# Wellhead and Tubing Hanger Tolerance Analysis

Independent tolerance review and analysis of a subsea wellhead and tubing hanger system, using an unconventional methodology based on 3-D CAD modelling for highest accuracy

**Client**: TOTAL E&P **Time**: 2016

**Location**: Kaombo, Angola

***Neptune*** were engaged by TOTAL to carry out an independent study on two key aspects of a subsea vertical Christmas tree (VXT) and tubing hanger (TH) system to be used for their Kaombo Project. The first element of the scope was to undertake an independent tolerance study of the system to assess the worst-case misalignment of the Horizontal Connection System (HCS) Hub relative to the Production Guide Base (PGB) Landing Frame. The objective was to verify and give greater confidence on the tolerance stack-up analysis carried out by the equipment OEM. The second element of the scope was to identify any potential clashes between mating parts and to recommend areas where manufacturing tolerance could be relaxed.

The tolerance analysis methodology adopted by ***Neptune*** was completely different from that utilised by the equipment OEM. This was done to achieve the maximum level of independence of analysis, thus maximising the validity of the verification study. The equipment OEM's methodology was based on extracting numerical dimensions and tolerances from the production drawings and then manually generating numerical relationships, using a suitable mathematical software package. This methodology is well established across many engineering sectors and is wholly valid. It does however have one inherent disadvantage in that the mathematical relations being built are independent of the actual 3-D models of the equipment.

***Neptune***'s methodology utilised the construction of full presentative 3-D CAD models of individual components. The geometry of each component included the actual tolerances that would be applied to them during the manufacturing processes. The parts were then assembled as they would be in practice. Geometrical mates (i.e. connections) were applied to replicate their interactions in practice. The geometry was then offset through the individual part to part clearances, to establish various worst-case misalignment scenarios.

As outcomes of this tolerance study, a number of misalignments of individual interfaces and assemblies were identified. Several clashes were also identified between the components. Detailed analysis was carried out of the causes for these clashes with several drawing anomalies and potential improvements highlighted. These results were communicated with the equipment OEM and the operator, and recommendations were made for correction and improvement.

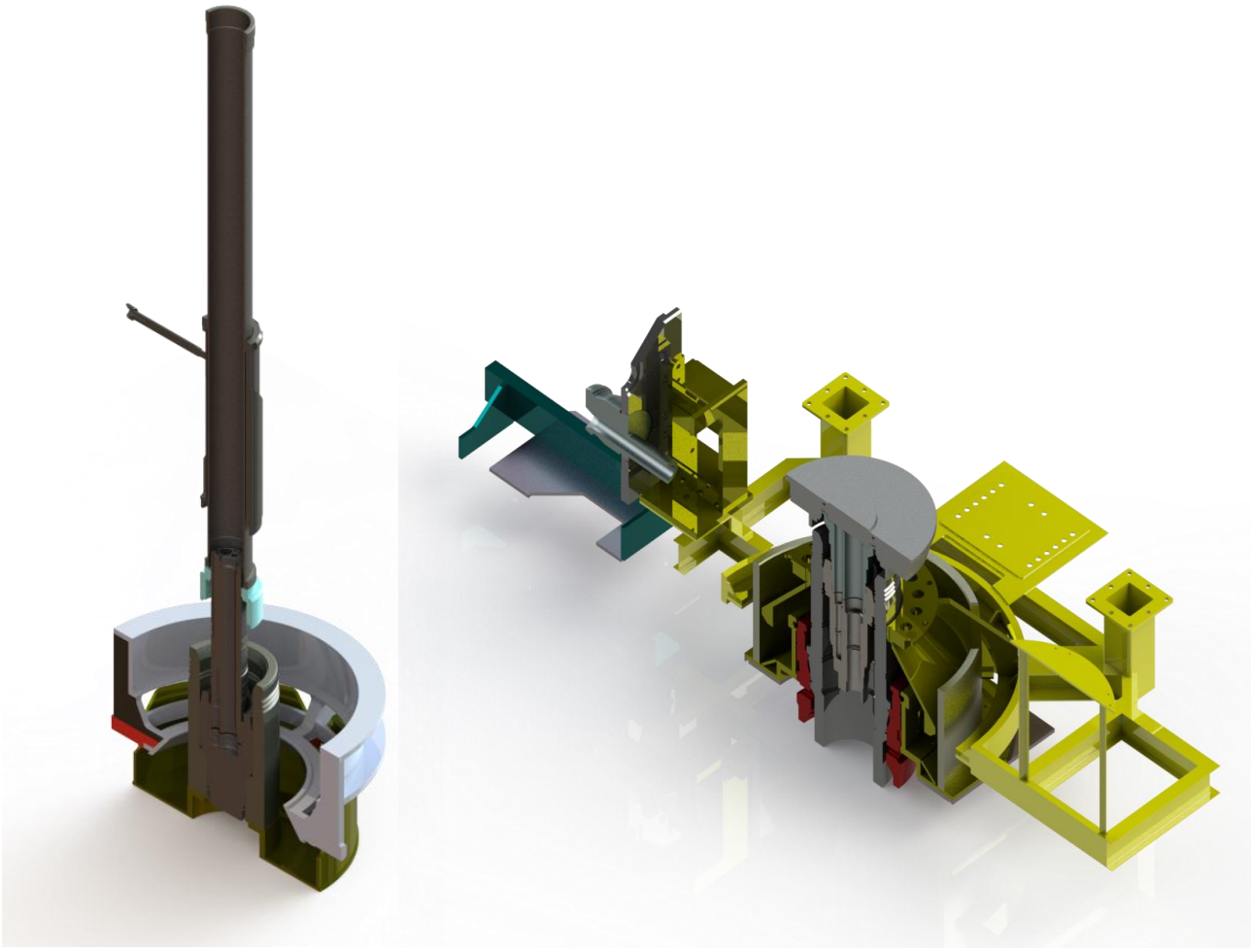

Figure 1: CAD models of wellhead, tubing hanger and tubing hanger orientation joint components, constructed for the CAD-based tolerance analysis.