

Mooring Stiffness Impact on the Survivability of MODUs

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ABSTRACT

During 2004-2005, three consecutive category-5 hurricanes (Ivan, Katrina, and Rita) hit the central region of Gulf of Mexico (GOM) and damaged numerous drilling and production platforms including Noble Jim Thomson (NJT) drilling semi-submersible. In the present study, the progressive failure of the mooring system of a Mobil Offshore Drilling Unit (MODU) similar to NJT during the hind-cast non-collinear hurricane Ivan wind-wave-current environment is numerically simulated. A time-domain vessel-mooring coupled dynamic analysis computer program is used to simulate the sequence of the progressive mooring-line failure of the original steel mooring system. The numerically simulated results are compared with the available NJT forensic-analysis data. An alternative polyester taut mooring system was also analyzed to determine if it could have survived the same extreme environment. The polyester system generally performed better and unexpectedly survived.

KEY WORDS: Hull-mooring coupled dynamic analysis, Progressive failure of lines, Forensic data, steel mooring, polyester mooring, Impact of mooring stiffness, survivability

INTRODUCTION

During 2004-2005, unprecedented three consecutive category-5 hurricanes (Ivan, Katrina, and Rita) equivalent to 1000-yr storm hit the central region of Gulf of Mexico (GOM) and damaged numerous drilling and production platforms there. Since then, a number of forensic studies have been conducted to better understand the cause of failure and develop reasonable strategy for future design. The Noble Jim Thompson (NJT) drilling semi-submersible platform was within the eye path of hurricane Ivan while location in Mississippi Canyon Block 383. The mean water depth of the region was 5800ft. The NJT semi-taut mooring system composed of steel wire-chain-wire with suction piles failed during the storm and the platform drifted about 30 miles southeast of its original location to Block 656. The forensic field analysis for the progressive failure of the NJT mooring system is well documented in Sharples (2006).

In the present study, the failure behavior of a generic MODU with a

hull and mooring system very similar to the NJT during a storm environment condition similar to that experienced by the NJT in Ivan is numerically simulated. A time-domain vessel-mooring coupled dynamic analysis computer program developed by Kim et al. (e.g. 1999, 2001) is used to simulate the sequential breakdown of lines in the Ivan environment that NJT experienced. The numerical tool has been extensively verified through comparisons against various experimental and field reports (Ward et al. 2004, Halkyard et al. 2004). The numerical prediction and simulated results for the failed system are compared with the available NJT forensic-analysis data.

Next, the original steel wire-chain-wire mooring system is replaced by a polyester mooring to investigate the performance of the alternative system in the same environment. The performance of the two different mooring designs is systematically compared to illustrate the possibility of more survivable mooring design without increasing cost much. The comparative study hopes to provide certain insight for mooring-stiffness impact on the survivability of MODUs. The non-collinear wind-wave-current Ivan environment conditions used for the present comparative study were hindcast by Oceanweather Inc. (OWI) (2004).

Compared to traditional steel mooring lines, the polyester line is lighter and can be designed to have greater minimum break loading (MBL) and when used as a taut mooring system can provide a smaller horizontal displacement (watch circle) that is beneficial to riser design and offers better chance of survivability in harsh environment. Its advantage becomes more noticeable as water depth further increases by allowing larger deck loads and smaller foot-print on the seabed, which is very crucial in deep- and ultra-deepwater development..

In the present numerical simulations with polyester lines, linear and constant axial stiffness EA is assumed for simplicity by neglecting the possible creep/hysteresis behavior (Lee et al., 2000). Since the maximum tension is of primary importance for the present study, the storm stiffness (EA) is employed instead of post-installation stiffness. A more sophisticated polyester-mooring analysis including nonlinear stress-strain relationship is given, for example, in Arcandra (2001). Through the present comparative study, it is seen that the traditional steel wire-chain-wire mooring system is more vulnerable to Ivan-like hurricane environment than the alternative polyester mooring system, which implies that stronger and more reliable mooring system can be designed by using polyester lines with the same hull load capacity.