

1 Riser Gas Handling System and Method of Use

2

3 The present invention relates to a riser gas handling system and method of use, and in
4 particular to riser gas handling systems for subsea applications. A particular aspect of the
5 invention relates to riser gas handling systems that enable managed pressure drilling
6 operations.

7

8 Background to the invention

9

10 Drilling operations typically use a rotating drill bit on the end of a drillstring. Mud is pumped
11 down the drillstring from a rig mud pumping system and returned to the surface flowing in
12 the annulus between the drillstring and the well. The returning mud exits the annulus
13 above a blow-out preventer (BOP) into a mud return line where it freely flows into solids
14 control equipment to allow sand and cuttings to be removed from the well. The mud is
15 stored in holding tanks until it is pumped back down the well.

16

17 The mud which is pumped down the drillstring performs multiple functions, including
18 providing hydraulic power to drilling tools at the end of the drillstring, stabilising the well,
19 and cooling the drillbit. The mud provides pressure in the well which prevents an influx of

1 pressurised gas or oil from any hydrocarbon bearing formations. The pressure is a function
2 of the mud density, friction in the wellbore caused by the flowing mud, and the vertical
3 depth of the well. The density of the mud must be controlled to provide a pressure at the
4 bottom of the well which is above the pore pressure (the pressure at which the well may
5 collapse or allow a hydrocarbon influx) but below the fracture pressure (the pressure
6 where the well structure could fracture).

7
8 Managed Pressure Drilling (MPD) is a form of drilling where the pressure at the bottom of
9 the well is more precisely controlled using various methods apart from controlling the mud
10 density. MPD is used to drill wells in conditions where the local geology makes
11 conventional drilling difficult or impossible.

12
13 For MCD operations the mud circulation system becomes a closed loop with returning mud
14 from the wellbore flowing into an arrangement of valves or manifolds that can apply
15 backpressure or route the flow to other processing systems. The annulus is capped above
16 the BOP using a seal, typically a rotating control device (RCD).

17
18 Offshore drilling relies on the use of a tubular, known as a drilling riser, which allows the
19 annulus to extend from the seabed to the surface. For floating drilling vessels, a riser
20 section known as a slip joint or telescopic joint is used to allow the free movement of the
21 drilling vessel caused by wave motion.

22
23 Below the telescopic joint, the riser is held in position using a device known as a tension
24 ring, connected to an arrangement of cylinders via cable or directly, which provides a
25 constant tension to the sections of riser below the tension ring.

26
27 During subsea drilling operations, whether drilling conventionally or by managed pressure
28 drilling, well control issues may arise due to complex formation conditions. One example is
29 the uncontrolled release of gas that can occur when a gas kick is not detected by
30 conventional means and passes through the blow out preventer (BOP) into the marine
31 riser.

32
33 Sudden uncontrolled expansion of gas in the marine riser may result in rapid gas ascend
34 up the riser carrying a large volume of mud out of the riser at high pressure. This presents
35 a serious risk to personnel on the rig.

1 Furthermore, such a rapid loss of mud may result in the riser becoming partially evacuated
2 which may lead to riser damage or collapse due to hydrostatic pressure.

3
4 A riser gas handling (RGH) system is required to respond quickly to a gas influx to divert
5 and release the gas in a controlled manner thereby avoiding potential dangers to rig
6 personnel and mitigating damage to the riser and rig infrastructure.

7
8 Early riser gas handling and managed pressure drilling systems such as those disclosed in
9 US 7,866,399, US 8,347,982, US 2013014991 and US 2001040052 utilise a riser
10 arrangement known as 'Above the Tension Ring' (ATR). In ATR configurations, the
11 flowspool, riser isolation device, and rotating control device are installed above the tension
12 ring. This equipment has a lower tension rating which allows the equipment to be
13 positioned above the tension ring.

14
15 However, this configuration occupies space that would normally be used by the telescopic
16 joint, reducing the possible stroke of the telescopic section. This reduces the possible
17 geographic deployments of the drilling vessel and limits it to areas with a calmer range of
18 sea states. It is not suitable for deep water applications with dynamic sea conditions.

19
20 To provide a full range of motion of the telescopic joint, an arrangement known as Below
21 Tension Ring (BTR) was adopted in the industry. Examples of BTR arrangements are
22 disclosed in US9605502, US4626135 and US20140209316.

23
24 In these BTR configurations, the flowspool, riser isolation device, and rotating control
25 device are installed below the tension ring. In this arrangement, the telescopic joint can
26 fully extend and contract to its full length, allowing a greater range of geographic
27 deployments and more dynamic sea conditions.

28
29 However, the BTR configuration limits access to key components of the riser and requires
30 time consuming and costly operations to install, replace and/or repair RGH and drilling
31 components located beneath the tension ring. These operations involve closing the well,
32 disconnecting the riser from the subsea BOP, and pulling the entire riser string and
33 disassembling it section by section until the desired component housing is reached. Once
34 the component has been replaced or repaired, the entire riser string must be reassembled
35 in sections as the BOP is reattached to the wellhead.

1 Summary of the invention

2
3 It is an object of an aspect of the present invention to obviate or at least mitigate the
4 foregoing disadvantages of prior art riser gas handling systems.

5
6 It is another object of an aspect of the present invention to provide a robust, reliable and
7 compact RGH system suitable for deployment on riser assemblies used in a variety of
8 drilling sites and areas which experience dynamic sea conditions.

9
10 It is a further object of an aspect of the present invention to provide marine risers with a
11 riser gas handling system with improved reliability and accessibility and which is capable
12 of supporting conventional and managed pressure drilling systems.

13
14 It is another object of an aspect of the present invention to provide a marine riser
15 conversion system for RGH operations which enables managed pressure drilling
16 operations.

17
18 Further aims of the invention will become apparent from the following description.

19
20 According to a first aspect of the invention there is provided a riser assembly comprising:
21 a riser flow spool;
22 a riser isolation device and
23 an upper riser disconnect assembly;
24 wherein at least the riser flow spool is located on a riser below a riser tension ring and
25 wherein the upper riser disconnect assembly is located above the riser tension ring.

26
27 Preferably the riser flow spool and the riser isolation device are configured to be
28 connected to the riser below the tension ring.

29
30 By providing components of a RGH system including the Riser Flow Spool (RFS) and/or
31 the Riser Isolation Device (RID) below the tension ring and an upper riser disconnect
32 assembly above the tension ring the space available above the tension ring is maximized.
33 This may reduce the impact on the stroke length of a slip joint and enables the riser to be
34 utilised in a wide range of drilling sites and areas which experience dynamic sea
35 conditions and significant heave movements.

1 The upper riser disconnect assembly may be configured to connect to a rotating control
2 device (RCD). The rotating control device may be disposed above the upper riser
3 disconnect assembly. The rotating control device may be disposed above the riser tension
4 ring.

5
6 Preferably the RCD releasably connects above the upper riser disconnect assembly.
7 Preferably the RCD releasably connects to the riser assembly above the upper riser
8 disconnect assembly.

9
10 The RCD comprises one or more seals encased in a rotating bearing. The bearing sits in a
11 housing that may provide lubrication for the movement of the bearing. The RCD may
12 include latching elements that hold the bearing in a vertical position against a force
13 possibly present in the wellbore. The RCD may require regular replacement of the seals,
14 due to the axial movement of the drill pipe through the seals which cause wear. This wear
15 can be aggravated by the surface finish of the drill pipe, the pressure in the wellbore, the
16 vertical speed of the drill pipe, and the load on the seal caused by the connection points
17 (known as tool joints).

18
19 In conventional riser configurations, the replacement of the seal involves sealing the well
20 below the RCD (typically performed using one or more of the sealing elements in the
21 BOP), then unlatching the bearing element which is then retrieved by pulling the drillstring
22 out of the well.

23
24 By providing a RCD that can be releasably connected to the riser assembly by inclusion of
25 an upper riser disconnect assembly disposed above the riser tension ring, the RCD may
26 be installed, removed and/or temporarily disconnected for maintenance operations without
27 having to remove components of the lower riser assembly below the tension ring or
28 disconnect the riser string from the BOP or wellhead. This allows the RCD to be quickly
29 and conveniently installed and/or removed from the riser assembly above the tension ring
30 while minimising any impact on the stroke length of the slip joint.

31
32 A further benefit of an embodiment of the invention is that the RCD may be quickly and
33 easily installed on the riser assembly only when managed pressure drilling is required.
34 Conventional drilling with RGH functionality may be performed during routine drilling.
35 However, in the event that the conditions of the wellbore change preventing conventional

1 techniques, the drill system may be adapted for managed pressure drilling. By installing an
2 RCD and/or other MPD equipment only when required may result in lower operation costs.

3
4 An additional benefit of an embodiment of the invention is improved hose management as
5 the hoses and control lines connected to the RID and RFS may be vertically offset from
6 the tensioning system, which includes the tension ring, tension cylinders and tension rods
7 and/or lines. This may prevent the RGH hoses from being hindered by the tensioning
8 cylinders or rods connected to the tensioning rings.

9
10 Preferably the RID is positioned above the RFS on the riser string. Preferably, the RID is
11 closed during a riser gas handling event.

12
13 The upper riser disconnect assembly, riser flow spool and/or riser isolation device may be
14 controlled remotely. Preferably the RID is controlled remotely.

15
16 The RID may comprise a packing element. Preferably the RID comprises at least one
17 sensor to monitor actuation of the packing element and/or sealing of the RID. The RID
18 may comprise pressure control for sealing the RID. The RID may be dimensioned to fit
19 through a platform rig floor rotary table.

20
21 The RFS may have at least one flowline. The at least one flowline may be configured to be
22 connected to a distribution assembly, choke assembly and/or a mud-gas separator. The at
23 least one flowline may be connected to a safety valve. The safety valve may be configured
24 to divert riser gas overboard. Preferably, the RFS has multiple flowlines.

25
26 The RFS may be configured to be connected to at least one hose. The at least one hose
27 may be configured to be vertically offset from the tensioning system.

28
29 Preferably the RID and RFS are integrated in a single unit. The RID and RFS may be
30 combined into an integrated riser joint. By providing the RID and RFS in a compact and
31 lightweight integrated unit it may enable flexibility and easy handling of the RID and RFS
32 during installation, removal and maintenance operations. The integrated riser joint may be
33 dimensioned to pass through the rig floor rotary table.

34

1 Preferably the RFS has at least one valve assembly. The at least one valve assembly may
2 be configured to open a pathway between the riser annulus and the distribution assembly,
3 choke assembly and/or a mud-gas separator in the event of a riser gas influx.

4
5 The RFS assembly may be dimensioned to fit through a platform rig floor rotary table.
6 Preferably the RFS is compact and lightweight to allow quick rig up/rig down time.

7
8 Preferably the tension ring is coupled to a tensioning system to allow relative vertical
9 movement between the riser and the platform.

10
11 Preferably the tension ring is disposed between the tensioning system and the riser.
12 The tension ring may be disposed circumferentially about a portion of the riser, a portion of
13 the RID, a portion of slip joint, an outer barrel of a slip joint, a portion of the upper riser
14 disconnect assembly and/or a tension joint.

15
16 The upper riser disconnect assembly may be connected to a RCD and/or other drilling
17 operation components. The upper riser disconnect assembly may be configured to allow
18 the RCD and/or other drilling operation components to be releasably latched to the riser
19 assembly.

20
21 The upper riser disconnect assembly may comprise an upper connector and a lower
22 connector. The upper and lower connectors may be configured to disconnect from one
23 another. The separated upper and lower connectors may be configured to connect to one
24 another. The upper and lower connectors may be configured to connect to or disconnect
25 from one another on command.

26
27 The upper connector may be to an RCD or other drilling/riser components. The lower
28 connector of the upper riser disconnect assembly may be connected to a tension ring,
29 tension joint and/or an outer slip joint barrel.

30
31 Preferably the upper riser disconnect assembly is a slip joint disconnect assembly.

32
33 The upper riser disconnect assembly may comprise at least one sensor to monitor and/or
34 indicate a latched and/or unlatched status.

35

1 Preferably the upper riser disconnect assembly is a quick disconnect assembly. The upper
2 riser disconnect assembly may be controlled remotely. Preferably the upper riser
3 disconnect assembly is configured for remote releasably latching/unlatching.

4
5 Preferably the upper riser disconnect assembly is configured for assembly to the slip joint
6 above the tension ring.

7
8 The upper riser disconnect assembly may be disposed below the slip joint.

9
10 The slip joint may be a two-part slip joint. Alternatively, the slip joint may be a three or
11 more part slip joint. The slip joint may comprise at least one sealing assembly. The slip
12 joint may comprise two telescopic members. The slip joint may comprise more than two
13 telescopic members.

14
15 The RCD may be installed onto the RGH system to allow a managed pressure drilling
16 operation without requiring structural modifications to the RGH system. The RCD may be
17 connected to the upper riser disconnect assembly located above the tension ring.

18
19 The RCD may be configured to seal off the riser annulus while a drill string is located in the
20 RCD.

21
22 The system may comprise a choke. The choke may receive the drilling fluid from the
23 annulus below the RCD, and may be an MPD choke.

24
25 According to a second aspect of the invention there is provided a system for handling gas
26 in a riser comprising:

27 a riser flow spool;

28 a riser isolation device and

29 an upper riser disconnect assembly;

30 wherein at least the riser flow spool is configured to be connected to the riser below a riser
31 tension ring and wherein the upper riser disconnect assembly is configured to be
32 connected to the riser above the tension ring.

33
34 Preferably the riser flow spool and the riser isolation device are configured to be
35 connected to the riser below the tension ring.

1
2 Preferably the upper riser disconnect assembly is configured to be connected to a slip joint
3 above the tension ring.
4

5 A rotary control device may be configured to be connected to the upper riser disconnect
6 assembly above the tension ring. Preferably the rotary control device and/or the upper
7 riser disconnect assembly is configured to be releasably connected to the riser assembly
8 above the tension ring.
9

10 Embodiments of the second aspect of the invention may include one or more features of
11 the first aspect of the invention or its embodiments, or vice versa.
12

13 According to a third aspect of the invention there is provided a system for handling gas in a
14 riser to enable managed pressure drilling operations comprising:

15 a riser flow spool;

16 a riser isolation device;

17 an upper riser disconnect assembly and;

18 a rotary control device;

19 wherein at least the riser flow spool is configured to be connected to the riser below a riser
20 tension ring and wherein the upper riser disconnect assembly and the rotary control device
21 are configured to be connected to the riser above the tension ring.
22

23 Preferably the riser flow spool and the riser isolation device are configured to be
24 connected to the riser below the tension ring.
25

26 Preferably the upper riser disconnect assembly is configured to be connected to a slip joint
27 above the tension ring.
28

29 Preferably the rotary control device may be configured to be connected to the upper riser
30 disconnect assembly above the tension ring. Preferably the rotary control device is
31 configured to be releasably connected to the riser assembly above the tension ring via the
32 upper riser disconnect assembly.
33

34 Embodiments of the third aspect of the invention may include one or more features of the
35 first or second aspects of the invention or its embodiments, or vice versa.

1 According to a fourth aspect of the invention there is provided a method of installing a riser
2 gas handling system in a subsea riser comprising:
3 installing a riser flow spool assembly on the riser below the tension ring; and
4 installing an upper riser disconnect assembly above the tension ring.

5
6 The method may comprise installing a riser isolation device below the tension ring. The
7 method may comprise installing a riser isolation device on the riser string below the
8 tension ring.

9
10 The method may comprise installing the riser flow spool assembly below the riser isolation
11 device.

12
13 The method may comprise providing a distribution assembly and/or a choke manifold.
14 The method may comprise making up a tension ring. The method may comprise
15 connecting the tension ring to the riser, riser isolation device, slip joint and/or the upper
16 riser disconnect assembly.

17
18 The method may comprise raising the RID and RFS to a position just below the tension
19 ring. The method may comprise raising the RID and RFS to a position just below the
20 tension ring by positioning a riser tension joint between the RID and the tension ring.

21
22 The method may comprise connecting a RCD and/or other drilling components to the
23 upper riser disconnect assembly.

24
25 The method may comprise installing the upper riser disconnect assembly on the riser
26 string above the tension ring. The method may comprise bolting, welding and/or clamping
27 the rotary control device onto an upper connector of the upper riser disconnect assembly.

28 The method may comprise connecting a lower connector of the upper riser disconnect
29 assembly onto a tension ring, tension joint and/or an outer slip joint barrel. The method
30 may comprise connecting the slip joint to the rotary control device

31
32 The method may comprise coupling the upper and lower connectors of the upper riser
33 disconnect assembly.

34

1 Embodiments of the fourth aspect of the invention may include one or more features of the
2 first, second or third aspects of the invention or their embodiments, or vice versa.

3
4 According to a fifth aspect of the invention there is provided a method of installing a riser
5 gas handling system to enable managed pressure subsea drilling on a subsea riser
6 comprising:
7 installing a riser flow spool assembly on the riser below the tension ring; and
8 installing an upper riser disconnect assembly and a rotary control device above the tension
9 ring.

10
11 The method may comprise installing a riser isolation device below the tension ring. The
12 method may comprise installing a riser isolation device on the riser string below the
13 tension ring.

14 The method may comprise providing a distribution assembly, a choke manifold and/or
15 MPD choke manifold.

16
17 The method may comprise making up the tension ring. The method may comprise
18 connecting the tension ring to the riser, RID, slip joint and/or the upper riser disconnect
19 assembly.

20
21 The method may comprise installing the upper riser disconnect assembly on the riser
22 string and then installing the rotary control device onto the upper riser disconnect
23 assembly. The rotary control device may be installed on the upper riser disconnect
24 assembly by releasably latching onto the upper riser disconnect assembly.

25
26 Embodiments of the fifth aspect of the invention may include one or more features of the
27 first to fourth aspects of the invention or their embodiments, or vice versa.

28
29 According to a sixth aspect of the invention there is provided a method of converting a
30 marine riser for RGH operations comprising:

31 installing a riser flow spool assembly on the riser below the tension ring; and
32 installing an upper riser disconnect assembly above the tension ring.

33

1 The method may comprise installing a riser isolation device below the tension ring. The
2 method may comprise installing a riser isolation device on the riser string below the
3 tension ring.

4
5 The method may comprise removing an existing slip joint and/or an existing slip joint inner
6 barrel on the subsea riser.

7
8 The method may comprise installing the RFS and RID onto an existing riser. The method
9 may comprise installing the RFS and RID onto an existing riser above an existing riser
10 termination joint.

11
12 The method may comprise installing a riser auxiliary line termination joint on the existing
13 riser. The method may comprise installing the RFS and RID onto the termination joint.

14
15 The method may comprise making up the tension ring. The method may comprise
16 connecting the tension ring to the riser, RID, slip joint and/or the upper riser disconnect
17 assembly.

18
19 The method may comprise installing a slip joint outer barrel onto the RID. The tension ring
20 may be made up and connected to the slip joint outer barrel.

21
22 The method may comprise installing the upper riser disconnect assembly above the
23 tension ring.

24
25 The method may comprise reversibly latching a slip joint to the upper riser disconnect
26 assembly.

27
28 Embodiments of the sixth aspect of the invention may include one or more features of the
29 first to fifth third aspects of the invention or their embodiments, or vice versa.

30
31 According to a seventh aspect of the invention there is provided a method of converting a
32 marine riser for RGH operations which enables managed pressure subsea drilling
33 operations comprising:
34 installing a riser flow spool assembly on the riser below the tension ring; and

1 installing an upper riser disconnect assembly and a rotary control device above the tension
2 ring.

3
4 The method may comprise installing a riser isolation device below the tension ring. The
5 method may comprise installing a riser isolation device on the riser string below the
6 tension ring.

7
8 The method may comprise providing a distribution assembly, a choke manifold and/or
9 MPD choke manifold.

10
11 The method may comprise removing an existing slip joint and/or an existing slip joint inner
12 barrel on the subsea riser.

13
14 The method may comprise installing the RFS and RID onto an existing riser. The method
15 may comprise installing the RFS and RID onto an existing riser above an existing riser
16 termination joint.

17
18 The method may comprise installing a riser auxiliary line termination joint on the existing
19 riser. The method may comprise installing the RFS and RID onto the termination joint.

20
21 The method may comprise making up the tension ring. The method may comprise
22 connecting the tension ring to the riser, RID, slip joint and/or the upper riser disconnect
23 assembly.

24
25 The method may comprise installing a slip joint outer barrel onto the RID. The tension ring
26 may be made up and connected to the slip joint outer barrel.

27
28 The method may comprise installing a lower connector of the upper riser disconnect
29 assembly on the riser string above the tension ring. The method may comprise installing a
30 rotary control device made up with a connector configured to releasably latch onto the
31 lower connector of the upper riser disconnect assembly.

32
33 The method may comprise bolting, welding and/or clamping the rotary control device onto
34 an upper connector of the upper riser disconnect assembly. The method may comprise
35 connecting a lower connector of the upper riser disconnect assembly onto a tension ring,

1 tension joint and/or an outer slip joint barrel. The method may comprise connecting the slip
2 joint to the rotary control device.

3
4 The method may comprise coupling/decoupling the upper and lower connectors of the
5 upper riser disconnect assembly to/from one another.

6
7 The method may comprise connecting a slip joint to the rotary control device.

8
9 Embodiments of the seventh aspect of the invention may include one or more features of
10 any of the first to sixth aspects of the invention or their embodiments, or vice versa.

11
12 According to an eighth aspect of the invention there is provided a method of handling riser
13 gas in a subsea riser comprising:

14 providing a riser assembly comprising:

15 a riser flow spool;

16 a riser isolation device and

17 an upper riser disconnect assembly;

18 wherein the riser flow spool is located on a riser below a riser tension ring and wherein the
19 upper riser disconnect assembly is located above the riser tension ring;

20 actuating the riser isolation device to close the riser above the riser flow spool and

21 actuating the riser flow spool to divert gas trapped below the riser isolation device.

22
23 Preferably the riser flow spool and the riser isolation device are configured to be
24 connected to the riser below the tension ring.

25
26 The method may comprise actuating a blowout preventer on the riser to close the riser
27 below the flow spool.

28
29 The method may comprise actuating a distribution manifold and/or riser gas handling
30 choke to control the diversion of gas trapped below the riser isolation device.

31
32 The method may comprise opening valves on the riser flow spool, distribution manifold
33 and/or riser gas handling choke to enable the gas to flow to a mud gas separator.

34

1 Embodiments of the eighth aspect of the invention may include one or more features of
2 any of the first to seventh aspects of the invention or their embodiments, or vice versa.

3
4 According to a ninth aspect of the invention there is provided a method of handling riser
5 gas in a subsea riser during managed pressure subsea drilling operations comprising:
6 providing a riser assembly comprising:

7 a riser flow spool;

8 a riser isolation device and

9 an upper riser disconnect assembly;

10 wherein the riser flow spool is located on a riser below a riser tension ring and wherein the
11 upper riser disconnect assembly is located above the riser tension ring;

12 actuating the riser isolation device to close the riser above the riser flow spool and

13 actuating the riser flow spool to divert gas trapped below the riser isolation device.

14
15 Preferably the riser flow spool and the riser isolation device are configured to be
16 connected to the riser below the tension ring.

17
18 The method may comprise providing a rotary control device. The rotary control device may
19 be releasably connected to the upper riser disconnect assembly.

20
21 The method may comprise actuating a blowout preventer on the riser to close the riser
22 below the flow spool.

23
24 The method may comprise controlling the diversion of gas trapped below the riser isolation
25 device. The method may comprise actuating a distribution manifold and/or riser gas
26 handling choke to control the diversion of gas trapped below the riser isolation device.

27
28 The method may comprise opening valves on the riser flow spool, distribution manifold
29 and/or riser gas handling choke to enable the gas to flow to a mud gas separator.

30
31 Embodiments of the ninth aspect of the invention may include one or more features of any
32 of the first to eighth aspects of the invention or their embodiments, or vice versa.

33
34 According to a tenth aspect of the invention, there is provided a kit of parts for converting a
35 riser for riser gas handling operations, the kit of parts including:

1 a riser flow spool;
2 a riser isolation device and
3 an upper riser disconnect assembly;
4 wherein the riser flow spool and riser isolation device are mountable on a riser string below
5 a riser tension ring; and
6 wherein the upper riser disconnect assembly is mountable on the riser string above the
7 riser tension ring.

8

9 Preferably, the riser flow spool has connections configured to engage and connect to a
10 riser below a riser tension ring.

11

12 The riser flow spool may be engageable with the riser isolation device. Preferably, the riser
13 flow spool and riser isolation device form an integrated unit.

14

15 The kit of parts may comprise a slip joint.

16

17 Preferably, the upper riser disconnect assembly has connections configured to engage
18 and mount a slip joint above a riser tension ring.

19

20 The kit of parts may comprise a choke manifold and/or distribution manifold.

21

22 The kit of parts may comprise a rotary control device for converting a riser for riser gas
23 handling operations which enables managed pressure subsea drilling operations. The
24 rotary control device may be mountable on the riser string above the riser tension ring.

25

26 Preferably the rotary control device may be releasably mountable on the upper riser
27 disconnect assembly.

28

29 Embodiments of the tenth aspect of the invention may include one or more features of any
30 of the first to ninth aspects of the invention or their embodiments, or vice versa.

31

32 According to an eleventh aspect of the invention there is provided a method of installing a
33 rotary control device in a riser with riser gas handling comprising:

34 providing a riser assembly comprising

35 a riser flow spool;

1 a riser isolation device; and
2 an upper riser disconnect assembly;
3 wherein at least the riser flow spool is connected to the riser below a riser tension ring and
4 wherein the upper riser disconnect assembly is connected to the riser above the tension
5 ring and
6 connecting a rotary control device to the upper riser disconnect assembly.

7
8 Preferably the riser flow spool and the riser isolation device are configured to be
9 connected to the riser below the tension ring.

10
11 The method may comprise closing a blowout preventer on the riser prior to connecting the
12 rotary control device to the upper riser disconnect assembly.

13
14 Embodiments of the eleventh aspect of the invention may include one or more features of
15 any of the first to tenth aspects of the invention or their embodiments, or vice versa.

16
17 According to a twelfth aspect of the invention there is provided a method of recovering a
18 rotary control device from a riser comprising:

19 providing a riser assembly comprising

20 a riser flow spool;

21 a riser isolation device;

22 an upper riser disconnect assembly and

23 a rotary control device;

24 wherein at least the riser flow spool is connected to the riser below a riser tension ring and

25 wherein the upper riser disconnect assembly and the rotary control device are connected

26 to the riser above the tension ring and

27 disconnecting the rotary control device from the riser above the tension ring.

28
29 The method may comprise actuating the upper riser disconnect assembly to disconnect
30 the rotary control device from the riser assembly.

31
32 The method may comprise closing a blowout preventer on the riser prior to disconnect the
33 rotary control device.

34

1 Embodiments of the twelfth aspect of the invention may include one or more features of
2 any of the first to eleventh aspects of the invention or their embodiments, or vice versa.

3
4 According to a thirteenth aspect of the invention there is provided a method of replacing a
5 rotary control device on a riser comprising:

6 providing a riser assembly comprising

7 a riser flow spool;

8 a riser isolation device;

9 an upper riser disconnect assembly and

10 a rotary control device;

11 wherein at least the riser flow spool is connected to the riser below a riser tension ring and

12 wherein the upper riser disconnect assembly and the rotary control device are connected

13 to the riser above the tension ring;

14 disconnecting the rotary control device; and

15 connecting a replacement rotary control device to the riser above the tension ring.

16
17 The method may comprise actuating the upper riser disconnect assembly to disconnect

18 the rotary control device from the riser assembly. The method may comprise actuating the

19 upper riser disconnect assembly to disconnect the upper riser disconnect assembly and

20 rotary control device from the riser assembly.

21
22 The method may comprise actuating the upper riser disconnect assembly to connect the

23 replacement rotary control device to the riser assembly. The method may comprise

24 actuating the upper riser disconnect assembly to connect the upper riser disconnect

25 assembly and replacement rotary control device to the riser assembly.

26
27 The method may comprise closing a blowout preventer on the riser prior to disconnect the

28 rotary control device. The method may comprise closing a blowout preventer on the riser

29 prior to connecting the replacement rotary control device.

30
31 Embodiments of the thirteenth aspect of the invention may include one or more features of

32 any of the first to twelfth aspects of the invention or their embodiments, or vice versa.

Brief description of the drawings

There will now be described, by way of example only, various embodiments of the invention with reference to the drawings, of which:

Figures 1A and 1B are representations of riser assemblies according to the prior art;

Figure 2 is a schematic representation of a riser assembly with a RGH system for conventional drilling according to a first embodiment of the invention;

Figure 3 is a schematic representation of a riser assembly with a RGH system for managed pressure drilling according to a second embodiment of the invention;

Figure 4A, 4B and 4C are schematic representations of conventional riser assemblies shown in Figure 1A and 1B converted for RGH operations;

Figure 5A and 5B are schematic representations of the riser assemblies with RGH systems of Figures 4A and 4B for managed pressure drilling according to an embodiment of the invention;

Figure 6 is a block diagram of a RGH system for a conventional drilling operation according to an embodiment of the invention; and

Figure 7 is a block diagram of a RGH system for a managed pressure drilling operation according to a further embodiment of the invention.

Figure 8 is schematic drawings of a riser assembly with an integrated RGH system according to an embodiment of the invention.

Figure 9A and 9B are schematic drawings of different configurations of riser assembly with an integrated RGH system for managed pressure drilling according to an embodiment of the invention.

Detailed description of preferred embodiments

Figures 1A and 1B show features of conventional drilling riser assemblies for extracting oil and natural gas from a subsea reservoir known in the prior art.

The riser assembly 10 comprises a riser 12 located between a rig platform 16 and a blowout preventer (BOP) assembly (not shown) secured to the top of the wellhead. The riser 12 is connected to a slip joint 14. The slip joint 14 is configured to respond to heave movement of the platform 16 during dynamic sea conditions.

A portion of platform 16 is shown, which may be a floating rig or drillship. The platform supports the riser assembly 10 and comprises a moon pool opening 18. A plurality of tensioning cylinders 20 are secured to the platform and exert an upward force on rods or cables 22. The lower end of each rod or cable 22 is connected to a riser tensioning ring 24 which is connected to maintain the stability of the riser 12 in the offshore environment.

External auxiliary lines 26 are connected to the BOP (not shown) and circulate fluids and provide control lines to the BOP. A termination ring 28 is disposed circumferentially about a portion of the riser 12. The auxiliary lines 26 terminate at the termination ring. Flexible hoses 30 are connected to the termination ring 28 and extend upward coupling to the platform. The hoses 30 have been truncated in these drawings for clarity. The termination joint 28 provides fluid communication between the auxiliary lines 26 and the flexible hoses 30.

Figure 2 schematically shows features of the riser assembly with RGH according to a first embodiment of the present invention. It will be appreciated that the RGH system can adopt different configurations depending on the type of riser system on which it is being installed and the type of drilling operation. Figure 2 represents one possible configuration that the RGH system may adopt.

The riser assembly 100 with RGH system comprises a riser 112 located between a platform 116 and a blowout preventer (BOP) assembly (not shown) secured to the top of the wellhead.

1 The RGH system comprises a riser flow spool (RFS) 134 connected to the riser 112 and a
2 riser isolation device (RID) 136 mounted above the RFS 134. The RFS and RID are
3 disposed on the riser string below the tension ring 124.

4
5 The RFS comprises two flexible hoses 140 which have been truncated in Figure 2 for
6 clarity. The hoses 140 are connected to a choke manifold or distribution manifold (not
7 shown) to divert return flow to the choke manifold and/or distribution manifold for handling
8 as discussed in Figure 6 below.

9
10 The tension ring 124 is disposed circumferentially about a tension joint 125 located
11 between the RID 136 and the quick disconnect assembly 150. Although in this example
12 the tension ring 124 is connected to tension joint 125, it may alternatively be connected to
13 an existing rig outer barrel located between the RID 136 and the quick disconnect
14 assembly 150. The RID 136 and RFS 134 are disposed below the tension ring 124 and
15 the quick disconnect assembly 150 is disposed above the tension ring 124.

16
17 Tensioning cylinders 120 are secured to the platform 116 and exert an upward force on
18 rods or cables 122. The lower end of each rod or cable 122 is connected to a riser
19 tensioning ring 124 which is connected to maintain the stability of the riser string.

20 The quick disconnect assembly 150 is connected to a slip joint 114. The slip joint 114 is
21 configured to respond to heave movement of the platform 116 during dynamic sea
22 conditions. The platform 116 supports the riser 112 and RGH system 100. The slip joint is
23 a telescopic three-part slip joint. However, it is appreciated that other types of slip joint
24 may be used. The slip joint enables the riser system to adjust in length as the platform
25 heaves in response to motion of the waves.

26
27 It will be appreciated that this is an example configuration of an RGH system and that
28 other components may be included in an RGH system depending on the type of drilling
29 operation. In some embodiments, the riser gas handling system may include additional
30 assemblies such as a rotating control device and/or diverter systems capable of releasably
31 coupling to the RGH system for different drilling operations.

32
33 Figure 3 schematically shows features of the riser assembly 200 with RGH system
34 enabled for Managed Pressure Drilling (MPD) operations according to an embodiment of
35 the present invention. The RGH system 200 is similar to the system 100 described in

Figure 2 and will be understood from the description of Figure 2. However, the system 200 described in Figure 3 includes a rotating control device (RCD) 260 connected above the quick disconnect assembly 250 and below the slip joint 214.

In this configuration the RCD 260 is disposed above the tension ring 224 and may be easily installed on the riser assembly when managed pressure drilling is required.

The RCD 260 is a drill through device with a rotating internal sealing element that seals against the drill string to create a pressure-tight barrier. The RCD 260 is installed between the disconnect assembly 250 and the slip joint 214 above the tension ring 224.

A MPD choke manifold is also provided (not shown). The choke manifold is connected to the distribution manifold and is configured to receive drilling fluid from the annulus and restricts the flow of the drilling fluid to adjust the pressure in the annulus.

When managed pressure drilling operations are not required the RCD 260 may be removed by decoupling and/or unlatching the quick disconnect assembly 250. The RGH system will then adopt the configuration described in Figure 2. By facilitating the easy installation and/or removal of the RCD it may only be installed when MPD operation are required. This may extend the working lifespan of the RCD and reduce operating costs.

By locating the RCD 260 above the tension ring 224 the RCD 260 may be quickly and easily removed without removing components of the RGH system 200 below the tension ring 224 or disconnecting the BOP. The compact size of the RCD 260 and the quick disconnect assembly 250 above the tension ring 224 reduces or minimises loss of stroke length of the slip joint, without adjustment of the vertical position of the tension ring from its preferred location. This facilitates marine riser assemblies to be located in areas which experience dynamic sea conditions to be converted for RGH systems.

Figure 4A, 4B and 4C show schematic representation of conventional drill systems shown in Figure 1A and 1B converted for RGH operations.

In Figure 1A the auxiliary lines 26 terminate below the slip joint. As shown in Figure 4A, to convert this riser for RGH operations the existing slip joint shown as 14 in Figure 1A is removed. The RFS 334 and RID 336 are installed onto the existing riser 312 above the

1 existing riser termination ring 328. The tension ring 324 is made up and connected above
2 the RID 336 on the tension joint 325. The lower connector 350a of the disconnect
3 assembly 350 is then installed on the tension joint 325 above the tension ring 324. The
4 telescopic slip joint 314 is made up with an upper connector 350b and is run in and
5 releasably latched to the lower connector of the disconnect assembly 350.

6
7 To convert the conventional drill systems shown in Figure 1B for RGH operations there are
8 two options for terminating the auxiliary lines. The first example provides a riser assembly
9 RGH system 400 with the auxiliary lines terminating below the RFS and RID as described
10 below and shown in Figure 4B. An alternative is to provide a riser assembly RGH system
11 500 with the auxiliary lines terminating above the RFS and RID as described below and
12 shown in Figure 4C.

13
14 To install the RGH system 400 with the auxiliary lines terminating below the RFS and RID
15 as shown in Figure 4B, the existing slip joint shown as 14 in Figure 1B is removed.

16
17 A new riser auxiliary line termination joint 462 is installed on the existing riser 412. The
18 RFS 434 and RID 436 are installed above the termination joint 462. The tension ring 424 is
19 made up and connected to a tension joint 425 positioned above the RID 436. The lower
20 connector 450a of disconnect assembly 450 is installed above the tension ring 424. The
21 telescopic slip joint 414 is made up with upper connector 450b and run in and releasably
22 latched to the lower connector 450a of disconnect assembly 450.

23
24 Figure 4C shows a conventional drill system shown in Figure 1B converted to include a
25 RGH system. In Figure 1B the auxiliary lines 26 terminate on the slip joint outer barrel. The
26 example shown in Figure 4C provides a riser assembly 500 with the auxiliary lines 526
27 terminating above the RFS 534 and RID 536.

28
29 To install the RGH system in this type riser assembly the existing slip joint inner barrel is
30 removed. The RFS 534 and RID 536 are installed onto the existing riser 512. The slip joint
31 outer barrel 515 is installed onto the RID 536. The tension ring is made up and connected
32 to an upper end of the slip joint outer barrel 515. The lower connector 550a of quick
33 disconnect assembly 550 is then installed on the slip joint outer barrel 515 above the
34 tension ring 524. The telescopic joint 514 is made up with an upper connector 550b and is

1 run in and releasably latched to the lower connector 550a of quick disconnect assembly
2 550.

3
4 Figures 5A and 5B show schematic representations of the RGH systems of Figures 4A
5 and 4B setup for managed pressure drilling according to an embodiment of the invention.

6
7 The system 600 is similar to the configuration of the systems 300, 500 described in
8 Figures 4A and 4C and will be understood from the descriptions of Figure 4A and 4C
9 above. However, the system 600 described in Figures 5A and 5B includes a rotating
10 control device (RCD) 660 connected above the quick disconnect assembly and below the
11 slip joint 614.

12
13 A MPD choke manifold is also provided (not shown). The choke manifold is connected to
14 the distribution manifold and receives drilling fluid from the riser annulus. The RCD 660
15 and choke manifold control are configured to maintain the desired pressure in the annulus
16 to allow managed pressure drilling operations.

17
18 By locating the RCD 660 above the tension ring 624 the RCD 660 may be quickly and
19 easily removed without removing components of the RGH system below the tension ring
20 or requiring the BOP to be disconnected. The compact size of the RCD and the quick
21 disconnect assembly above the tension ring maximizes the space available above the
22 tension ring 624 and minimizes the loss of the slip joint stroke length.

23
24 Figure 6 shows a flow diagram of a method of operating the RGH system during a
25 conventional drilling operation.

26
27 The RGH system 700 is similar to the configuration of the system 200 described in Figure
28 2 and will be understood from the description of Figure 2 above.

29
30 The RGH system 700 comprises a RFS 734 with two return flowlines 730 and 731. The
31 RFS is also provided with a riser protection line 732. In this example the flowlines are six
32 inch flexible hoses. However, it should be appreciated that a different number and
33 configuration of flowlines may be used.

34

1 The RGH system 700 also comprises a RID 736 and quick disconnect assembly 750. The
2 RID 736 comprises a packing element (not shown). A tension ring (not shown) is
3 configured to be connected to the riser assembly between the RID 736 and quick
4 disconnect assembly 750.

5
6 During conventional drilling operations, the RID is open. In the event of a gas kick,
7 formation gas may go into solution in the mud and may get past the subsea BOP resulting
8 in release of gas into the riser which may endanger personnel and damage the riser and
9 platform.

10
11 An annular BOP (not shown) located on the lower riser is closed to seal around the drill
12 string. The RID 736 is closed around the drill string to isolate the upper riser system and
13 allow any gas in the riser to be contained.

14
15 After the RID 736 has been closed a volume of gas is trapped below the RID. The function
16 of the RFS 734 is to divert the isolated gas. The options for venting the gas are either to a
17 Mud-Gas Separator 780 (MGS) via the RGH choke or can be diverted overboard via valve
18 776e.

19
20 A riser over pressure protection system will vent the gas overboard via the riser protection
21 line 732 on the RFS in the event of a control system failure.

22
23 In order to circulate the gas to the MGS 780, isolation valves 730a and 731a on the RFS
24 are opened to allow trapped gas to be safely circulated along at least one of the flowlines
25 730 and 731 to the distribution manifold 770 and choke manifold 772 for gas handling.
26 Valves 774a, 774b, 774c and 774d in the distribution manifold 770 and valves 776a, 776c
27 on the choke manifold 772 are opened to open a pathway to the RGH chokes 776b and
28 776d used to maintain a back pressure in the riser allowing the gas to be circulated out in
29 a controlled manor to the MGS to capture and separate large volume of free gas from the
30 mud. The gas once separated from the mud is then safely vented via pathway 782.

31
32 Figure 7 shows a flow diagram of a method of operating the RGH system during
33 conventional drilling operations.

34

1 The method of operating the RGH system described in system 800 is similar to the method
2 of operating the RGH system described in system 700 and Figure 6 and will be understood
3 from the description of Figure 6 above. However, the system 800 includes operation of a
4 rotating control device (RCD) 860 connected above the quick disconnect assembly 850
5 and below the slip joint 814.

6
7 During managed pressure drilling operations, the RCD 860 provides a rotating internal
8 sealing element that seals against the drill string to create a pressure-tight barrier for the
9 purpose of controlling the pressure or fluid flow to surface. A MPD Choke Manifold 868 is
10 connected to the distribution manifold 870 and enables control of the annular pressure by
11 increasing or decreasing the annual flow.

12
13 In the event of a gas kick the annular BOP (not shown) located on the lower riser is closed
14 to seal around the drill string. The RID 836 is closed around the drill string to isolate the
15 upper riser system and allow any gas in the riser to be contained. The gas handling
16 method as described in Figure 6 above is followed while valve 874e on the distribution
17 manifold 870 is isolated.

18
19 Figure 8 shows a schematic drawing of a riser assembly with an integrated RGH.
20 The riser assembly 900 comprises a riser 912 located between a rig platform 916 and a
21 blowout preventer (BOP) assembly (not shown) secured to the top of the wellhead. The
22 riser 912 is connected to a slip joint 914. A rig diverter 913a and flex joint 913b are located
23 at the top of the riser assembly. The slip joint 914 is configured to respond to heave
24 movement of the platform 916 during dynamic sea conditions.

25
26 A portion of platform 916 is shown, which may be a floating rig or drillship. The platform
27 supports the riser assembly 900 and comprises a moon pool opening 918. A plurality of
28 tensioning cylinders 920 are secured to the platform and exert an upward force on rods or
29 cables 922. The lower end of each rod or cable 922 is connected to a riser tensioning ring
30 924 which is connected to maintain the stability of the riser 912 in the offshore
31 environment.

32
33 The RGH system integrated on the riser assembly comprises a riser flow spool (RFS) 934
34 connected to the riser 912 and a riser isolation device (RID) 936 mounted above the RFS

1 934. The RFS and RID are disposed on the riser string below the tension ring 924. The
2 RFS comprises two flexible hoses 940.

3
4 The tension ring 924 is connected to a tension joint 925 which is positioned between the
5 RID 936 and the quick disconnect assembly 950. Although in this example the tension ring
6 is shown connected an interface between the RID 936 and the quick disconnect assembly
7 950, the tension ring may be connected to other components of the riser assembly. The
8 RID 936 and RFS 934 are disposed below the tension ring 924 and the quick disconnect
9 assembly 950 is disposed above the tension ring 924.

10 The quick disconnect assembly 950 is connected to the slip joint 914. The slip joint 914 is
11 configured to respond to heave movement of the platform 916 during dynamic sea
12 conditions. The platform 916 supports the riser 912. The slip joint 914 is a telescopic three-
13 part slip joint. However, it is appreciated that other types of slip joint may be used. The slip
14 joint enables the riser system to adjust in length as the platform heaves in response to
15 motion of the waves.

16
17 Figure 9A and 9B are schematic drawings of different configurations of riser assembly with
18 an integrated RGH system for managed pressure drilling.

19
20 The riser assembly described in Figures 9A and 9B is similar to the configuration of the
21 assembly in Figure 8 and will be understood from the description of Figure 8 above.

22 However, riser assemblies described in Figures 9A and 9B includes a rotating control
23 device (RCD) 1060 connected above the quick disconnect assembly and below the slip
24 joint 1014.

25
26 By locating the RCD 1060 above the tension ring 1024 the RCD 1060 may be quickly and
27 easily removed from the riser assembly without requiring the removal of components of the
28 riser assembly 1000 below the tension ring 1024 or disconnecting the BOP. The compact
29 size of the RCD 1060 and the quick disconnect assembly 1050 above the tension ring
30 1024 enable the riser assembly to maximise the space available above the tension ring
31 and minimise the loss of the slip joint stroke length. This facilitates marine riser assemblies
32 to be located in areas which experience dynamic sea conditions to be converted for RGH
33 systems.

1 The quick disconnect assembly 1050 is releasably connected to a RCD 1060. The slip
2 joint 1014 is connected to the RCD 1060. The slip joint 1014 is configured to respond to
3 heave movement of the platform 1016 during dynamic sea conditions. The platform 1016
4 supports the riser 1012. The slip joint 1014 is a telescopic three-part slip joint. However, it
5 is appreciated that other types of slip joint may be used. The slip joint enables the riser
6 system to adjust in length as the platform heaves in response to motion of the waves.

7
8 The riser assembly described in Figure 9B is similar to the configuration of the assembly in
9 Figure 9A. However, in Figure 9B the tension joint 1025 (Figure 9A) is not present. The
10 tension ring interface is a rig telescopic joint outer barrel 1027.

11 The RID 1036 and RFS 1034 are mounted on the riser 1012. The rig telescopic joint outer
12 barrel 1027 is connected above the RID 1036. The tension ring 1024 is connected to rig
13 telescopic joint outer barrel 1027.

14
15 The quick disconnect assembly 1050, RCD 1060 and slip joint 1014 are connected as
16 described in Figure 9A above.

17
18 Throughout the specification, unless the context demands otherwise, the terms 'comprise'
19 or 'include', or variations such as 'comprises' or 'comprising', 'includes' or 'including' will be
20 understood to imply the inclusion of a stated integer or group of integers, but not the
21 exclusion of any other integer or group of integers.

22
23 Furthermore, relative terms such as", "lower", "upper", "up", "down", above, below and the
24 like are used herein to indicate directions and locations as they apply to the appended
25 drawings and will not be construed as limiting the invention and features thereof to
26 particular arrangements or orientations.

27
28 The RGH systems described above may be provided with a plurality of pressure sensors
29 and/or flow meters disposed throughout the RGH system to monitor pressure and/or flow
30 rate at various stages of the RGH system.

31
32 The invention provides a system for handling gas in a riser. The system comprises
33 a riser flow spool, a riser isolation device and an upper riser disconnect assembly wherein
34 at least the riser flow spool is connected to the riser below a riser tension ring and the
35 upper riser disconnect assembly is located above the riser tension ring.

1 The present invention provides a riser gas handling system with improved reliability and
2 accessibility and which is capable of supporting conventional and managed pressure
3 drilling systems.

4
5 The invention may facilitate the conversion of marine riser assemblies for RGH operations
6 which enable conventional and/or managed pressure drilling operations.

7
8 By providing an upper riser disconnect assembly above the tension ring, components of
9 the drilling or RGH operation may quickly, safely and easily installed and/or removed from
10 the riser assembly without requiring the BOP to be disconnected and the riser string pulled
11 to surface. This configuration may allow components of a riser assembly, drilling system or
12 RGH system to be installed only when they are required.

13
14 By providing at least the RFS below the tension ring and the upper riser disconnect
15 assembly above the tension ring, the invention facilitates the easy and efficient installation
16 and/or recovery of drilling operation components such as a RCD from the upper riser
17 assembly while reducing and/or minimising a loss of stroke length in a slip joint provided
18 above the tension ring. This improves the ability of the riser assembly to withstand
19 dynamic heave conditions.

20
21 Embodiments of the invention may provide improved hose management as the hoses and
22 control lines connected to at least the RFS may be vertically offset from the tensioning
23 system by being located below the tension ring. By positioning the RFS hoses under the
24 tension ring they are not hindered by the tensioning cylinders or rods connected to the
25 tension ring.

26
27 The foregoing description of the invention has been presented for the purposes of
28 illustration and description and is not intended to be exhaustive or to limit the invention to
29 the precise form disclosed. The described embodiments were chosen and described in
30 order to best explain the principles of the invention and its practical application to thereby
31 enable others skilled in the art to best utilise the invention in various embodiments and
32 with various modifications as are suited to the particular use contemplated. Therefore,
33 further modifications or improvements may be incorporated without departing from the
34 scope of the invention herein intended.

Claims

1. A riser assembly (100, 200, 300, 400, 500, 600, 700, 800, 900, 1000) comprising:
 - a riser flow spool (134, 234, 334, 434, 534, 634, 734, 834, 934, 1034);
 - a riser isolation device (136, 236, 336, 436, 536, 636, 736, 836, 936, 1036) and
 - an upper riser disconnect assembly (150, 250, 350, 450, 550, 650, 750, 850, 950, 1050);
 wherein at least the riser flow spool is configured to be located on a riser (112, 212, 312, 412, 512, 612, 712, 812, 912, 1012) below a riser tension ring (124, 224, 324, 424, 524, 624, 724, 824, 924, 1024) and wherein the upper riser disconnect assembly is configured to be located above the riser tension ring.
2. The riser assembly (100, 200, 300, 400, 500, 600, 700, 800, 900, 1000) of claim 1 wherein the riser isolation device (136, 236, 336, 436, 536, 636, 736, 836, 936, 1036) is configured to be connected to the riser (112, 212, 312, 412, 512, 612, 712, 812, 912, 1012) below the tension ring (124, 224, 324, 424, 524, 624, 724, 824, 924, 1024).
3. The riser assembly (100, 200, 300, 400, 500, 600, 700, 800, 900, 1000) of claim 1 or claim 2 wherein the upper riser disconnect assembly (150, 250, 350, 450, 550, 650, 750, 850, 950, 1050) is configured to be connected to a rotating control device (260, 660, 860, 1060).
4. The riser assembly (100, 200, 300, 400, 500, 600, 700, 800, 900, 1000) of claim 3 wherein the rotating control device (260, 660, 860, 1060) is configured to be disposed above the upper riser disconnect assembly and/or wherein the upper riser disconnect assembly (150, 250, 350, 450, 550, 650, 750, 850, 950, 1050) is configured to be disposed below a slip joint (114, 214, 314, 414, 514, 614, 714, 814, 914, 1014).
5. The riser assembly (100, 200, 300, 400, 500, 600, 700, 800, 900, 1000) of any preceding claim wherein the riser flow spool (134, 234, 334, 434, 534, 634, 734, 834, 934, 1034) comprises at least one flowline (730, 731, 732), wherein the at least one flowline is configured to be connected to a distribution assembly (770), choke assembly (772), a safety valve and/or a mud-gas separator (780).

- 1
2 6. The riser assembly (100, 200, 300, 400, 500, 600, 700, 800, 900, 1000) of any
3 preceding claim wherein the upper riser disconnect assembly (150, 250, 350, 450,
4 550, 650, 750, 850, 950, 1050) comprises an upper connector and a lower connector
5 wherein the upper and lower connectors are configured to disconnect from one
6 another.
7
- 8 7. A system for handling gas in a riser (112, 212, 312, 412, 512, 612, 712, 812, 912,
9 1012) comprising the riser assembly (100, 200, 300, 400, 500, 600, 700, 800, 900,
10 1000) of any claims 1 to 6.
11
- 12 8. A method of installing a riser gas handling system in a subsea riser (112, 212, 312,
13 412, 512, 612, 712, 812, 912, 1012) comprising:
14 installing a riser flow spool assembly on the riser below the tension ring (124, 224,
15 324, 424, 524, 624, 724, 824, 924, 1024); and
16 installing an upper riser disconnect assembly (150, 250, 350, 450, 550, 650, 750,
17 850, 950, 1050) above the tension ring.
18
- 19 9. The method according to claim 8 comprising installing a riser isolation device 136,
20 236, 336, 436, 536, 636, 736, 836, 936, 1036) below the tension ring (124, 224, 324,
21 424, 524, 624, 724, 824, 924, 1024).
22
- 23 10. The method according to any one of claims 8 to 9 comprising installing a rotary
24 control device (260, 660, 860, 1060) above the tension ring (124, 224, 324, 424, 524,
25 624, 724, 824, 924, 1024) to enable managed pressure subsea drilling.
26
- 27 11. A method of converting a marine riser for RGH operations comprising:
28 installing a riser assembly (100, 200, 300, 400, 500, 600, 700, 800, 900, 1000) of
29 any of claims 1 to 6.
30
- 31 12. A method of handling riser gas in a subsea riser
32 using a riser assembly (100, 200, 300, 400, 500, 600, 700, 800, 900, 1000)
33 comprising:
34 a riser flow spool (134, 234, 334, 434, 534, 634, 734, 834, 934, 1034);
35 a riser isolation device (136, 236, 336, 436, 536, 636, 736, 836, 936, 1036) and

- 1 an upper riser disconnect assembly (150, 250, 350, 450, 550, 650, 750, 850,
2 950,1050); the method comprising:
3 locating the riser flow spool on a riser (112, 212, 312, 412, 512, 612, 712, 812, 912,
4 1012) below a riser tension ring (124, 224, 324, 424, 524, 624, 724, 824,
5 924,1024)and wherein the upper riser disconnect assembly is located above the
6 riser tension ring;
7 actuating the riser isolation device to close the riser above the riser flow spool and
8 actuating the riser flow spool to divert gas trapped below the riser isolation device.
9
- 10 13. The method according to claim 12 comprising providing a rotary control device (260,
11 660, 860, 1060) above the riser tension ring during managed pressure subsea
12 drilling operations.
13
- 14 14. A method of installing a rotary control device (260, 660, 860, 1060) in a riser (112,
15 212, 312, 412, 512, 612, 712, 812, 912, 1012) with riser gas handling or recovering
16 rotary control device from a riser
17 using a riser assembly (100, 200, 300, 400, 500, 600, 700, 800, 900, 1000)
18 comprising
19 a riser flow spool (134, 234, 334, 434, 534, 634, 734, 834, 934,1034);
20 a riser isolation device (136, 236, 336, 436, 536, 636, 736, 836, 936,1036); and
21 an upper riser disconnect assembly (150, 250, 350, 450, 550, 650, 750, 850,
22 950,1050); the method comprising:
23 connecting at least the riser flow spool to the riser below a riser tension ring and
24 wherein the upper riser disconnect assembly is connected to the riser above the
25 tension ring; and
26 connecting a rotary control device (260, 660, 860, 1060) to the upper riser
27 disconnect assembly to install a rotary control device in a riser; or
28 disconnecting a rotary control device from the riser above the tension ring to recover
29 a rotary control device from a riser.
30
- 31 15. The method according to claim 14 comprising closing a blowout preventer on the
32 riser (112, 212, 312, 412, 512, 612, 712, 812, 912, 1012) prior to connecting or
33 disconnecting the rotary control device (260, 660, 860, 1060)..
34
35

- 1 16. The method according to claim 14 or 15 comprising actuating the upper riser
- 2 disconnect assembly (150, 250, 350, 450, 550, 650, 750, 850, 950, 1050) to connect
- 3 or disconnect the rotary control device (260, 660, 860, 1060) from the riser
- 4 assembly.