International Journal of Offshore and Polar Engineering (ISSN 1053-5381)

Vol. 32, No. 3, September 2022, pp. 307–312; https://doi.org/10.17736/ijope.2022.jc861

http://www.isope.org/publications

An Efficient Methodology of Estimating the Extreme Response of Risers from Floaters in Multidirectional Sea States

Andre Ramiro Amorim
Subsea 7
Rio de Janeiro, Brazil

Daniel Nalliah Karunakaran
Subsea 7
Stavanger, Norway

Danilo Abreu Souza Lima
Subsea 7
Rio de Janeiro, Brazil

Gabriel Rombado
ExxonMobil Global Projects
Houston, Texas, USA

Boje Tveraaen
Equinor
Oslo, Norway

An efficient methodology of estimating the extreme response of coupled risers (e.g., steel catenary risers or steel lazy wave risers) connected to deepwater floaters with large hang-off motions is presented. The conventional approach is to estimate the appropriate level of long-term response based on variable short-term sea states and multiple-floater loading conditions. This approach is computationally intensive and not considered practical for a typical project time frame. The methodology presented in this paper reduces computational efforts while maintaining a high level of accuracy by using directional sea state contour plots and combinations of floater loading conditions and offsets.

INTRODUCTION

Risers are an important component of any deepwater field development. Estimating the right level of long-term response for a given return period (e.g., 100 years or 10,000 years), combining varying sea states from every direction and floater motion variations due to draft and floater offsets, is computationally demanding.

Sea states for a given wave direction are often represented by a wave contour diagram that describes H_s/T_p combinations for a given return period or probability of exceedance (Haver et al., 2013). Further, the long-term response of risers and ancillary riser components connected to large motion floaters needs to have higher fractile response from every short-term sea state (Haver and Winterstein, 2008; Haver et al., 2013). Typically, for floaters with large motions and varying sea states, a 90% fractile level of response from short-term sea states gives an appropriate long-term response (Haver et al., 2013).

To estimate higher fractile extreme response, many short-term extremes are estimated and fitted to an extreme value distribution, like the Gumbel distribution. This often requires at least 30–40 independent 3-hour-long realizations to estimate extremes with an acceptable statistical certainty. Combining multiple sea states in each direction along the wave contour diagram, as well as all wave directions and variations in floater draft and offset, requires considerable computational resources. Such high computational demand is difficult to sustain on fast-paced projects wherein changes in design parameters are common.

The proposed state-of-the-art method consists of a lean computational effort that comprises the envelope of all possible extreme events combined with the probability of the non-exceedance level for each design parameter, such as stresses on hog bend and touchdown zone, hang-off, and top connector loads. A simplification can be made assuming that the largest response in the riser is related to the largest hang-off motion (Gemilang and Karunakaran, 2017). Applying this principle, the maximum motion at the hang-off point is estimated as a screening criterion to identify the governing sea state; this sea state is later applied to estimate the extreme response.

This method was verified and validated by performing 100 3-hour-long random response analyses for a production steel lazy wave riser (SLWR) and a steel catenary riser (SCR).

Received October 4, 2021; updated and further revised manuscript received by the editors December 17, 2021. The original version (prior to the final updated and revised manuscript) was presented at the Thirty-first International Ocean and Polar Engineering Conference (ISOPE-2021), Rhodes, Greece (virtual), June 20–25, 2021.

KEY WORDS: Rigid risers, SCR, SLWR, extreme response, global motion analysis, hydrodynamics, design method.

RISER RESPONSE PROCEDURE

Risers are designed based on extreme response for ultimate limit state (ULS) and accidental limit state (ALS) conditions. The