Assembly of turret and disconnectable buoy

The invention relates to an assembly of turret and disconnectable buoy, in which the turret at its lower end and the buoy at its upper end are provided with mating coupling provisions.

In offshore oil production, use is made of so called FPSO's (Floating Production, Storage and Offloading). FPSO's are ships which are permanently or semi-permanently anchored offshore at an oilfield for the purpose of receiving well fluids from the oil reservoir, separating the oil from the water and gas and storing the oil on board for later transfer to another vessel. Generally, the FPSO's are anchored by means of single point mooring systems of the internal or external turret type.

In some areas of the world, weather conditions can deteriorate so badly, such as due to hurricanes, that it is required to enable the FPSO to disconnect from its anchoring system and sail temporarily to safer waters. Likewise, in iceberg infested waters it is sometimes necessary to disconnect the FPSO to avoid damage to the vessel.

In these instances use is made of an disconnectable turret mooring system, which can be of the internal or the external type (in the one case the turret is fitted within the confines of the vessel hull, in the other case the turret is fitted forward of the bow of the vessel), comprising a disconnectable buoy, wherein the turret at its lower end and the buoy at its upper end are provided with mating coupling provisions.

In the design of a disconnectable turret particular care needs to be given to the interface between the lower end of the turret and the upper end of the disconnectable buoy.

Ideally this interface is preloaded in such a way as to avoid that a gap is created between the turret and the buoy under external anchoring and wave load conditions.

Since generally the turret and the buoy are cilindrical or conical structures with a large diameter, it is also important to interlock these structures in such a way that both act as a single structure when connected. Another objective is to achieve a good fit between the structures at their interface, without resorting to tight and hence expensive machining tolerances.

The assemblies according to the state of the art provide a buoy with a protruding conical upper end which has to be received in a correspondingly shaped conical lower recess of the turret. These known assemblies suffer from the significant drawback that whereas the conical interface eases fit up of the two structures, the conical recess must be fabricated extremely heavy and sturdy to resist the radial loads which follow from the two parts being connected. Very significant preload is required to assure that the buoy and turret do not separate under external loads arising from anchoring and waves. If such preload cannot be achieved sufficiently, locking means, which connect the disconnectable buoy to the turret, are subject to high cyclic load variations following from these anchoring and wave loads and hence may fail prematurely.

The objectives of this invention are met by an assembly of turret and disconnectable buoy, in which the turret at its lower end and the buoy at its upper end are provided with mating coupling provisions, characterized in that the coupling provisions comprise an annular projection protruding from one of the turret and buoy towards the other of the turret and buoy and a correspondingly shaped annular recess on the other of the turret and buoy for receiving the annular projection, wherein the annular projection has a base which is wider than a top thereof, whereas the annular recess has a top which is wider than a base thereof.

Preferred embodiments of the assembly in accordance with the present invention are subject of the depending claims.

The annular projection and annular recess are machined to a tolerance such that if they are engaged one to another, under an axial compression force, one of these parts deforms more than the other in a radial direction such as to become compliant with the other part in a form-fit. By applying a nominal preload to this interface, both parts of the assembly now work as one single part, there being no tendency for the engaged parts to separate.

The tolerances of machining are selected such that the diameter growth of the weakest part, typically the lower end of the turret structure, under a compression force, is limited to such a percentage of tangential elongation that it avoids achieving the yield stress of the material (steel) being employed in the parts. Once this stress level is reached, a further increase of the compressive force merely increases loacal stresses in the radial section of the parts and increases the contact stresses between these parts. This is a very stiff load path, with locking means which connect the disconnectable buoy to the turret forming part of a much lesser stiff load path. Hence these locking means are not subject to any significant cyclic loads .

Since a very high internal contact stress is achieved over the tapering surfaces of the projection and recess, these parts can also act as a sealing device against the seawater to allow the turret to be pumped dry after a connect operation. An additional sealing member (e.g. a soft rubber or mild steel ring) may be fitted between the annular projection and annular recess.

The invention will be elucidated while referring to the drawing, in which:

Fig. 1 shows schematically a typical FPSO with an internal turret being anchored to the seabed in a manner

known per se using a disconnectable buoy;

Fig. 2 shows schematically and on an enlarged scale the interface between a turret and disconnectable buoy; and

Fig. 3 shows schematically an embodiment with additional sealing member.

Referring to figure 1, a FPSO 1 is shown which, in a manner known per se, is provided with an internal turret 2 which, at its lower end, is connected to a disconnectable buoy 3. The buoy 3 is anchored to the bottom of the sea 4 by means of anchor lines 5, whereas a production line 6 is connected between a well bore 7 and the buoy 3 (and leads further through the turret towards an appropriate on-board installation, not shown).

Referring to figure 2, the interface between the lower end of the turret 2 and the upper end of the disconnectable buoy 3 is illustrated schematically in a longitudinal cross section and in a situation before being assembled. As shown, the upper end of the buoy 3 is provided with an annular projection 4 protruding from the buoy, whereas the lower end of the turret is provided with a correspondingly shaped annular recess 5 for receiving the annular projection 4. The annular projection has a base 6 which is wider than a top 7 thereof, wheras the annular recess has a top (mouth) 8 which is wider than a base 9 thereof. Specifically, in the illustrated embodiment, the cross-section of the annular projection and annular recess has a trapezoidal shape. As a result assembling these parts (i.e. entering the annular projection 4 into the annular recess 5) is very easy and leads to an optimised load path between the turret 2 and buoy 3.

It is possible too that the annular projection is part of the turret and that the annular recess is provided in the buoy. Further it is conceivable to provide more than one annular projection with corresponding annular recess; in

such a case it would be possible that each of the turret and buoy comprises at least one annular projection and at least one annular recess.

It is noted that the provision of an annular projection and annular recess does not prevent that, in accordance with the state of the art, the lower end of the turret 2 and upper end of the buoy have corresponding tapering shapes (as indicated schematically in figure 2 by dotted lines).

Finally figure 3 represents on a larger scale a sealing member 10 interpositioned between an annular projection 4 and an annular recess 5. Specifically the sealing member 10 is provided between the top 7 of the annular projection 4 and the base 9 of the annular recess 5. Preferably the sealing member is attached to the base 9 of the annular recess. The seal member may compise a soft rubber or mild steel ring.

The invention is not limited to the embodiments described before, which may be varied widely within the scope of the invention as defined by the appending claims.

CLAIMS

1. Assembly of turret and disconnectable buoy, in which the turret at its lower end and the buoy at its upper end are provided with mating coupling provisions, **characterized in that** the coupling provisions comprise an annular projection protruding from one of the turret and buoy towards the other of the turret and buoy and a correspondingly shaped annular recess on the other of the turret and buoy for receiving the annular projection, wherein the annular projection has a base which is wider than a top thereof, whereas the annular recess has a top which is wider than a base thereof.

2. Assembly according to claim 2, wherein the cross-section of the annular projection and annular recess has a trapezoidal shape.

3. Assembly according to claim 1 or 2, wherein the annular projection is provided on the buoy whereas the annular recess is provided in the turret.

4. Assembly according to any of the previous claims, wherein a sealing member is provided between the annular projection and the annular recess.

5. Assembly according to claim 4, wherein the sealing member is provided between the top of the annular projection and the base of the annular recess.

6. Assembly according to claim 5, wherein the sealing member is attached to the base of the annular recess.

7. Assembly according to any of the claims 4-6, wherein the seal member is a soft rubber or mild steel ring.