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Model Testing and Complex Numerical Simulations for Offshore Installation

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ABSTRACT

This paper describes the analysis performed for the installation of two top-side modules on the Njord FPU by Saipem UK's dynamically positioned S7000 crane vessel. The purpose of the analysis was to determine the operational limits of the offshore installation. The complete analysis consisted of hydrodynamic scale model tests, time-domain computer simulations and observations made during the actual installation offshore. The model tests were carried out in MARIN's Offshore Basin. The computer simulations were carried out using the multi-body time-domain simulation tool LIFSIM. In the present paper special attention is paid to novel scale modeling techniques and recent developments in the numerical simulations.

KEY WORDS: Top-side module installation; semi-submersible crane vessel SSCV; floating production unit FPU; model tests; time-domain simulations; full scale measurements; modeling techniques.

NOMENCLATURE

ABS	Acrylonitrile Butadiene Styrene (a plastic)
B	Width, [m]
D	Column diameter, [m]
DEH	Dehydration module
DP	Dynamic Positioning
FDM	Fused Deposition Modeling
FPU	Floating Production Unit
GM_T	Transverse metacentric height, [m]
H	Height, [m]
L_{oa}	Vessel overall length, [m]
L_{pp}	Vessel length between perpendiculars, [m]
$L_{pontoon}$	Pontoon length, [m]
M	Mass, [tonnes]
PID	proportional-integral-derivative (controller)
QTF	Quadratic Transfer Function
SSCV	Semi-submersible crane vessel
T	Vessel draft, [m]
TEG	Regeneration Module
Δ	Vessel displacement mass, [tonnes]

INTRODUCTION

Summer 2007, two gas modules have been installed on the Njord FPU, on the Norwegian Continental Shelf, to enable gas exports from the Njord Field production facilities. The 100 and 200 tonnes modules were placed onto the FPU deck by Saipem's dynamically positioned S7000 SSCV. Detailed model tests and computer simulations were carried out by MARIN and Saipem UK. The purpose of this analysis was to optimize the lifting operation and to investigate the limiting environmental conditions in which the modules could still be installed safely. Experiences gained from the actual installation in the field proved to be valuable feedback for the performed analysis.

The model tests were carried out in MARIN's Offshore Basin. Various sea states and wave directions, relevant to the Njord field, were modeled. Detailed scale models of the S7000, the Njord FPU and both modules were constructed at a scale of 1:50. The S7000 was equipped with a DP system, including the controller, Kalman filters and azimuthing thrusters. The installation sequences were modeled in detail by using an automatic control of the crane. Measured signals included motions of the floaters and gas modules, loads in the hoisting arrangement and loads on the supports and guides. The FPU mooring loads and S7000 thruster performance were monitored as well.

Fig. 1 - Model Tests in MARIN's Offshore Basin