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Design Methodology for the Structural Capacity and Shakedown Assessment of Bolted Joint Connections in Subsea Open Water Systems

Abstract

In this paper, a design methodology is presented for analysing a non-gasketed bolted flange connector, for subsea applications where the flange is subject to various combinations of mechanical loading.
The proposed methodology is aligned with the API 17G 2nd Edition [API 2006] and ISO 13628-7:05 [ISO 2005] standards and combines linear elastic and elastic-plastic analysis approaches to determine structural capacity and assess shakedown.

Structural analysis using the finite element method (FEM) was carried out for a bolted flange connection of an open water bore selector (OWBS), subjected to internal pressure, bending and temperature. Stress linearisation and classification were used to evaluate the structural capacity of the bolts modelled using linear-elastic material.

Global and local strain based criteria were used to evaluate the structural capacity of the flanges modelled with elastic-plastic material. Analysis results of the OWBS are detailed for a normal operating condition and show the importance of prying.

The analysis is compared with a hydrostatic pressure test for FAT (factory acceptance test) and analysis results obtained from a shakedown analysis indicate that crack initiation is located on the outer surface of the flanges.

The proposed methodology provides guidance to ensure correct and safe application of non-gasketed bolted flange connectors, in offshore environments. In particular, the methodology addresses bolt prying, which is critical for preventing full separation and thread failure in bolted flange connectors subjected to combined mechanical loads.