The wire rope needs careful maintenance due to long term abrasion where it is in contact with seabed (J. Herbich, 1999).

Fig. 1 Typical semisubmersible offshore platform
(Source: Indomigas Oil and Gas-Indonesia, 2009)

A number of researchers have attempted to investigate the hydrodynamic characteristics of semisubmersibles under damaged mooring conditions. An experimental work aimed to determine the motion response characteristics and operating limits of semisubmersibles in abnormal heel and trim angles was studied by B. Stone (B. Stone, 1986). A model in 1:100 scale of a moored semisubmersible with four columns and twin pontoons was...