

Title: Connector Assembly for Connecting a Hose to a Tubular

Description of Invention

5 The present invention relates to a connector assembly for connecting a hose to a tubular, particularly, but not exclusively, for connecting a flexible rubber hose to a flow spool provided in a drilling riser.

10 During drilling of an underwater wellbore, a riser is provided to return the drilling fluid (mud), cuttings and any other solids or fluids from the wellbore to the surface. The drill string extends down the centre of the riser, and the returning drilling fluid, cuttings etc flow along the annular space in the riser around the drill string (the riser annulus).

15 When drilling of the wellbore is carried out using a floating rig such as a drill ship, a semi-submersible, floating drilling or production platform, it is known to provide the riser with a slip joint which allows the riser to lengthen and shorten as the rig moves up and down as the sea level rises and falls with the tides and the waves. A ball joint (or flex-joint) is also provided to accommodate angular displacement of the riser from the vertical. The returning drilling fluid leaves the riser via a diverter which is mounted above the slip joint.

20 Such a slip joint is, for example, described in US 4,626,135, and comprises an outer tube section which is connected to the wellhead, and an inner tube section which sits within the outer tube section and which is connected to the rig floor. Seals are provided between the outer and inner tube sections, and these substantially prevent leakage of fluid from the riser whilst allowing the inner tube section to slide relative to the outer tube section.

25 This system also includes an annular blow out preventer which is located below the slip joint, and which is used as a gas handler to divert the flow of gas from a well control incident. An auxiliary choke line extends from the riser

below the point at which the riser annulus is closed by the blowout preventer, and, in the event of such an incident, the blow out preventer is closed, and a valve in an auxiliary choke line opened, so that the formation gas may be circulated out via the auxiliary choke line.

- 5     Drilling methods, such as managed pressure drilling (MPD) or mud cap drilling, which involve the pressurisation of fluid in the wellbore annulus are becoming increasingly important, and these require the ability to contain fluid pressure in the riser annulus during drilling. Examples of these type of systems are disclosed in US 6,904,981 and US 7,044,237.
- 10    In floating drilling rigs, wave motion means that the seals between the outer and inner tube sections of the slip joint are subjected to significant movement, and, as a result the pressure sealing capacity of the seals in conventional slip joint designs is limited. As a result, it is not possible to use the conventional marine riser drilling system described above for MPD.
- 15    To address this issue, an alternative system is presented in US2005/0061546 and US 6,913,092, in which a “rotating control head” including rotating blow out preventer (RBOP) or rotating control device (RCD) mounted above the slip joint. Connectors for diverting fluid from the riser are provided on the RCH housing below the RCD / RBOP. When used for MPD, the slip joint is locked
- 20    to eliminate movement across the slip joint seal, the RCD or RBOP is closed, and fluid returns are directed to the rig’s systems (separators, shakers etc) via hoses connected to the connectors.

A further alternative system is disclosed in WO2011/104279. In this system, the returning drilling fluid exits the riser via a flow spool which is mounted

- 25    below the RCD and above the slip joint. In this case, a high pressure slip joint is required – an example of a suitable design is disclosed in WO2012/143723.

It is also known to avoid subjecting the flow spool to high pressures during MPD by mounting the RCD / RBOP below the slip joint. Such an alternative

system for providing pressurised riser assembly is disclosed in US 2008/0105434. In this system, a universal riser section (OURS) is placed in the riser below the slip joint. The OURS includes, amongst other things, at least one rotating control device (RCD), together with all the usual connections and attachments required to operate the RCD, and at least one outlet for the fluid returns.

It is also known to replace a conventional slip-joint system with a specialised rotating control head system which includes one or more long “flow crosses” – conduits which extend horizontally from the riser, a flow spool or the rotating control device (RCD) housing. Valving and flexible hoses hang from each of the flow crosses, and the mud is returned from the riser annulus via the flow crosses and hoses.

Where fluid lines are connected to riser below the slip joint, the flexibility of the hoses accommodates the heave of the rig floor relative to the riser.

The present invention relates to an improved connector assembly for connecting hoses to a drilling riser, via a flow spool or the like, as is required in the systems mentioned above.

According to a first aspect of the invention we provide a connector assembly for connecting a hose to a tubular element, the connector assembly comprising a tubular housing which encloses a main passage extending generally parallel to a longitudinal axis of the housing and which is provided with a side passage extending through the housing from the exterior of the housing into the main passage, the side passage further extending through a connector tube which is mounted on the exterior of the housing, the connector further being provided with a hose connector adapted to be secured to an end of the hose and to engage with the connector tube for connecting the hose to the tubular element, the hose connector comprising a pipe portion which is adapted to mate with the connector tube so that the interior of the hose is

connected to the side passage, wherein the assembly is further provided with a latch which is operable to urge the connector tube and pipe portion into engagement and to prevent separation of the connector tube and pipe portion when the two are mated to connect the interior of the hose with the side  
5 passage.

The latch may be hydraulically operated.

The latch may be movable between an open position in which the connector tube and pipe portion may be separated, and a closed position in which it prevents separation of the connector tube and pipe portion, and configured  
10 such that, on movement of the latch from the closed position to the open position, the latch pushes the connector tube and pipe portion apart.

Advantageously the pipe portion is adapted to be placed over the connector tube so that the connector tube extends into the pipe portion when the two parts mate to connect the interior of the hose with the side passage.

15 In this case, the pipe portion is provided with a radially outwardly extending flange at its free end, and the latch is provided with a lowermost catch part and an uppermost catch part and is configured such that when the latch is in the closed position the uppermost catch part bears down on the flange thus preventing the pipe portion of being lifted off the connector tube, and as the  
20 latch is moved to the open position, the lowermost catch part pushes the flange up to commence lifting the pipe portion off the connector tube.

According to a second aspect of the invention we provide a connector for connecting a hose to a tubular element, the connector comprising two generally parallel pipe portions connected by a intermediate pipe portion, the  
25 connector being provided with a mounting part on which is located a first suspension part and a second suspension part to each of which a flexible elongate element such as a wire, chain or rope may, in use, be secured for lowering the connector into engagement with the tubular element, the two

suspension parts being spaced relative to one another, wherein one or both of the suspension parts is movable relative to the mounting part so that the separation of the suspension parts generally perpendicular to the two generally parallel pipe portions may be varied.

- 5 In one embodiment, only one of the suspension parts is movable relative to the mounting part so that the separation of the suspension parts generally perpendicular to the two generally parallel pipe portions may be varied.

In one embodiment, the intermediate portion is curved. In this case, the intermediate portion may be generally semicircular.

- 10 One or both of the suspension parts may comprise a loop which is pivotally mounted on the mounting part of the connector.

The or each movable suspension part may be mounted on a slider which can slide along a slot provided in the mounting part, each suspension part also including a fastener which is operable to releasably lock the slider in a desired

- 15 location relative to the slot.

The or each movable suspension part may be provided with a ratchet mechanism which is operable to assist in retaining the or each suspension part in the desired position relative to the mounting part.

- 20 According to a third aspect of the invention we provide a drilling riser and hose assembly, the hose being connected to the riser using a connector according to the first aspect of the invention.

The tubular element may be part of a flow spool mounted on the riser.

- 25 According to a fourth aspect of the invention we provide a connector assembly for connecting a hose to a tubular element, the connector assembly comprising a tubular housing which encloses a main passage extending generally parallel to a longitudinal axis of the housing and which is provided

with a side passage extending through the housing from the exterior of the housing into the main passage, the side passage further extending through a connector tube which is mounted on the exterior of the housing, wherein the connector assembly is further provided with an alignment structure which has  
5 a top part which extends radially outwardly relative to the tubular housing above a free end of the connector tube so that the longitudinal axis of the connector tube passes through the top part of the alignment structure.

In one embodiment the connector tube is mounted on the exterior of the housing such that a longitudinal axis of the connector tube is generally parallel  
10 to the longitudinal axis of the housing.

In one embodiment, the connector tube extends from a first end of the housing and the top part of the alignment structure extends from the housing between the connector tube and a second end of the housing.

The top part of the alignment structure may be inclined relative to the housing  
15 such that the portion closest to the housing is nearest to the connector tube, and the portion furthest from the housing is further away from the connector tube.

The alignment structure may further include two side parts which extend generally parallel to the longitudinal axis of the connector tube and which are  
20 arranged either side of the connector tube so that at least part of the connector tube is located between the two side parts.

In one embodiment, the connector assembly further comprises a hose connector adapted to be secured to an end of the hose and engaged with the connector tube for connecting the hose to the tubular element, the hose  
25 connector comprising two generally parallel pipe portions connected by a intermediate pipe portion, the connector being provided with a mounting part on which is located at least one suspension part to which a wire may, in use, be secured for lowering the hose connector into engagement with the

connector tube, the space between the top part of the alignment structure and the connector tube being greater than the length of the hose connector generally parallel to the two generally parallel pipe portions.

5 The hose connector may have any of the features of the connector according to the first aspect of the invention.

The tubular housing may be configured to be mounted on a drilling riser.

10 According to a fifth aspect of the invention we provide a connector assembly for connecting a hose to a tubular element, the connector assembly comprising a tubular housing which encloses a main passage extending generally parallel to a longitudinal axis of the housing and which is provided with a side passage extending through the housing from the exterior of the housing into the main passage, the side passage further extending through a connector tube which is mounted on the exterior of the housing, the connector further being provided with a hose connector adapted to be secured to an end  
15 of the hose and to engage with the connector tube for connecting the hose to the tubular element, the hose connector comprising a pipe portion which is adapted to mate with the connector tube so that the interior of the hose is connected to the side passage, wherein the connector tube and pipe portion of the hose connector are both circular in transverse cross-section and are both  
20 provided with a plurality of teeth which may be engaged to assist in retaining the connector tube and pipe portion in a desired angular orientation relative to one another.

Advantageously one of the connector tube and the pipe portion is adapted to extend into the other of the pipe portion or connector tube when the two parts  
25 mate to connect the interior of the hose with the side passage. In one embodiment, the pipe portion is adapted to be placed over the connector tube so that the connector tube extends into the pipe portion when the two parts mate to connect the interior of the hose with the side passage.

In this case, the one of the connector tube or pipe portion which is located outside the other when the two mate to connect the interior of the hose with the side passage may be provided with a radially outwardly extending flange at its free end, the teeth being provided in a surface of the flange which, in use,  
5 extends perpendicular to the longitudinal axis of the connector tube.

The assembly may further be provided with a latch which is operable to urge the teeth of the connector tube and pipe portion into engagement and to prevent separation of the connector tube and pipe portion when the two are mated to connect the interior of the hose with the side passage.

10 The latch may be hydraulically operated.

The latch may be movable between an open position in which the connector tube and pipe portion may be separated, and a closed position in which it prevents separation of the connector tube and pipe portion, and configured such that, on movement of the latch from the closed position to the open  
15 position, the latch pushes the connector tube and pipe portion apart.

The tubular housing may be adapted to be secured to a drilling riser.

According to a sixth aspect of the invention we provide a riser flow diversion assembly having a main passage, a side port connecting the main passage with the exterior of the flow spool, and mounting parts suitable for mounting  
20 the assembly on a riser so that the main passage forms a continuous passage with the riser, the assembly further including a hose connector assembly comprising a connector tube through which the side passage extends, and which is mounted on the exterior of the housing such that the a longitudinal axis of the connector tube is generally parallel to the main passage.

25 The riser flow diversion assembly may be provided with a plurality of side ports, each of which has an associated hose connector assembly. In this

case, the hose connectors may be spaced around the circumference of the flow spool in a substantially regular array.

Advantageously, the outer diameter of the flow spool and associated hose connector(s) does not exceed 46.5 inches.

- 5     The hose connector assembly of the riser flow diversion assembly may have any feature or any combination of features of the connector assembly according to the third, fourth or fifth aspect of the invention.

An embodiment of the invention will now be described, by way of example only, with reference to the following figures, of which

- 10    FIGURE 1 shows a first perspective view of a hose connector according to third aspect of the invention,

FIGURE 2 shows a second perspective view of the hose connector shown in Figure 1,

- 15    FIGURE 3 shows a perspective view of a hose and gooseneck assembly for use in connection with the hose connector illustrated in Figures 1 and 2, and according to the second aspect of the invention,

FIGURE 4 shows a perspective view of the hose and gooseneck assembly shown in Figure 3 mounted on the hose connector shown in Figures 1 and 2,

- 20    FIGURE 5 shows a schematic illustration of an offshore drilling rig including a hose, gooseneck assembly and hose connector.

FIGURE 6 shows an exploded illustration of the hose and gooseneck assembly shown in Figure 3,

- 25    FIGURE 7a, 7b and 7c show the gooseneck assembly of Figures 3 and 6 with the adjustable support part in a a) first position, b) second, intermediate, position, and c) third position,

FIGURE 8 is a further illustration of the gooseneck assembly of Figures 3 and 6 with the separation of the support parts labelled X,

FIGURE 9 is an illustration of a hose and gooseneck assembly of Figures 3 and 6 with the distance between the fixed point from which the hose hangs and the gooseneck connector labelled  $L_h$  (horizontal separation) and  $L_v$  (vertical separation),

FIGURE 10 is a graph of X against  $L_h$  for a range of values of  $L_v$  and for various lengths of hose,

FIGURE 11a & 11b show perspective illustrations of the alignment formation of the hose connector shown in Figures 1 and 2,

FIGURE 12 shows an explode perspective illustration of the alignment formation of the hose connector shown in Figures 1 and 2,

FIGURE 13a shows a perspective view from underneath of the gooseneck connector shown in Figure 3, and FIGURE 13b shows a detailed perspective view of the teeth, teeth support part and hose connector tube of the hose connector illustrated in Figures 1 and 2,

FIGURE 14 shows a detailed perspective illustration of the gooseneck connector and a portion of hose connector of Figure 1, 2 and 3, with the gooseneck connector engaged with the hose connector,

FIGURE 15 shows an exploded perspective illustration of the lock assembly of the hose connector illustrated in Figures 1 and 2,

FIGURE 16 shows a perspective view of the lock actuator assembly of the hose connector illustrated in Figures 1 and 2, and

FIGURE 17a shows a perspective illustration of one of the guide plates, and FIGURE 17b the latch part, of the lock assembly illustrated in Figure 15,

FIGURES 18a, 18b, 18c, 18d and 18e illustrate schematically the relative positions of the latch part, guide plate and gooseneck connector during locking and unlocking of the lock assembly.

Referring now to Figures 1 and 2, there is shown a hose connector 10 comprising a side port connector 12 for connection to a side port in a drilling riser (not shown), two side port isolation valves 14, a trapped gas displacement valve 16, and hose connector tube 18. The hose connector 10 has a main passage which extends from the side port connector 12 to the hose connector tube 18. The hose connector tube 18 has a longitudinal axis which, in use, typically extends generally vertically.

The side port connector 12 is, in use, secured to the riser so that a main passage in the hose connector 10 forms a continuous passage with a side passage in the riser. In this example, this is achieved by means of a flange 12a and a plurality of bolts 12b extending through apertures in the flange 12a. These bolts may be used to fasten the hose connector to a corresponding flange provided around the side port in the riser.

Advantageously, the side port is provided in a flow diversion assembly such as a flow spool, which is mounted on the riser, the flow spool having a main passage which forms a continuous passage with the riser, the side port connecting the main passage with the exterior of the flow spool. The hose connector 10 is preferably arranged so that the longitudinal axis of the hose connector tube 18 extends generally parallel to the main passage of the flow spool. The flow spool may be provided with a plurality of side ports, each of which has an associated hose connector. In this case, the hose connectors are preferably spaced around the circumference of the flow spool in a substantially regular array.

In one embodiment of the invention, the outer diameter of the flow spool and associated hose connector(s) does not exceed 46.5 inches. This maximum

outer diameter of 46.5 inches leaves minimal design space to work with for the flow spool and gooseneck design, given the minimum required inner diameter (ID) of the flow spool's main bore and the minimum ID that is required for the flow line bores within the spool, which ultimately dictates the OD of the flow spool. The minimum ID design of the flow line bores, which form the continuous passageways when connected to the gooseneck assembly mitigate erosion within the flow spool's flow lines over a range of predicted fluid flow and solids rates through the lines. The compactness of the design, means that the flow spool and associated hose connector(s) can be drifted through the rotary table for its installation, using the rig's hoisting system and completing the connection into the riser on the rig floor utilizing the rig spider to suspend it in the rotary table. This reduces the installation and removal complexities of the flowspool substantially, resulting in a safer, more time efficient installation/removal sequence into/out of the riser. Exceeding this envelope requires the flow spool to be installed through the moonpool area, which becomes complex and riskier with cranes and tugger lines, and personnel suspended above the open water.

The side port isolation valves 14 are operable to close the main passage in the hose connector 10, thus substantially preventing flow of fluid from or into the riser via the side port. These are of conventional construction, and may be ball valves, for example.

The trapped gas displacement valve 16 is used to create a flow path to displace trapped gas between the gooseneck connection and the base of the blowout preventer. The valve rejoins the flow line and flows the gas to the choke manifold or RGH manifold. This valve 16 is opened only after the side port valves 14 are closed in order to bleed the trapped pressure or displace the trapped gas.

Referring now to Figure 3, there is shown an end of a hose 20, with a connector 22 mounted thereon. In this example, the connector 22 is a

gooseneck connector 22 which comprises a tube having a first portion 22a which is connected to the hose 20, and a second portion 22b which is adapted to be engaged with the hose connector tube 18 of the hose connector 10. The first portion 22a and the second portion 22b of the gooseneck connector 22 are generally parallel and are joined by a generally semicircular intermediate portion 22c. The gooseneck connector 22 thus forms a generally U-shaped passage which, when the second portion 22b is connected to the hose connector 10 forms a continuous passage connecting the main passage of the hose connector 10 with the interior of the hose 20.

10 The hose 20 is secured to the first portion 22a of the gooseneck connector 22 by means of a conventional hose clamp and seal arrangement 24. A Techlok clamp connector 24b made by the Vector Technology Group may be used, for example. During installation, the connection between the hose 20 and the gooseneck connector 22 is made up on surface, on the rig floor.

15 In this example, when the gooseneck connector 22 is mounted on the hose connector 10, the hose connector tube 18 is located within the second portion 22b of the gooseneck connector 22. This is illustrated in Figure 4. In other words, in the connection between the gooseneck connector 22 and the hose connector 10, the second portion 22b of the gooseneck connector 22 forms the female part, whilst the hose connector tube 18 forms the male part. This may be reversed, however. Appropriate, and conventional, seals are provided to ensure a substantially fluid tight seal between the hose connector tube 18 and the gooseneck connector 22.

25 The second portion 22b of the gooseneck connector 22 is provided with a locking flange 26 which extends radially outwardly thereof. In this embodiment, the locking flange 26 extends from the very end of the second portion 22b.

An example of an offshore drilling rig in which hoses 20 are connected to a drilling riser 28 is illustrated in Figure 5. This figure shows a floating drilling rig 30 suitable for use in oil / gas drilling and production. The riser 28 extends up from a wellhead (not shown) mounted at the top of the well bore (not shown).

5 The top end of the riser 28 is provided with a slip joint 32, having an outer barrel and an inner barrel, the inner barrel being suspended from the rig floor by wire cables 34 and tensioners 36. In this example, the rig is to be used in managed pressure drilling (MPD) and so a rotating pressure containment apparatus 38 such as a rotating control device (RCD) or rotating BOP (RBOP)  
10 is provided in the riser 28 below the slip joint 32. The rotating pressure containment apparatus 38 allows pressure in the wellbore to be controlled by closing the top of the riser 28. The hoses 20 are connected to the riser 28 below the rotating pressure containment apparatus 38, in this example via a flow spool 40.

15 In this example, the hoses 20 are high flow rate large bore API hoses, and provide a return line for returning the drilling fluid (mud), cuttings and any other solids or fluids from the wellbore to the surface. The return line extends from the flow spool 40 to a choke manifold 42, from which the returning fluid is diverted to the rig's mud pit 44 via conventional separator systems 46 (mud  
20 gas separator, shaker table etc).

In one embodiment, the flow spool 40 is provided with three side ports, each of which is connected to the surface by a separate hose 20 and hose connector 10. The three hose connectors 10 are spaced around the circumference of the flow spool 40, with the longitudinal axis of the main passage of the hose  
25 connector 10 extending generally parallel to the longitudinal axis of the riser 28. The three hose connectors 10 are advantageously positioned at generally the same height on the flow spool 40.

In normal use, two of these may serve to return drilling fluid to the mud pits 44, as described above, whilst the third is controlled by two programmable

pressure-relief valves that will discharge returns to a diverter if pressure levels in the riser 40 reach dangerous levels. It will be appreciated that the number and size of the hoses 20 may be varied to provide increased redundancy or varying peak flow rate capacity, depending on the requirements of a particular drilling operation. It should also be appreciated that one or more of the hoses 20 could serve as injection points to pump fluid down the annulus whilst conducting pressurised mudcap drilling, for example.

During drilling, a drill string 48 extends down into the riser 28 from a rotary table 50 mounted on the rig floor 54. Derrick 52 is provided to lower the drill string 48 into the riser 28.

During installation, the flow spool 40 and rotating pressure containment apparatus 38 are mounted on top of the riser 28. The hydraulic connections to the side ports in the flow spool 40 are then made by lowering the end of each hose 20 with the gooseneck connector 22 mounted thereon, onto one of the hose connectors 10. The attachments provided on the gooseneck connector 22 to facilitate this will now be described with reference to Figures 3 and 6.

As illustrated in Figures 3 and 6, the gooseneck connector 22 is provided with two suspension parts 56a, 56b, to which wires may be secured, and the wires used to lower the hose 20 and gooseneck connector 22 onto the hose connector 10 on the flow spool 40. During this process, the gooseneck connector 22 is arranged with the open end of the second portion 22b pointing downwards. In this embodiment, the hose connector 10 is arranged on the flow spool 40 so that the hose connector tube 18 extends generally vertically upwardly. By providing two suspension parts 56a, 56b, the gooseneck connector 22 can be suspended by two separate wires, and the relative lengths of these can be altered to ensure that the first and second portions 22a, 22b of the gooseneck connector 22 are aligned generally parallel to the longitudinal axis of the hose connector tube 18, in this embodiment, generally vertically. This ensures that gooseneck 22 is correctly aligned to be lowered

over the hose connector tube 18. This process may be assisted by configuring the gooseneck 22 so that the relative positions of the suspension parts 56a, 56b can be altered.

5 In this example the suspension parts 56a, 56b are loops which will hereinafter be referred to as padeyes. The padeyes 56a, 56b are secured to a mounting part 58 which extends from the intermediate portion 22c of the gooseneck connector 22, so that each can pivot relative to the mounting part 58. In this example, the padeyes are secured using bolts, but it will be appreciated that other fasteners may equally be used. In this example the first padeye 56a is  
10 bolted onto a carrier 60 which is movable relative to the mounting part 58, whilst the position of second padeye 56b is fixed. It should be appreciated, however, that both padeyes 56a, 56b could be mounted in such a way as to be capable of translational movement relative to the mounting part 58.

15 In this embodiment, the carrier 60 has two generally parallel legs 60a, 60b which are arranged on either side of the mounting part 58. These legs 60a, 60b and the mounting part 58 are each provided with a slot 58a, and the carrier 60 is secured to the mounting part 58 by means of a fastener 60c (two nut and bolt assemblies in this example) which extend through these slots. The carrier 60 may therefore slide along the mounting part 58, from one end of  
20 the slot 58a to the other, and may be fixed in the desired position by tightening the fasteners 60c. Three of the possible positions of the first padeye 56a are illustrated in Figures 7a, 7b and 7c. As can be seen, in Figure 7c, the first padeye 56a is as close to the second padeye 56b as is possible, in Figure 7a, the first padeye 56a is as far from the second padeye 56b as is possible, whilst  
25 in Figure 7b, the first padeye 56a is in an intermediate position.

Although the force of the fasteners may be enough to retain the carrier 60 in the desired position, but, in this example, to assist in this, the carrier 60 and mounting part 58 are provided with a ratchet mechanism comprising a toothed edge 58b of the mounting part 58, and a toothed wedge 62. The toothed

wedge 62 is located between the legs 60a, 60b of the carrier, and secured by means of a bolt 62a so that its teeth engage with the teeth of the toothed edge 58b of the mounting part 58.

As mentioned above, the facility for altering the separation of the two padeyes 56a, 56b can be useful in assisting an operator in maintaining the gooseneck connector 22 in the desired orientation parallel to the longitudinal axis of the hose connector tube 18, whilst mating the second portion 22b with the hose connector tube 18. Referring to Figure 8 and Figure 9, the ideal location of the pad eye lifting point is a function of the length of the hose (HL), the vertical separation between the point of connection of the hose in the rig moon pool area and the hose connector tube 18 on the flow spool ( $L_v$ ), and the horizontal separation between the first padeye 56a and the point of connection of the hose ( $L_h$ ). Decreasing or increasing the hose length HL and/or moving the connection point of the hose relative to the hose connector tube 18 creates a greater or lesser angle between the female end of the gooseneck connector 22 and the vertical axis, when the gooseneck connector 22 is in position to be lowered onto the hose connector tube 18.

Referring now to Figure 10, this shows the relationship between the separation of the padeyes 56a, 56b (shown as X in Figure 8) required for the gooseneck connector 22 to hang vertically from the first padeye 56a when the gooseneck connector 22 has reached the hose connector tube 18, and the horizontal separation of a fixed end of the hose 20 and first suspension part 56a (shown as  $L_h$  in Figure 9) for various values of vertical separation of the fixed end of the hose 20 and the first suspension part 56a (shown as  $L_v$  in Figure 9), and for various hose lengths (HL). For example, for a 90 foot long hose 20, if, when the gooseneck connector 22 is mounted on the hose connector 18, the horizontal separation of the fixed end of the hose 20 and the first padeye 56a will be 5 meters ( $L_h = 5$ ), and the first suspension part 56a is located 5 meters below the fixed end of the hose 20 ( $L_v = -5$ ), the separation of the first suspension part 56a and second suspension part 56b should be set to 90 mm

(point P on Figure 10). Alternatively, for a 120 foot hose, when the first padeye 56a is aligned horizontally with the fixed point of the hose 20 ( $L_v = 0$ ), and  $L_h$  is 3m, the padeye separation X should be set to around 30 mm (point Q on Figure 10).

- 5 The wire attached to the second padeye 56b could, of course, be used to alter the orientation of the gooseneck connector 22, by pulling upwardly on this wire to counteract any clockwise (as shown in figures 7a, 7b, & 7c, 8 and 9) rotation of the gooseneck connector 22 caused by the weight of hose 20. The hose 20 and gooseneck connector 22 are a significant weight together, however, and it
- 10 is preferable to avoid, or minimise, the need to use to this wire to rotate the gooseneck connector 22 by setting the padeye separation X to the correct value.

The movement of the “wire” or tugger line vertically upwards or downwards through its hydraulic-pneumatic lifting controls provide the vertical

- 15 displacement/movement capability during installation. The padeye separation X is set/adjusted before the procedure is started. Once the gooseneck connector padeye is connected to the tugger line and suspended in the moon pool, only a vertical adjustment can be made through the tugger controls. If it is the first time the system is installed on a particular rig with a specific hose
- 20 type/length, it may be the case a further horizontal adjustment may be required during the first installation procedure, which would require the gooseneck connector to be laid down again so the padeye separation X can be adjusted. However, once this first rig up is completed, there should be no more adjustments required with X for this specific rig setup and hose type/length.

- 25 Referring again to Figures 1 and 2, these show that the hose connector 10 is also provided with an alignment formation 64 which is mounted over and around the hose connector tube 18. The alignment formation provides a guide which, when a gooseneck 22 is lowered towards the hose connector 10, engages with the gooseneck 22 to guide it into position so that the gooseneck

22 can be dropped down into sealing engagement with the hose connector 10. To achieve this, in this example, the alignment formation 64 has surfaces which extend generally parallel to the longitudinal axis of the hose connector tube 18, to partially enclose the hose connector tube 18. These surfaces form an open front large enough for a gooseneck connector 22 to pass through, and converge such that the cross-sectional area enclosed by the surfaces generally parallel to the longitudinal axis of the hose connector tube 18 decreases from the open front to the back.

One embodiment of alignment formation is shown in more detail in Figures 11a, 11b, and Figure 12, and comprises a sidewall 66 and top part 68. The side wall 66 comprises a plate bent about an axis generally parallel to the longitudinal axis of the hose connector tube 18, to form two substantially flat portions 66a, 66b which are inclined at an angle of between  $45^\circ$  and  $135^\circ$  to one another (preferably around  $90^\circ$ ), joined by a curved intermediate portion 66c. The hose connector tube 18 is located between the two substantially flat portions 66a, 66b, and adjacent the intermediate portion 66c. The side wall 66 thus forms a wide open front to ensure that it is not too difficult for an operator to lower the gooseneck connector 22 into the alignment formation, whilst converging on the hose connector tube 18 to guide the gooseneck connector 22 into vertical alignment with the hose connector tube 18.

The top part 68 extends between the flat portions 66a, 66b of the side wall 66. It is located above the hose connector tube 18 so that the longitudinal axis of the hose connector tube 18 passes through the top part 68, and is inclined at an angle of less than  $90^\circ$  to this longitudinal axis so that it slopes to be closer to the hose connector tube 18 moving towards the intermediate portion 66c of the side wall 66. This may assist in guiding the gooseneck connector 22 down onto the hose connector tube 18.

Advantageously, the depth of the top part 68 is set such that when the mounting part 58 of the gooseneck connector 22 engages with the top part 68

as the gooseneck connector 22 is lowered towards the hose connector tube 18, the second portion 22b of the gooseneck connector 22 is in line with the hose connector tube 18 and not too close to the intermediate portion 66c of the side plate 66. In other words, so that engagement of the mounting part 58  
5 of the gooseneck connector 22 with the top part 68 of the alignment formation 64 prevents the gooseneck connector 22 from being inserted too far into the alignment formation 64.

When the gooseneck connector 22 is located on the hose connector tube 18, it will be appreciated that, if the hose 20 is not in line with the gooseneck connector 22 (i.e. extending in generally the same plane as the bent tube forming the gooseneck connector 22), the hose 20 will exert a twisting force on the gooseneck connector 22 as it is forced to bend. The hoses used in the applications described above can be extremely long and heavy, and, as a result, the shear stress in the gooseneck connector 22 induced by a  
10 misaligned hose 20 can be significant. Moreover, the twisting force required to bend the hose 20 out of alignment can make it very difficult for an operator to connect the gooseneck connector 22 to the hose connector 10. To reduce the likelihood or extent of such misalignment, in one embodiment of the invention, the gooseneck connector 22 and hose connector 10 are configured such that  
15 the angular orientation of the gooseneck connector 22 about the longitudinal axis of the hose connector tube 18 may be varied.

In this embodiment, the gooseneck connector 22 and hose connector tube 18 are both circular in transverse cross-section. As such, the gooseneck connector 22 may be mounted on the hose connector tube 18 at any relative  
20 angular orientation. Means are provided, however, to substantially prevent rotation of the gooseneck connector 22 on the hose connector tube 18 once it is installed at the desired angle.

In this example, this is achieved by the use of a meshing teeth arrangement, as illustrated in Figures 13a, 13b and 14. Referring first to Figure 13a, the end

face 22c of the second portion 22b of the gooseneck connector 22 is provided with a line of teeth 70 which extend along a portion of the circumference of a circle centred about the longitudinal axis of the second portion 22b of the gooseneck connector 22. In this example, the teeth 70 extend around  
5 approximately half the circle. Corresponding teeth 72 are provided on the hose connector 10, mounted on a support part 74 which extends around a portion of the outer circumference of the hose connector tube 18, as illustrated in Figure 13b. Both sets of teeth 70, 72 are positioned such that they engage when the gooseneck connector 22 is mounted on the hose connector tube 18  
10 as illustrated in Figure 14. It will be appreciated that this interlocking of the teeth 70, 72 restricts rotation of the gooseneck connector 22 about the hose connector tube 18.

In this example, the teeth 70 on the gooseneck connector 22 are positioned on the side of the second portion 22b closest to the first portion 22a, and the teeth  
15 on the hose connector 10 mounted on the opposite side of the hose connector tube 18 to the intermediate portion 66c of the side wall 66 of the alignment formation 64. It will be appreciated, however, that this need not be the case, and they may be positioned on the opposite sides.

Interlocking of the teeth 70, 72 will not, of course, completely prevent  
20 movement of the gooseneck connector 22 relative to the hose connector 10. An additional lock is preferably provided to prevent the gooseneck connector 22 from sliding up the hose connector tube 18 until the teeth 70, 72 are no longer engaged.

In one embodiment, the lock is hydraulically actuated by means of a piston  
25 and cylinder arrangement. In this example, the hose connector 10 is provided with two such locks, but one or more than two could equally be provided. These are mounted on opposite sides of the hose connector 10, just below the hose connector tube 18.

The lock actuators are best illustrated in Figure 16, which shows the lowermost end of the cylinders 76a, 76b and the uppermost ends of the pistons 78a, 78b, along with a hydraulic line 80a, 80b, by means of which the pressurised fluid required to move the pistons 78a, 78b is supplied to the cylinders 76a, 76b from a control pod located on the flow spool. The actuators are mounted so that the pistons 78a, 78b extend upwardly from their respective cylinder 76a, 76b generally parallel to the longitudinal axis of the hose connector tube 18, although limited pivoting movement of the actuators from the vertical, towards and away from the hose connector tube 18 is permitted. In this example, this pivoting movement is achieved by having each cylinder 76a, 76b supported between two support arms 77a, 77b, by means of a pair of trunnions 79a, 79a' which extend from opposite sides of the cylinder 76a, 76b.

Each lock is also each provided with a latch part 82a, which is mounted above the piston 76a between two guide plates 84a, 84a', 84b, 84b', as illustrated in Figure 15. The latch part 82a is illustrated in detail in Figure 17b, and includes a pair of generally parallel arms 86, 86', each having an aperture there through, a lowermost catch 88, an uppermost catch 90, and a guide pin 92 which extends generally perpendicular to the two catches 88, 90. The free end of the piston 78a is located between the two arms 86, 86' of the latch part 82a, and the latch part 82a is secured to the piston 78a by means of a pin or bolt 94a which extends through the aperture in the first arm 86, through a corresponding aperture provided in the free end of the piston 78a, and out of the aperture in the second arm 86'. The latch part 82a may therefore pivot relative to the piston 78a about the pin / bolt 94.

One of the guide plates 84a is illustrated in Figure 17a. Each guide plate 84a, 84a', 84b, 84b' includes a guide slot 96a, 96a', 96b, 96b', which has a main portion, which is arranged generally parallel to the longitudinal axis of the hose connector tube 18, between two inclined end portions which extend at an angle of around 45° to the main portion, one to the right of the main portion,

and the other to the left. The guide plates 84a, 84a', 84b, 84b' are each arranged so that the uppermost inclined portion of the guide slot 96a, 96a', 96b, 96b' extends away from the hose connector tube 18, whilst the lowermost inclined portion of the guide slot 96a, 96a', 96b, 96b' extends towards the hose connector tube 18. This is best seen in Figure 1, Figure 2, and Figures 18a, 18b, 18c, 18d and 18e.

The ends of the pin or bolt 94a by means of which the latch part 82a is secured to the piston 78a extend through the guide slots 96a, 96a' of the two guide plates 84a, 84a' on either side of the latch part 82a. This means that as the piston 78a moves into and out of its cylinder 76a, the pin/bolt 94a moves along the guide slots 96a, 96a', movement of the pin/bolt 94a into either of the inclined end portions of the guide slot 96a, 96a' causing the cylinder 76a, 76b and piston 78a, 78b to pivot about the trunnions 79a, 79a', 79b, 79b to move latch part 82a towards or away from the hose connector tube 18. This is best seen in Figure 16.

The guide plates 84a, 84a', 84b, 84b' also have a generally L-shaped guide recess 98a which is located in the face of the guide plate 84a, 84a', 84b, 84b' adjacent to the latch part 82a. The guide pin 92 extends into the guide recess 98a so that the edges of the recess confine the guide pin 92 to movement within the guide recess 98a only. The effect of this on movement of the latch part 82a as the piston 78a, 78b moves into and out of its cylinder 76a, 76b is shown in Figures 18a, 18b, 18c, 18d & 18e.

During the mounting of the gooseneck connector 22 on the hose connector tube 18, pressurised fluid is supplied to the cylinders 76a, 76b so the pistons 78a, 78b are extended out of their cylinder 76a, 76b. The pin/bolt 94a lies at the uppermost end of the guide slot 96a and the guide pin 92 is located at an uppermost end of the guide recess 98a. The movement of the pin/bolt 94a along the uppermost inclined portion of the guide slot 96a away from the hose connector tube 18 causes the latch part 82a to tip back so that the uppermost

catch 90 is further from the hose connector tube 18 than the lowermost catch 88. The latch part 82a is positioned relative to the hose tube connector 18 such that as the second portion 22b of the gooseneck connector 22 is lowered onto the hose connector tube 18, the locking flange 26 can pass the  
 5 uppermost catch 90, and come to rest on the lowermost catch 88 of the latch part 82a. This is illustrated in Figure 18a.

Once the gooseneck connector 22 is in the desired orientation relative to the hose connector tube 18, it is locked in place by the release of pressurised fluid from the cylinders 76a, 76b. The pin/bolt 94a moves down the guide slot 96a,  
 10 and the guide pin 92 moves down the vertical portion of the guide recess 98a. The movement of the pin/bolt 94a down the uppermost inclined portion of the guide slot 96a and into the intermediate portion (towards the hose connector tube 18) causes the latch part 82a to tip forwards so that the uppermost catch 90 moves towards the hose connector tube 18 until is it generally the same  
 15 distance from the hose connector tube 18 as the lowermost catch 88. As the pin / bolt 94a moves down the intermediate portion of the guide slot 96a, the uppermost catch 90 pushes down on the locking flange 26, moving the second portion 22b of the gooseneck connector 22 towards the teeth 72. This is illustrated in Figure 18b.

20 Finally, the pin/bolt 94a enters the lowermost inclined portion of the guide slot 96a as the teeth 70 of the gooseneck connector 22 engage with the teeth 72 on the hose connector 10. The resulting movement of the pin/bolt 94a towards the hose connector tube 18 causes the guide pin 92 to move generally horizontally along the bottom of the guide recess 98a also towards the hose  
 25 connector tube 18. This, in turn, causes the latch part 82a to tip backwards so that the lowermost catch 88 moves towards the hose connector tube 18, whilst the uppermost catch 90 moves towards it and engages with an uppermost surface of the locking flange 26. This is illustrated in Figure 18c. The locking flange 26 is therefore captured between the uppermost catch 90 and  
 30 lowermost catch 88 of the locking part 82a, and movement of the gooseneck

connector 22 relative to the hose connector 10 can only (within reason) be achieved by the lifting of the piston 78a, 78b in its cylinder 76a, 76b.

When it is desired to release the gooseneck connector 22 from the hose connector 10, pressurised fluid is supplied to the cylinders 76a, 76b. The  
5 pin/bolt 94a moves up the guide slot 96a, and the guide pin 92 moves along and up the guide recess 98a. The movement of the pin/bolt 94a out of the lowermost inclined portion of the guide slot 96a and into the intermediate portion (away from the hose connector tube 18) and the movement of the  
10 guide pin 92 horizontally along the bottom of the guide recess 98a also away from the hose connector tube 18, causes the latch part 82a to tip backwards so that the uppermost catch 90 moves away from the hose connector tube 18, and the lowermost catch 88 moves towards it. As the pin / bolt 94a moves up the intermediate portion of the guide slot 96a, the lowermost catch 88 pushes up on the locking flange 26, moving the second portion 22b of the gooseneck  
15 connector 22 away from the teeth 72. This is illustrated in Figure 18d.

The final upward movement of the pin/bolt 94a along the uppermost inclined portion of the guide slot 96a away from the hose connector tube 18 again causes the latch part 82a to tip back so that the uppermost catch 90 is further from the hose connector tube 18 than the lowermost catch 88. The locking  
20 flange 26 can then pass the uppermost catch 90, and be removed from the hose connector tube 18. This is illustrated in Figure 18e.

The use of a fluid pressure operated actuator to push the gooseneck connector 22 up the hose connector tube 18 may be particularly useful as marine growth on the assembly can mean that significant force may be  
25 required to separate the second portion 22b of the gooseneck connector 22 from the hose connector tube 18. The freedom of the gooseneck connector 22 to pivot about the hose connector tube 18 can also assist in the breakage of marine growth.

Advantageously, where the hose connector 10 is to be mounted on a flow spool 40 as illustrated in Figure 5, it is located at a lower end of the flow spool 40 so that there is sufficient clearance between the hose connector 10 and the slip joint 32 to allow for simultaneous connection of the hose 20 to the hose connector 10 and connection of the slip joint 32 at the top of the riser 28. The opportunity to perform these procedures in parallel can reduce rig up time over the moon pool. The hose connections can be made up below the rotary table 50 whilst a top cross over flange is suspended by a spider on the rig floor 54. This allows the base of the slip joint 32 to be connected to the top of the rotating pressure containment apparatus 38 at the same time as the hose connections are being made. If the hose connector 10 is too high up the flow spool 40, there may not be enough clearance to lower the gooseneck connector 22 onto the hose connector tube 18 with the slip joint 32 in place. In this case, it would be necessary to wait until all the hose connections are made before installing the slip joint 32.

When used in this specification and claims, the terms "comprises" and "comprising" and variations thereof mean that the specified features, steps or integers are included. The terms are not to be interpreted to exclude the presence of other features, steps or components.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

## CLAIMS

1. A connector assembly for connecting a hose to a tubular element, the connector assembly comprising a tubular housing which encloses a main passage extending generally parallel to a longitudinal axis of the tubular housing and which is provided with a side passage extending through the tubular housing from the exterior of the tubular housing into the main passage, the side passage further extending through a connector tube which is mounted on the exterior of the tubular housing, the connector assembly further being provided with a hose connector adapted to be secured to an end of the hose and to engage with the connector tube for connecting the hose to the tubular element, the hose connector comprising a pipe portion which is adapted to mate with the connector tube so that the interior of the hose is connected to the side passage, wherein the connector assembly is further provided with a latch which is operable to urge the connector tube and the pipe portion into engagement and to prevent separation of the connector tube and the pipe portion when the two are mated to connect the interior of the hose with the side passage,
- and wherein the latch is movable between an open position in which the connector tube and the pipe portion may be separated, and a closed position in which it prevents separation of the connector tube and the pipe portion, and configured such that, on movement of the latch from the closed position to the open position, the latch pushes the connector tube and the pipe portion apart.
2. The connector assembly according to claim 1 wherein the latch is hydraulically operated.
3. The connector assembly according to claim 1 or 2 wherein the pipe portion is adapted to be placed over the connector tube so that the connector tube extends into the pipe portion when the two parts mate to connect the interior of the hose with the side passage.

4. The connector assembly according to claim 3 wherein the pipe portion is provided with a radially outwardly extending flange at its free end, and the latch is provided with a lowermost catch and an uppermost catch and is configured such that when the latch is in the closed position the uppermost catch bears down on the flange thus preventing the pipe portion of being lifted off the connector tube, and as the latch is moved to the open position, the lowermost catch pushes the flange up to commence lifting the pipe portion off the connector tube.
5. The connector assembly according to any one of claims 1 to 4 wherein the tubular housing is adapted to be secured to a drilling riser.
6. The connector assembly according to any preceding claim wherein the latch is pivotally mounted relative to the connector tube.
7. The connector assembly according to any preceding claim wherein the latch includes a pair of generally parallel arms, each having an aperture therethrough.
8. The connector assembly according to claim 7 wherein the latch is secured to a piston by means of a pin or bolt which extends through the aperture in the first arm, through a corresponding aperture in the free end of the piston and through the aperture in the second arm, so that the latch part may pivot relative to the piston about the pin/bolt.
9. The connector assembly according to claim 8 wherein the piston is mounted in a cylinder which extends generally parallel to a longitudinal axis of the connector tube in such a way that limited pivoting movement of the piston and cylinder towards and away from the connector tube is permitted.
10. The connector assembly according to claim 4 or any one of claims 5 to 9 where dependent on claim 4, wherein the latch also includes a guide pin which extends generally perpendicular to the two catches.

11. The connector assembly according to claim 8 or claim 9, or claim 10 where dependent on claim 8, further comprising a guide plate mounted on the connector tube, the guide plate including a guide slot into which an end of the pin/bolt extends.

5 12. The connector assembly according to claims 10 and 11 wherein the guide plate further includes a generally L-shaped guide recess which is located in the face of the guide plate adjacent the latch part, the guide pin extending into the guide recess so that the edges of the recess confine the guide pin to movement within the guide recess only.

10 13. The connector assembly according to claims 10 and 11, or claim 12, wherein the connector assembly includes two guide plates, and the latch part includes two guide pins each of which extends generally perpendicular to the catches in opposite directions, the latch part being mounted between the guide plates such that the each end of the pin/bolt extends into the guide slot of one  
15 of the guide plates, and each guide pin extends into an L-shaped recess of one of the guide plates.

14. A drilling riser and hose assembly, the hose being connected to the drilling riser using a connector or connector assembly according to any preceding claim.

20 15. A drilling riser and hose assembly according to claim 14 wherein the tubular element is part of a flow spool mounted on the riser.