RISER BENDING RELIEF JOINT

Field of the Invention

The present invention relates to a connector with a gimbal joint operable as a bending relief joint, to relieve the bending stress applied at high bending locations in a subsea riser, in the event that the applied bending moments exceed a predetermined bending limit.

Background of the Invention

Offshore oil and gas production installations typically have a wellhead on the seabed and production connections on a subsea tree. For production completion or workover purposes, a riser pipe string may be connected between the subsea tree and a surface vessel, such as a semi-submersible or drill-ship responsible for carrying out the desired well intervention.

The surface vessel may be maintained in position above the well by means of anchors or by dynamic location using the global positioning system (GPS) and thrusters in the vessel to counteract drift. In operating conditions, some angular displacement of the surface vessel away from the vertical above the well will be acceptable to cope with drift caused by changes in local conditions, including tides and weather. In a given situation the operating range within which a surface vessel may safely drift will depend on various factors, including the tensile and bending limits of the riser. In unexpected or extreme circumstances, for example if an anchor slips or GPS fails or in a sudden storm, the surface vessel may drift to the extent that emergency action may be required to avoid damage to the riser or the wellhead.

For such purposes, the riser string may include a safety joint – a ‘weak link’ designed to fail in tension below the limits of an ordinary riser pipe. To protect the wellhead, an emergency disconnect package (EDP) utilising a quick disconnect connector (such as described in WO 2009/019515) may be provided at the base of the riser string.

In the past, various types of ball joint or flexible connectors have been proposed to allow some degree of continuing flexure in a tubular riser string, for example as described in US-A-3 433 504, US-A-3 977 707, US-A-3 523 578 and US-3 695 633.

However, these systems are not themselves designed to be triggered by, or to provide protection against, excessive bending moments which may be applied to or by the riser, in cases of extreme angular displacement from the vertical. Further difficulties may also arise owing to local environmental differences such as strength of tides and depth of the water at the well site. In shallower water, a surface vessel is necessarily more limited in absolute terms in the extent of

allowable drift, and the shorter length of riser behaves more rigidly than longer lengths in deep water. Different stresses arise and safety systems need to be adapted correspondingly.

The present invention is directed at providing means for relieving bending stress in a subsea riser, which means may be adjustable to selected limits and to address variations in relevant operating parameters in different locations.

Summary of the Invention

According to the present invention from one aspect, there is provided a connector for use with a subsea riser installation, the connector comprising a body with a first connecting face having a through-passageway and adapted for connection to a first, external conduit element and a gimbal joint within the body, the gimbal joint having a through-passageway which is substantially aligned with the through-passageway in the first face, and a second connecting face on an opposite side of the connector to the first connecting face and adapted for connection to a second external conduit element, the connector further comprising at least one detent mechanism adapted to engage a corresponding locating feature on the gimbal joint, whereby the through-passageways are maintained in alignment and the gimbal joint prevented from moving relative to the body until a predetermined bending moment is applied to the gimbal joint across the axis of its through-passageway.

According to the present invention from another aspect, there is provided a method of providing a relief joint for a riser installation, the method comprising: providing a connector comprising a body with a first connecting face having a through-passageway; providing a gimbal joint within the body, the gimbal joint having a through-passageway which is substantially aligned with the through-passageway in the first face, and a second connecting face on an opposite side of the connector to the first connecting face; connecting the first connecting face to a first, external conduit element; and connecting the second connecting face to a second external conduit element, the method further comprising providing at least one detent mechanism which engages a corresponding locating feature on the gimbal joint, whereby the through-passageways are maintained in alignment and the gimbal joint is prevented from moving relative to the body until a predetermined bending moment is applied to the gimbal joint across the axis of its through-passageway.

It will be appreciated that the first and second external conduit elements referred to above may include riser pipe or other tubular elements or wellhead fixtures such as a blowout preventer, and do not themselves form part of the connector itself.

A connector and method according to the present invention have the advantage that the through-passageways and riser are maintained in alignment within a safe working range of bending moment, but when the predetermined limit is reached the bending stress can be quickly and consistently

relieved before damage occurs to connected riser or wellhead elements. Any tooling that is run through the passageways is also protected and extra opportunity to retrieve such tooling is provided.

Preferably, a plurality of detent mechanisms are provided, spaced around the body to engage corresponding locating features on the gimbal joint. In this case, preferably, the mechanisms are evenly spaced around the axis of the through-passageway of the body.

The or each detent mechanism preferably includes adjustment means for adjusting the force to be applied to the corresponding locating feature for determining the predetermined bending moment required to trigger movement of the gimbal joint.

The or each detent mechanism may comprise a detent acted on by spring means, such as disk or coil or composite springs.

The or each adjustment means could comprise means for adjusting the spring rate of the spring means of the detent mechanism if the latter includes spring means; or the or each adjustment means could comprise hydraulic means.

The or each detent mechanism could be disposed in a direction normal to the axis of the through-passageway of the body. Alternatively, the or each detent mechanism could be disposed in a direction inclined relative to the axis of the through-passageway of the body.

The body could comprise an outer body part which receives the gimbal joint and an inner body part retaining the gimbal joint in place.

The present invention also combines a riser installation including a connector according to the invention.

The utilisation of an adjustable detent mechanism in co-operation with a locating feature on the gimbal joint offers the advantage that the connector may be mechanically reset simply by repositioning of the respective external conduit elements in alignment (for example by repositioning a surface vessel in alignment above the wellhead-connector-riser assembly so that the or each detent mechanism re-engages with the relevant locating feature in the connector). Additionally, if the or each detent mechanism trips and a disconnect is carried out at a connector lower in the stack, the or each mechanism will reset under gravity allowing for possible re-connection or a normal recovery to the vessel.

In a further alternative arrangement, the or each detent mechanism may comprise a shear member which is designed to shear when the limiting bending moment is applied. Such an arrangement would have the disadvantage, however, that it could not be reset without reinstalling a replacement shear member.

Brief Description of the Drawings

Fig. 1 is a perspective view of one embodiment of a connector according to the present invention;

Fig. 2 is a perspective vertical section across the plane AA' of Fig. 1 with the gimbal in the locked vertical position;

Fig. 3 is a plane vertical section across AA' of Fig. 1 also with the gimbal in the locked vertical position;

Fig. 4 is a perspective vertical section across the plane AA' of Fig. 1 with the gimbal displaced from the vertical and its detents disengaged;

Fig. 5 is a plane vertical section across AA' of Fig. 1 with the gimbal displaced as in Figure 4;

Fig. 6 is a perspective view of an alternative embodiment of a connector according to the present invention;

Fig. 7 is a perspective vertical section across the plane BB' of Fig. 6 with the gimbal in the locked vertical position;

Fig. 8 is a plane vertical section across BB' of Fig. 6 also with the gimbal in the locked vertical position;

Fig. 9 is a perspective vertical section across the plane BB' of Fig. 6 with the gimbal displaced from the vertical and its detents disengaged;

Fig. 10 is a plane vertical section across BB' of Fig. 6 with the gimbal displaced as in Fig. 9;

Fig. 11 is a diagram illustrating how the safe operating range for a surface vessel may be extended by use of a connector according to the present invention.

Detailed Description of Embodiments of the Invention

Figs. 1 to 5 illustrate the construction and operation of one embodiment of a connector 10A according to the present invention for operating as a riser bending relief joint. Connector 10A comprises outer and inner body parts 11,12 which contain a joint comprising a gimbal joint 15. In this embodiment, the gimbal joint 15 is inserted in the outer body part 11 from the lower side and retained in place by the inner body part 12 which is threaded (or otherwise fixed) into the outer body part 11. The inner body part 12 has a through-passageway in the form of a bore 14 and a lower face 13 which, in this embodiment, is intended for connection to an emergency disconnect package (EDP). The gimbal joint 15 has a through-passageway in the form of a bore 17 which is axially aligned with bore 14

when the gimbal is in the locked vertical position shown in Figs. 2 and 3. The upper face 16 of the gimbal joint 15 is intended for connection to a riser string.

The gimbal joint 15 is provided with locating features 21, which are engaged by detents 20 of detent mechanisms in the body part 11. Fluid seals (not shown) are provided circumferentially round the gimbal joint 15 in the region 18 between gimbal joint 15 and outer body part 11. The detents 20 are inserted in ports 19 and are spaced evenly around the outer body part 11, and are forced into engagement with features 21 by springs of the detent mechanisms, such as coil springs 22 or disk springs 23.

The springs are shown held in place by retaining mounts 24 of the detent mechanisms, which mounts can incorporate spacers or other means to adjust the spring rates.

Although not shown, it will be apparent that the springs could be replaced by alternative means, such as hydraulically driven pistons to adjust the force applied to the detents 20.

As shown in Figs. 4 and 5, when a sufficient bending moment has been applied by a riser connected to the upper face 16 of gimbal 15, the detents 20 disengage from the locating features 21 and the gimbal joint 15 is free to rotate angularly away from the vertical and thereby relieve bending stress applied by the attached riser through the connector to the wellhead, the bores 14 and 17 no longer being aligned. A profile is cut in each of bores 14 and 17 to ensure no snagging and to facilitate the bores no longer being aligned.

Figs. 6 to 10 illustrate the construction and operation of an alternative embodiment of a connector 10B according to the present invention. In this embodiment, the ports 19 and the detent mechanisms 20,22,23,24 around the upper part of body part 11 are not disposed horizontally relative to the axes of the bores 14 and 17 (that is in directions normal to the axis of bore 14) but are inclined relative to bore 14. It is anticipated that such an alternative disposition of the ports 19 and components of the detent mechanisms 20,22,23,24 may be preferable in situations where lateral access is more restricted for some reason or where an alternative load path within the tool is desired. Components in Figs. 7 to 10 which correspond with components in Figs. 2-5 have been identified by the same reference numerals as in Figs. 2 to 5.

The diagram of Fig. 11 illustrates, schematically how the safe operating area for a surface vessel 32 may be increased by using a connector 10 according to the present invention positioned above a wellhead 30 and connected to riser string 31. The connector 10 maintains the gimbal joint of the connector and connected riser in rigid alignment close to the wellhead 30 until the vessel 32 is displaced from central location 1 vertically above the wellhead to a location 2 on a circular perimeter P2, when a predetermined bending moment applied to the gimbal joint triggers release of the detents.

The surface vessel may then move safely to a position 3 within a wider circular perimeter P3 without excessive tensile or bending stress being applied to the riser string 31 and wellhead 30. The riser string may incorporate a tensile weak link 33 and the wellhead may be provided with a quick-release emergency disconnect package (EDP) 34 to operate and avoid damage should the surface vessel be likely to go outside the safety perimeter P3.

In the examples described, the body 11,12 of the connector is connected to an EDP and the gimbal 15 is connected to a riser. It will be apparent that a connector according to the present invention may also be adapted for connection in an inverted form if necessary – i.e. with the gimbal joint for connection to an EDP and the body adapted for connection to a riser.

Claims

1. A connector (10A) for use with a subsea riser installation, the connector (10A) comprising a body with a first connecting face having a through-passageway (14) and adapted for connection to a first, external conduit element and further comprising a ball joint (15) within the body, the ball joint (15) having a through-passageway (17) which is substantially aligned with the through-passageway (14) in the first face, and the ball joint having a second connecting face on an opposite side of the connector (10A) to the first connecting face and adapted for connection to a second external conduit element, characterised in that the connector (10A) further comprises at least one detent mechanism adapted to engage a corresponding locating feature on the ball joint (15), whereby the through-passageways are maintained in alignment and the detent mechanism prevents the ball joint (15) from moving relative to the body until a predetermined bending moment is applied to the ball joint across the axis of its through-passageway.

2. A connector (10A) according to claim 1, wherein a plurality of detent mechanisms (20) are provided spaced around the body to engage corresponding locating features on the ball joint (15).

3. A connector (10A) according to claim 2, wherein the detent mechanisms (20) are evenly spaced around the axis of the through-passageway of the body.

4. A connector (10A) according to any preceding claim, wherein the or each detent mechanism (20) includes adjustment means for adjusting the force to be applied to the corresponding locating feature for determining the predetermined bending moment required to trigger movement of the ball joint (15).

5. A connector (10A) according to any preceding claim, wherein the or each detent mechanism (20) comprises a detent acted on by spring means.

6. A connector (10A) according to claim 5 as dependent on claim 4, wherein the or each adjustment means comprises means for adjusting the spring rate of the spring means of the detent mechanism.

7. A connector (10A) according to claim 4, wherein the or each adjustment means comprises hydraulic means.

8. A connector (10A) according to any preceding claim, wherein the or each detent mechanism (20) is disposed in a direction normal to the axis of the through-passageway of the body.

9. A connector (10A) according to any of claims 1 to 7, wherein the or each detent mechanism (20) is disposed in a direction inclined relative to the axis of the through-passageway of the body.

10. A connector (10A) according to any preceding claim, wherein the body comprises an outer body part which receives the ball joint (15) and an inner body part retaining the ball joint (15) in place.

11. A riser installation including a connector (10A) according to any preceding claim.

12. A method of providing a relief joint for a riser installation, the method comprising: providing a connector (10A) comprising a body with a first connecting face having a through-passageway (14); providing a ball joint (15) within the body, the ball joint (15) having a through-passageway (17) which is substantially aligned with the through-passageway (14) in the first face, and the ball joint having a second connecting face on an opposite side of the connector (10A) to the first connecting face; connecting the first connecting face to a first, external conduit element; and connecting the second connecting face to a second external conduit element, characterised in that the method further comprises providing at least one detent mechanism which engages a corresponding locating feature on the ball joint (15), whereby the through-passageways are maintained in alignment and the detent mechanism prevents the ball joint (15) from moving relative to the body until a predetermined bending moment is applied to the ball joint (15) across the axis of its through-passageway.

13. A method according to claim 12, wherein a plurality of detent mechanisms (20) are provided, spaced around the body to engage corresponding locating features on the ball joint (15).

14. A method according to either of claims 12 and 13, including the step of adjusting the force applied by the or each detent mechanism (20) to the corresponding locating feature for determining the predetermined bending moment required to trigger movement of the ball joint (15).

15. A method according to any of claims 12 to 14, wherein the or each detent mechanism (20) comprises a detent acted on by spring means.

16. A method according to claim 15 as dependent on claim 14, wherein the adjusting step comprises adjusting the spring rate of the spring means of the or each detent mechanism (20).