

Safety joint and riser comprising such a safety joint

FIELD OF THE INVENTION AND PRIOR ART

5 The present invention relates to a safety joint according to the preamble of claim 1 to be included in a riser between a floating structure and a subsea installation. The invention also relates to a riser comprising such a safety joint.

10 Development within offshore oil and gas exploration in the recent years has been directed to subsea installations for processing and transport of oil and gas. The subsea installation is located at the well on the seabed and is connected to a floating structure by means of a so-called riser, which constitutes a conduit between the subsea installation and the floating structure. The subsea in-
15 stallation may be a wellhead or other type of equipment positioned on the seabed or in a fixed position above the seabed. The floating structure may for instance be a vessel. Movements of the floating structure due to waves, wind and sea-currents can cause bending of the riser and influence the tension thereof. The riser is designed to be capable of withstanding a certain amount
20 of bending and tension encountered during normal conditions. However, in an emergency situation, for instance due to severe weather conditions, the riser might be subjected to excessive bending and tensioning with a risk of damage to the riser and to the equipment connected to the riser. In order to avoid such
25 damage, a so-called emergency disconnect package can be used to disconnect the riser from the subsea installation in an emergency situation or if the operator predicts that adverse conditions are imminent. The emergency disconnect package is traditionally secured to the subsea installation below a stress
30 joint provided at the lower end of the riser. Such an arrangement is for instance disclosed in US 6 659 690 B1 and WO 2008/051092 A1. When the riser has to be disconnected from the subsea installation in an emergency situation, the emergency
35 disconnect package is actuated to release the stress joint and the riser from the subsea installation. Normally, the riser also

comprises a safety joint provided with a weak link that will automatically break when subjected to an excessive axial force. Such a safety joint may be located at the base of the stress joint or connected between the stress joint and the lowermost riser joint or between two riser joints at the lower end of the riser.

The safety joint of the present invention is particularly intended to be used in a completion and work over riser. A completion and work over riser is used in the oil and gas industry when oil and/or gas is to be extracted from one or more offshore wells. Completion and work over operations are performed on a subsea well-head using a completion and work over riser. A completion and work over riser may for instance be used for installing or retrieving a so-called X-mas tree. It may also be used for installing or pulling a so-called tubing hanger. With a dual bore riser it will be possible to circulate a fluid down through the production pipe and up through the annulus pipe or vice versa. Such fluid circulation may be used to clean a well and to test and verify a circulation path. The bore of the production pipe and the bore of the annulus pipe of a dual bore riser may be connected to two corresponding bores in an X-mas tree so that a wire line or coiled tubing can be used to access plugs or other devices installed in the bores of the X-mas tree. The bore of the production pipe of a riser may also be connected to the production tubing that extends from a tubing hanger all the way to the bottom of a well. Installing the tubing and tubing hanger is referred to as completing a well and is consequently a completion operation. When a well is completed, it is made ready for production of oil and/or gas or alternatively for injection of gas or water. If the well does not produce as expected, it may be overhauled or repaired in different ways. This is referred to as work over.

A completion and work over riser may be of the monobore type or the dual bore type. A dual bore riser comprises a production pipe and an annulus pipe extending in parallel with the production pipe. The production pipe is typically designed for taking a load and has strength for lifting, whereas the annulus pipe may be a

pressure containing pipe with no strength for lifting. A monobore riser comprises a production pipe but no annulus pipe.

SUMMARY OF THE INVENTION

- 5 The object of the present invention is to provide a new and advantageous safety arrangement for disconnection of a riser from a subsea installation, which in at least some aspect offers an advantage as compared to previously known safety arrangements.
- 10 According to the invention, this object is achieved by a safety joint having the features defined in claim 1.

The safety joint of the present invention is to be included in a riser between a floating structure and a subsea installation and
15 comprises:

- a first riser coupling at its upper end for connection to a corresponding riser coupling of a riser joint;
- a second riser coupling at its lower end for connection to a corresponding riser coupling of a riser joint or stress joint; and
- 20 - an emergency disconnect package with an emergency disconnect coupling arranged between the upper end and the lower end of the safety joint.

The safety joint of the present invention is to be located in a riser
25 above the stress joint which connects the riser to the subsea installation in question. By providing the emergency disconnect package in this safety joint above the stress joint and not at the conventional spot below the stress joint, the disconnection point of the riser string is moved to a location where it has appeared
30 that the tensile load is the dominant load even when the floating structure is offset to a large extent in the horizontal direction. At the conventional location for the emergency disconnect package below the stress joint, the emergency disconnect package is subjected to high bending moments, which requires the use of a
35 rather complex and bulky emergency disconnect coupling designed to be capable of disconnecting even when subjected to

high bending moments. With the location of the emergency disconnect package in a safety joint above the stress joint, it will be possible to use a more simple and slim emergency disconnect coupling with limited capability of disconnecting under high bending moments. Hereby, it will be possible to give the emergency disconnect package such a compact and slim design that the safety joint provided with the emergency disconnect package can pass through a conventionally sized drill floor opening of a floating structure.

According to an embodiment of the invention, the emergency disconnect package also comprises a retainer valve unit arranged in series with the emergency disconnect coupling between the upper end and the lower end of the safety joint.

According to an embodiment of the invention, the safety joint also comprises a weak link arranged in series with the emergency disconnect package between the upper end and the lower end of the safety joint. Hereby, the riser will be automatically disconnected from the subsea installation when subjected to an excessive tensile force.

The weak link is preferably arranged between the emergency disconnect package and the lower end of the safety joint. Hereby, in case the weak link is broken, a possible retainer valve unit included in the emergency disconnect package could prevent pressurized fluid in the riser above the safety joint from becoming a jet that may introduce undesirable and dangerous movements to the part of the riser which is left hanging from the floating structure.

Further advantages as well as advantageous features of the safety joint of the present invention will appear from the following description and the dependent claims.

The invention also relates to a riser having the features defined in claim 9.

BRIEF DESCRIPTION OF THE DRAWINGS

With reference to the appended drawings, a specific description of preferred embodiments of the invention cited as examples follows below. In the drawings:

5

Fig 1 is a schematic illustration of a riser arranged between a subsea installation and a floating structure, and

10 Fig 2 is a schematic lateral view of a safety joint according to an embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

15 Fig 1 shows a safety joint 30 according to the present invention arranged in a riser 1 which extends between a floating structure 2 and a subsea installation 3. In the illustrated example, the riser 1 is a completion and work over riser. The floating structure 2 is for instance a vessel and only parts thereof are illustrated very schematically in Fig 1. The illustrated parts of the floating structure 2 are a drill floor 4 and a cellar deck 5. In the illustrated example, the subsea installation 3 comprises a guide base 6 resting on the seabed 7 and a subsea tree 8 supported on the guide base. A well control package 9 is mounted to the subsea tree.

25 The riser 1 comprises a stress joint 10 at its lower end, through which the riser is connected to the subsea installation 3. The stress joint 10 has a flange 11 at its lower end 12, which flange is secured to an upper part of the well control package 9. The stress joint 10 tapers as seen from its wider lower end 12 towards its narrower upper end 13 and provides a gradual transition from the relatively compliant riser to the much stiffer well control package 9. The stress joint 10 is provided with a riser coupling at its upper end 13 for connection to a corresponding riser coupling of a riser joint 14 or safety joint 30.

35

The riser 1 extends above sea level 15 and comprises a tension joint 16 at its upper end. A riser tensioner 17 arranged on the floating structure 2 is provided with tension wires 18 connected to the tension joint 16. The riser tensioner 17 is used to tension the riser 1 through the tension wires 18 in order to provide a desired tension in the riser 1. At its upper end, the riser 1 is connected to equipment 19 arranged on the floating structure 2. In the illustrated example, this equipment comprises a surface tree 20 arranged in a tension frame 21.

The above-mentioned safety joint 30 and a number of conventional riser joints 14 are connected to each other and arranged in series with each other between the stress joint 10 and the tension joint 16 in order to form a conduit between the subsea installation 3 and the floating structure 2. The safety joint 30 of the present invention is of a design that allows it to be located at an elevation where it will be exposed to minimum bending loads, typically one or two riser joints above the stress joint 10.

The safety joint 30, which is illustrated in closer detail in Fig 2, comprises a first riser coupling 31 at its upper end 32 for connection to a corresponding riser coupling of a riser joint 14 and a second riser coupling 33 at its lower end 34 for connection to a corresponding riser coupling of a riser joint 14 or stress joint 10. An emergency disconnect package 35 is arranged between the upper end 32 and the lower end 34 of the safety joint. In the illustrated embodiment, the emergency disconnect package 35 comprises an emergency disconnect coupling 36 and a retainer valve unit 37 arranged in series with each other. The retainer valve unit 37 is with advantage arranged above the emergency disconnect coupling 36, i.e. between the emergency disconnect coupling 36 and the upper end 32 of the safety joint, as illustrated in Fig 2. However, the retainer valve unit 37 may alternatively be arranged below the emergency disconnect coupling 36, i.e. between the emergency disconnect coupling 36 and the lower end 34 of the safety joint.

The emergency disconnect coupling 36 is of such size that it is able to pass through a conventionally sized drill floor opening 22 in the drill floor 4. The emergency disconnect coupling 36 has an upper coupling part 36a and a lower coupling part 36b which are
5 releasable from each other by means of an actuator (not shown). This actuator is remote-controlled and triggered by means of an electric or hydraulic control signal transmitted from a control unit provided on the floating structure 2. Thus, the actuator is configured to disconnect the upper coupling part 36a from the
10 lower coupling part 36b when receiving a control signal from the control unit provided on the floating structure 2. The actuator is with advantage a hydraulic actuator. The emergency disconnect coupling 36 could for instance be a VetcoGray WITS connector or any other suitable type of connector.

15 The retainer valve unit 37 is also of such size that it is able to pass through a conventionally sized drill floor opening 22 in the drill floor 4. In case of a dual bore riser, the retainer valve unit 37 comprises a first retainer valve 37a for closing the production
20 pipe 38 and a second retainer valve 37b for closing the annulus pipe 39. In case of a monobore riser, the retainer valve unit 37 only comprises one retainer valve. The retainer valves 37a, 37b are normally maintained open. In an emergency situation, the retainer valves 37a, 37b are closed immediately before the dis-
25 connection of the emergency disconnect coupling 36 to thereby prevent the fluid contained in the riser above the safety joint 30 from being released to the sea. The respective retainer valve 37a, 37b is actuated by means of an actuator (not shown). This actuator is with advantage a hydraulic actuator and triggered by
30 means of an electric or hydraulic control signal transmitted from a control unit provided on the floating structure 2. Thus, the actuator is configured to close the associated retainer valve when receiving a control signal from the control unit provided on the floating structure 2. The production pipe retainer valve 37a could
35 for instance be a VetcoGray WITS retainer valve or any other suitable type of retainer valve.

In case of a dual bore riser, a circulation valve 37c may be arranged in a conduit 45 extending between the production pipe 38 and the annulus pipe 39, which conduit 45 has a first end connected to the bore of the annulus pipe 39 above the annulus pipe
5 retainer valve 37b and a second end connected to the bore of the production pipe 38 above the production pipe retainer valve 37a. The circulation valve 37c is normally maintained closed and can be opened subsequent to the closing of the production pipe retainer valve 37a and the annulus pipe retainer valve 37b to
10 thereby open a communication between the bore of the production pipe 38 and the bore of the annulus pipe 39 near the lower end of the disconnected part of the riser. Sea water or any other environmentally safe fluid can then be pumped down the annulus pipe 39 to lift the trapped fluid in the production pipe 38 back to
15 the floating structure 2 for processing and/or discard. When the riser is filled with sea water it can be disassembled and pulled back to the floating structure or be left in its prevailing position awaiting a later reconnection of the emergence disconnect coupling 36. The circulation valve 37c is actuated by means of an
20 actuator (not shown). This actuator is with advantage a hydraulic actuator.

The safety joint 30 is also provided with an accumulator unit 40, which comprises one or several accumulators 41 for accumulating
25 hydraulic fluid under pressure. In the embodiment illustrated in Fig 2, the accumulator unit 40 comprises several accumulators 41 arranged in a ring around the production pipe 38 and annulus pipe 39. The hydraulic actuator of the emergency disconnect coupling 36 is connected to the accumulator unit 40 in order to
30 allow hydraulic fluid under pressure to be supplied from the accumulator unit 40 to the hydraulic actuator when the hydraulic actuator is to release the two coupling parts 36a, 36b of the emergency disconnect coupling 36 from each other. The hydraulic actuator of the respective valve 37a, 37b, 37c included in the
35 retainer valve unit 37 is also connected to the accumulator unit 40 to allow the position of the respective retainer valve 37a, 37b and the circulation valve 37c to be controlled by means of

pressurized fluid from the accumulator unit. As an alternative, pressurized hydraulic fluid could be supplied to the above-mentioned actuators from suitable equipment on the floating structure 2.

5

Furthermore, the safety joint 30 comprises a weak link 42 arranged in series with the emergency disconnect package 35 between the upper end 32 and the lower end 34 of the safety joint. The weak link 42 is preferably arranged between the emergency
10 disconnect package 35 and the lower end 34 of the safety joint, as illustrated in Figs 1 and 2. However, the weak link 42 may alternatively be arranged between the emergency disconnect package 35 and the upper end 32 of the safety joint. The weak link 42 is designed to automatically break when subjected to a
15 tensile force exceeding a predetermined limit. Thus, the weak link 42 forms a weakened section of the safety joint 30. In the embodiment illustrated in Fig 2, the weak link 42 comprises an upper flange 43 and a lower flange 44 bolted to each other by means of bolts provided with a reduced cross-section having a
20 calibrated breaking strength. The weak link may alternatively be formed by a section of the production pipe 38 that has been machined down to form a weakened section that will break at a predetermined load. The weak link may also be of any other suitable type.

25

The retainer valves 37a, 37b of the retainer valve unit 37 are with advantage arranged to automatically close when the weak link 42 is broken. This could be achieved by designing the respective
30 retainer valve 37a, 37b as a fail-safe-close valve and looping the hydraulic control lines between the accumulator unit 40 and the retainer valve through the weak link 42. Hereby, the hydraulic pressure needed to maintain the retainer valves 37a, 37b open will disappear when the weak link 42 is broken and the retainer valves will then be automatically closed.

35

The safety joint 30 is preferably designed to fit within a cylindrical space having a diameter of 49 ½ inch (1257.3 mm), or alter-

natively 60 ½ inch (1536.7 mm), so as to thereby be able to pass through a conventionally sized drill floor opening 22.

5 One or more riser joints 14 may be provided between the stress joint 10 and the safety joint 30. In the example illustrated in Fig 1, one riser joint 14 is connected between the stress joint 10 and the safety joint 30. However, the safety joint 30 may alternatively be connected directly to the stress joint 10, i.e. with the riser coupling 33 at the lower end 34 of the safety joint connected di-
10 rectly to the riser coupling at the upper end 13 of the stress joint 10.

The lower part of the safety joint 30 up to and including the lower coupling part 36b of the emergency disconnect coupling 36 may
15 be used as the top end of a subsea lubricator tube. A work over riser may then be connected to the subsea lubricator stack through a riser string provided with the remaining part of the safety joint 30 at its lower end.

20 The invention is of course not in any way restricted to the embodiments described above. On the contrary, many possibilities to modifications thereof will be apparent to a person with ordinary skill in the art without departing from the basic idea of the invention such as defined in the appended claims.

CLAIMS

1. A safety joint to be included in a riser between a floating structure and a subsea installation, the safety joint (30) comprising a first riser coupling (31) at its upper end (32) for connection to a corresponding riser coupling of a riser joint and a
5 second riser coupling (33) at its lower end (34) for connection to a corresponding riser coupling of a riser joint or stress joint, **characterized** in that the safety joint (30) comprises an emergency disconnect package (35) with an emergency disconnect coupling (36) arranged between the upper end (32)
10 and the lower end (34) of the safety joint.
2. A safety joint according claim 1, **characterized** in that the emergency disconnect package (35) also comprises a retainer valve unit (37) arranged in series with the emergency
15 disconnect coupling (36) between the upper end (32) and the lower end (34) of the safety joint.
3. A safety joint according to claim 2, **characterized** in that the retainer valve unit (37) is arranged between the emergency
20 disconnect coupling (36) and the upper end (32) of the safety joint.
4. A safety joint according to any of claims 1-3, **characterized** in that the safety joint (30) comprises a weak link (42) arranged
25 in series with the emergency disconnect package (35) between the upper end (32) and the lower end (34) of the safety joint.
5. A safety joint according to claim 4, **characterized** in that the
30 weak link (42) is arranged between the emergency disconnect package (35) and the lower end (34) of the safety joint.
6. A safety joint according to any of claims 1-5, **characterized** in that the emergency disconnect coupling (36) has two coupling

parts (36a, 36b) which are releasable from each other by means of a remote-controlled actuator.

- 5 7. A safety joint according to claim 6, **characterized** in that said actuator is a hydraulic actuator.
- 10 8. A safety joint according to claim 7, **characterized** in that the safety joint (30) is provided with an accumulator unit (40) comprising one or more accumulators (41) for accumulating hydraulic fluid under pressure, the hydraulic actuator of the emergency disconnect coupling being connected to said accumulator unit (40) in order to allow hydraulic fluid under pressure to be supplied from the accumulator unit to the hydraulic actuator when the hydraulic actuator is to release the two coupling parts (36a, 36b) of the emergency disconnect coupling (36) from each other.
- 15 9. A riser extending between a floating structure and a subsea installation, the riser (1) comprising a stress joint (10) at its lower end, **characterized** in that the riser (1) comprises a safety joint (30) according to any of claims 1-8, the safety joint (30) being arranged above the stress joint (10).
- 20 10. A riser according to claim 9, **characterized** in that one or more riser joints (14) are provided between the stress joint (10) and the safety joint (30).
- 25 11. A riser according to claim 9, **characterized** in that the safety joint (30) is connected directly to the stress joint (10).
- 30 12. A riser according to any of claims 9-11, **characterized** in that the riser (1) is a completion and work over riser.