Installation of Subsea Equipment Protection Cover

Establishment of Operation Limits and Assessment of Operability and Weather Windows

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INTRODUCTION

Offshore lifting operations are one of the most common marine operations. In order to do a cost-effective installation waiting on weather should be minimised. Hence engine idling and pollution can also be reduced.

For a light lift operation the occurrence of slack in slings are critical and does usually determine the maximum sea state. The most critical phase is lowering through the splash zone and should therefore be simulated.

OBJECTIVES

- Describe a marine lifting operation in terms of the α-factor, operability and weather windows
- Determine maximum design sea state both manually and by simulations in SIMA
- Investigate the operability and waiting on weather

METHOD

MANUAL ESTIMATION

The design criteria can be found by use of DNV GL's Simplified Method [1], where F_{hyd} is dependent on inertia, drag, slamming and varying buoyancy. In order to prevent slack F_{hyd} should never exceed 90% of the object's submerged weight. The added mass and drag coefficients can be found theoretically in tables for a rectangular flat plate.

SIMULATION

The simulated design criteria is determined by the 10% quantile found by an inversed Gumbel CDF for converged parameters. This distribution is based on several extreme minima found in multiple wave series with random seed numbers. If the 10% quantile is greater than 10% of the object's submerged weight, the wave condition is operational.

OPERABILITY

An operation's operability is the probability that an operation of a certain length T_R can be carried out for given operational wave criteria Hs_{WF}. The actual duration of operation T_{op} is the predicted operation duration including *waiting on weather* (WOW). It is preferred to have T_{op} close to T_R.

CONCLUSION

The manually estimated design criterion was 1.64 m, which resulted in Hs_{WF} of 1.25 m. The simulated design criteria was Tp-dependent but was determined to be 2.5 m, which resulted in Hs_{WF} of 2 m. Mean T_{op}, hence WOW, decreased with 80% when Hs_{WF} increased from 1.25 m to 2 m.

By using simulations to determine the maximum operational sea state, waiting on weather will decrease and the operation efficiency will increase significantly.

FURTHER WORK

Before the operation can take place simulations for maximum tension should be performed in addition to equipment capacity checks. The slack criterion should be further investigated for cases where the snap forces do not exceed the material strength.

SIMULATION MODEL

The cover was made of Glass Reinforced Plastic (GRP) and had a mass of 11.9 t. The lifting system consisted of the vessel's crane tip, a crane winch, hook, hook wire, four slings, a spreader bar and the GRP cover, as shown in the figure to the right.

The cover was implemented as eleven slender elements in SIMA, were each slender element was given depth dependent added mass and drag. The implemented hydrodynamic parameters were estimated by CFD-analysis for amplitudes of 2.5 m. The cover was lifted with an angle of 68° to the horizontal. The initial location of the cover's lower end was 2.2 m above sea surface. With a winch speed of 0.2 m/s the cover was fully submerged after 76 s.

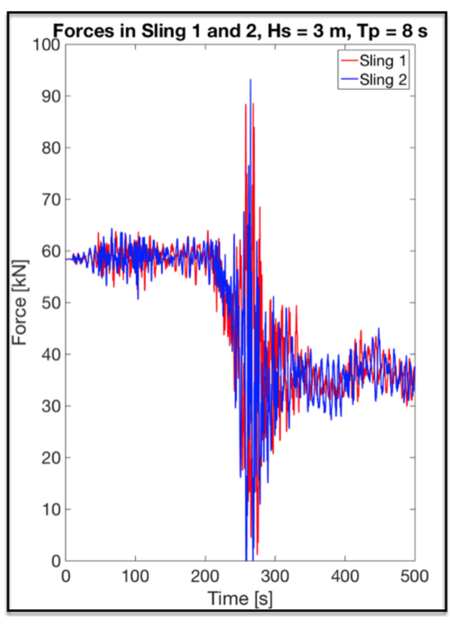
RESULTS

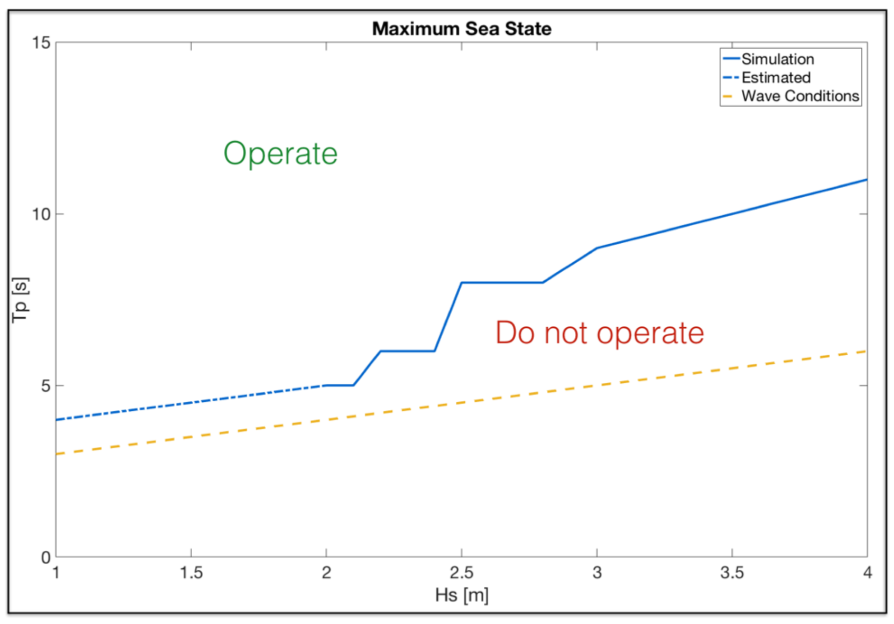
MANUALLY ESTIMATED DESIGN CRITERION

The total added mass was found by summing the vertical components of the longitudinal and vertical added mass, and was calculated to be 86.7 t. Slamming and varying buoyancy were omitted, thus F_{hyd} was proportional with relative velocity and linear scaling could be used to set the maximum sea state. The crane tip motion was found by the rigid body motion equation based on the relative coordinates between the crane tip and vessel COG [2]. The average manual estimated design criterion was **1.64 m** and constant for all Tp. Hence with an α-factor of 0.76 the operational criterion was **1.25 m**.

SIMULATED DESIGN CRITERIA

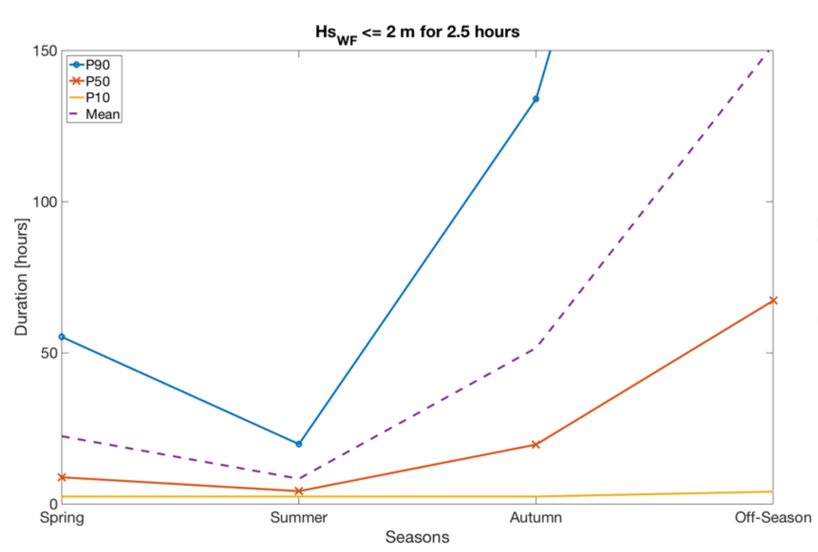
The simulated design criteria were found by investigating the tension in the lifting slings. If slack occurred for more than 10% of the seed numbers, the sea state was categorised as non-operational. The arising tension in sling 1 and 2 for a non-operational wave condition are shown in the left figure below. The simulated design criteria were dependent on both Hs and Tp and are shown in the right figure below. The average criterion was determined to be **2.5 m**. Hence the operational criterion was **2.0 m**, calculated an α-factor of 0.81.

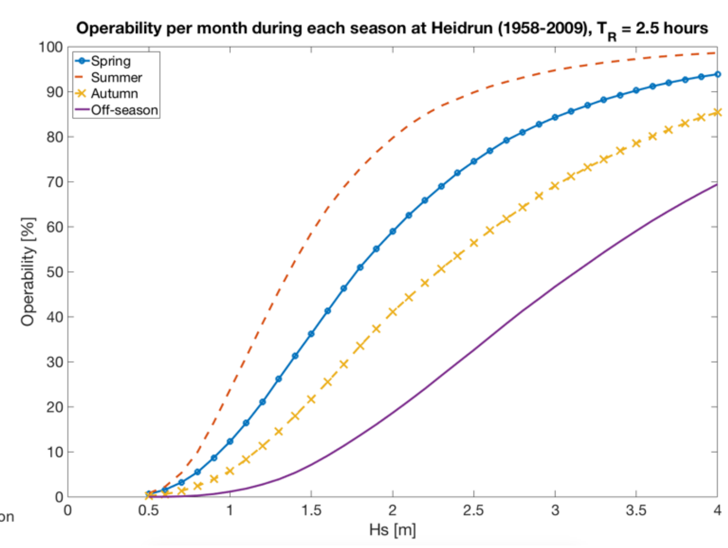




OPERABILITY

The season dependent operability at Heidrun for several operational criteria are shown in the right figure below. The season dependent T_{op} are illustrated in the left figure below.





REFERENCES:

[1] DNV GL (2011). *Recommended Practice - Modelling and Analysis of Marine Operations.* DNV-RP-H103

[2] Faltinsen (1990). *Sea Loads On Ships and Offshore Structures.* Cambridge University Press.