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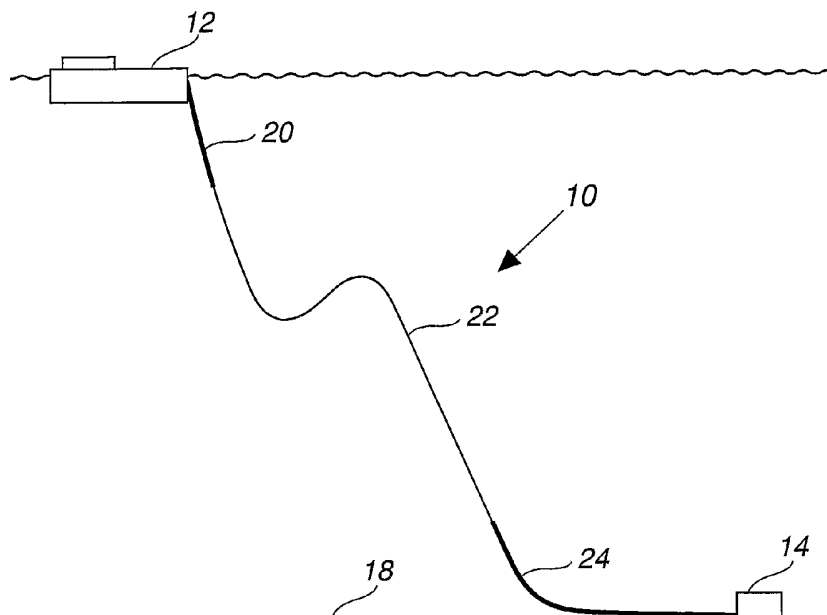
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(54) Title: A HYBRID RISER SYSTEM



(57) Abstract: A hybrid riser system (10) for connection between a floating unit (12) and a sub-sea unit (14) that is located at the sea floor (18). The riser system (10) comprises a composite conduit (22) for transporting a fluid between said floating (12) and sub-sea units (14) and at least one end pipe section (20,24) that is adapted to be connected between the floating (12) and/or the subsea unit (14) and the composite conduit (22). Said at least one end pipe section (20,24) comprises a metallic pipe or a non-bonded flexible pipe.

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A HYBRID RISER SYSTEM

TECHNICAL FIELD

The present invention concerns a hybrid riser system for
5 connection between a floating unit, such as a floating vessel
or a production unit for oil and gas production, and a sub-sea
unit, such as a sub-sea well facility, located at the sea
floor. The expression "riser system" is intended to mean a
pipe or a string adapted for transport of fluids, i.e. liquids
10 and gases or mixtures thereof, and in particular hydrocarbons,
such as oil and/or gas or injection fluids, such as methanol
or water, between the floating and sub-sea units.

BACKGROUND OF THE INVENTION

15 Riser systems include a conduit through which various fluids
are transported from a sub-sea facility located at the sea
floor to a floating platform or vessel on the sea surface,
such as a surface production and/or storage facility or vice
versa. The vessel or floating platform is constantly exposed
20 to movements, caused by waves, winds and surface and
underwater currents, for example. The floating platform is
therefore continuously subjected to forces causing it and the
riser system connected thereto to movements. Riser systems
must be able to withstand the forces exerted on them without
25 failure due to fatigue or the like. If part of a riser
undergoes fatigue or becomes damaged to the point of failure
or possible failure, at least part of the riser system has to
be replaced, which is both expensive and may be difficult and
time consuming to accomplish. When using light weight riser
30 pipes e.g. composite, additional weight may be required added
to the upper part of the riser that is connected to the
floating platform or vessel to ensure that the pipe is in
tension, however this additional weight compresses the riser,

adversely affects fluid flow through the riser system and increases manufacturing and installation costs.

US patent no. 5,639,187 discloses a marine riser system that
5 combines rigid, steel catenary risers with flexible flow
lines. The expression "catenary" meaning the curve assumed by
a cord of uniform density and cross section that is perfectly
flexible but not capable of being stretched and that hangs
freely from two fixed points. The steel catenary risers are
10 curved upward through the water in a gentle catenary path to a
large, submerged buoy, which, in turn, is moored to the sea
bottom by tension leg tether lines at a depth below the
turbulence zone of the water. The buoy maintains the rigid
steel catenary risers in a substantially vertical position in
15 the water. Flexible flow lines (commonly called jumpers) are
fluidly connected to the steel catenary risers at the buoy and
extend upward through the turbulence zone to the surface.

A disadvantage with such a system is that a large buoy and
20 clamping means are needed to support the heavy steel risers.
Mooring the buoy at a predetermined depth also requires
careful planning and engineering, which makes the design and
manufacture of the buoy complex, time consuming and expensive.
Furthermore, the equipment required for mooring the buoy
25 further increases manufacturing and installation costs.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a hybrid
riser system for connection between a floating unit, and a
30 sub-sea unit that is located at the sea floor, which can
withstand or accommodate forces exerted thereon due to
movements, such as those caused by the movement of the
floating unit.

This object is achieved by a riser system that includes a composite conduit for transporting a fluid, i.e. liquid or gas, between said floating and sub-sea units. The term "composite conduit" refers to a bonded pipe having an inner
5 liner and an outer protective sheath and optionally at least one reinforcing layer, such as the one described in international application WO 99/67561. WO 99/67561 describes a flexible riser comprising composite material. The riser comprises an inner liner of thermoplastic material, an
10 intermediate reinforced polymer multi layer component and an outer thermoplastic liner. The inner liner is continuously bonded to the intermediate, multi layer component, which is in turn continuously bonded to the outer liner. The inventive riser system also comprises at least one end pipe section that
15 is adapted to be connected between the floating and/or the subsea unit and the composite conduit. Said at least one end pipe section comprises a metallic pipe, i.e. a pipe made of or containing metal, or a non-bonded flexible pipe.

20 The term "non-bonded" is intended to mean a pipe consisting of a plurality of layers, comprising a metal or polymer for example, which are not bonded to each other and therefore free to move independently of one another. A non-bonded flexible pipe or a metallic pipe provides an end pipe section of
25 increased strength and weight which will not be deflected and bent like a composite conduit and thus eliminates the need for providing the riser system with additional weight.

The hybrid riser system according to the invention has a light
30 and almost buoyant composite conduit section, which implies less load impact on the floating unit. At least one end of the riser system, i.e. the end that is connected to the floating unit and/or the end that is connected to the sub-sea unit, is provided with an end pipe section that can better withstand or
35 accommodate the forces exerted on the riser system in the vicinity of the floating and/or sub-sea unit where the riser

is deflected and bent the most. The inventive riser system reduces top tension, touchdown curvature, touchdown compression and hold-back tension and is suitable for use at high hydrostatic pressures in deep and ultra deep water.

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According to an embodiment of the invention the length of the end pipe section that is connected to the floating unit is approximately 50-600 m. According to another embodiment of the invention the length of the end pipe section that is connected
10 to the subsea unit is approximately 50-100 m.

According to a further embodiment of the invention the length of the composite conduit is about 1000-1500 m or longer.

15 According to a yet further embodiment of the invention said at least one end pipe section is arranged to be negatively buoyant.

According to an embodiment of the invention the composite
20 conduit is constituted by a single, continuous conduit i.e. the composite conduit is connected to at least one end pipe section but there are no other connections along the length of the riser.

25 According to an embodiment of the invention the riser is adapted to assume a compliant configuration when installed e.g. free hanging (catenary), Lazy or step S or wave.

According to another embodiment of the invention the composite
30 conduit comprises a bonded pipe having an inner liner and an outer protective sheath, and optionally at least one reinforcing layer.

According to a further embodiment of the invention the
35 composite conduit is flexible enough to be spooled onto a reel with a hub radius of about 4500-8500 mm.

According to an embodiment of the invention the composite conduit and said at least one end pipe section have an internal diameter in the range of about 10-40 cm (4-16 inches).

5

According to a further embodiment of the invention the floating unit is a production or storage unit or a platform or vessel, the sub-sea unit is a sub-sea well facility, whereby the riser system is adapted for transport of fluids, in particular hydrocarbons, such as oil and/or gas, or injection fluids, such as methanol or water, between the floating and subsea units.

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DETAILED DESCRIPTION OF EMBODIMENTS

The present invention will hereinafter be further explained by means of non-limiting examples with reference to the appended figures where:

15

- Fig. 1 is a schematic view of a riser according to an embodiment of the invention connected between a production vessel and a sub-sea facility,
- Fig. 2 shows a connector for connecting an end pipe section of a riser to the central composite conduit section of the riser,
- Fig. 3 is a cross section of the central composite conduit section of a riser according to an embodiment of the invention, taken along the line A-A of Fig. 2.

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It should be noted that the drawings have not been drawn to scale and that the dimensions of certain features have been exaggerated for the sake of clarity.

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DETAILED DESCRIPTION OF EMBODIMENTS

Figure 1 shows a riser system 10 for connection between a floating unit 12 and a sub-sea unit 14 located on the sea floor 18. The floating unit 12 is, in the illustrated example, a floating production unit for processing well fluid, by removing gas and water for example, from a sub-sea well assembly 14, and conveying the fluid to an export pipeline or offloading to another vessel, such as an oil tanker, whereby the riser system 10 transports fluid from the sub-sea unit 14 to the floating unit 12. The floating production unit 12 may alternatively, or also, have equipment for injecting water or gas into a sub-sea well 14 for production purposes, whereby the riser 10 transports fluid from the floating unit 12 to the sub-sea unit 14.

A riser 10 comprises an upper metallic end pipe section 20, such as a continuous welded or threaded steel pipe, a central composite section 22, and a lower metallic end pipe section 24. Upper end pipe section 20 has a length of about 50 to 600 m and is negatively buoyant. Alternately, part or all of upper end pipe section 20 and/or the lower end pipe section 24 could be formed from a non-bonded flexible pipe. The lower end pipe section 24 connects to a sub-sea facility 14 on the sub-sea floor 18, such as a manifold or production/injection tree, at a location horizontally offset from production vessel 12. The riser 10 is constructed to assume a compliant configuration when installed. Movement of the floating unit is accommodated by the flexibility of the upper end pipe section, i.e. the non-bonded flexible pipe or metallic pipe. Tensioning means are not required to maintain tension in the riser 10. Tension is obtained through the upper end pipe section 20 and buoyancy is optionally applied to the central composite conduit section 22 in order to avoid compression in the riser string 10.

Central composite conduit section 22 constitutes most of the length of the riser 10, and is much longer than upper end pipe section 20 or the lower end pipe section 24. For example, the distance from vessel 12 to sub-sea facility 14 could be 2,000 meters with the central composite conduit section 22 being 1,500 meters or more in length. Central composite conduit section 22 is preferably neutral or slightly negative in buoyancy.

Lower end pipe section 24 is utilized in environments where flexibility is required to connect the lower end of riser 10 to a sub-sea facility 14 or where touch down compression may occur. In some environments, central composite conduit section 22 may be connected directly to sub-sea facility 14. Lower end pipe section 24 may include a metal tapered stress joint if necessary. Lower end pipe section 24 could also comprise non-bonded flexible pipe of a type described above. Lower section 21 could also comprise a continuous steel pipe having a similar structure to upper end pipe section 20. As shown in Fig. 1, since riser 10 has a compliant configuration, a portion of lower end pipe section 24 will likely lie on the sea floor 18. Lower end pipe section 24 is also much shorter than the length of central composite conduit section 22. For example, lower section 24 is preferably from about 50 to 100 meters in length.

The, or each, end pipe section 20, 24 can be connected to the composite conduit 22 onshore and stored on a reel for installation purposes or the end pipe section(s) could be wound on a separate reel and connected to the composite conduit during installation. The latter method would be more suitable when the end pipe section(s) comprise(s) a metallic pipe.

Figure 2 shows a flange-type connector 26, made of metal for example, for connecting a composite conduit 22 to an upper end

pipe section 20 and/or a lower end pipe section 24. The connector 26 is secured by a plurality of bolts 28. The flange-type connector 26 could be a standard API. Alternatively, a more compact flange could be used, but also a flex joint depending on the environment. Upper end pipe section 20 has a conventional floater connection, for example, which couples the riser 10 to the floating production unit 12. The floater connection could include a flex joint or a flange connection with a bend stiffener.

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Figure 3 shows a cross section of the central composite conduit section of the riser system (outer protective sheath not shown). According to an embodiment of the invention the conduit 22 has a fluid impervious inner liner 30, having an inner diameter typically ranging from about 15-30 cm (6-12 inches), which is continuous and extends from its upper end 20 to its lower end 24. Inner liner 30 may be formed from a conventional thermoplastic material, such as polyamides, polyvinylidene fluoride (PVDF), polyphenylene sulfide (PPS) or polyether ether ketone (PEEK), preferably having a thickness between 4-7 mm. A thermoplastic fibre reinforced tape 32, such as carbon fibre or glass fibre, is wrapped around liner 30 in various angles depending on loads and environment. The thermoplastic fibre reinforced tape 32 is then bonded to the liner 30 or tape substrate, by heating for example, which forms a high strength, lightweight tubular member. The upper and/or lower ends of the liner 30 are terminated in a composite-metallic interface connector 26.

At least one reinforcing layer can be added which are built up of unidirectional continuous fibres of carbon, glass, or aramid, which are embedded in thermoplastic resins. Typical thermoplastic resins are the following: polyamides (PA, PPA) polysulphone (PSU), polyether imide (PEI) and polyether sulphone (PES) or polyether ether ketone (PEEK).

The invention is of course not in any way restricted to the preferred embodiments described above. On the contrary, many possibilities to modifications thereof will be apparent to a person with ordinary skill in the art without departing from
5 the basic idea of the invention such as defined in the appended claims. For example, said at least one end pipe section may be integrally formed with the composite conduit rather than connecting said at least one end pipe section to the composite conduit.

CLAIMS

1. A hybrid riser system (10) for connection between a floating unit (12) and a sub-sea unit (14) that is located at the sea floor (18), **characterized in** that it comprises a composite conduit (22) for transporting a fluid between said floating (12) and sub-sea units (14) and at least one end pipe section (20,24) that is adapted to be connected between the floating (12) and/or the sub-sea unit (14) and the composite conduit (22), whereby said at least one end pipe section (20,24) comprises a metallic pipe or a non-bonded flexible pipe.
2. A riser system (10) according to claim 1, **characterized in** that the length of the end pipe section (20) that is connected to the floating unit (12) is approximately 50-600 m.
3. A riser system (10) according to claims 1-2, **characterized in** that the length of the end pipe section (24) that is connected to the sub-sea unit is approximately 50-100 m.
4. A riser system (10) according to claims 1-3, **characterized in** that the length of the composite conduit (22) is about 1000-1500 m or longer.
5. A riser system (10) according to claims 1-4, **characterized in** that said at least one end pipe section (20, 24) is arranged to be negatively buoyant.
6. A riser system (10) according to any of the preceding claims, **characterized in** that the composite conduit (22) is constituted by a single, continuous composite conduit.

7. A riser system (10) according to any of the preceding claims, **characterized in** that it is adapted to assume a compliant configuration when installed.

5 8. A riser system (10) according to any of the preceding claims, **characterized in** that the composite conduit (22) comprises a bonded pipe having an inner liner (30) and an outer protective sheath, and optionally at least one reinforcing layer (32).

10

9. A riser system (10) according to any of the preceding claims, **characterized in** that the composite conduit (22) is flexible enough to be spooled onto a reel with a hub radius of about 4500-8500 mm.

15

10. A riser system (10) according to any of the preceding claims, **characterized in** that the composite conduit (22) and said at least one end pipe section (20,24) have an internal diameter in the range of about 10-40 cm.

20

11. A riser system (10) according to any of the preceding claims, **characterized in** that the floating unit (12) is a production or storage unit or a platform or vessel, and the sub-sea unit (14) is a sub-sea well facility, wherein the riser system (10) is adapted for transport of fluids, in particular hydrocarbons, such as oil and/or gas, or injection fluids, such as methanol or water, between the floating (12) and sub-sea (14) units.

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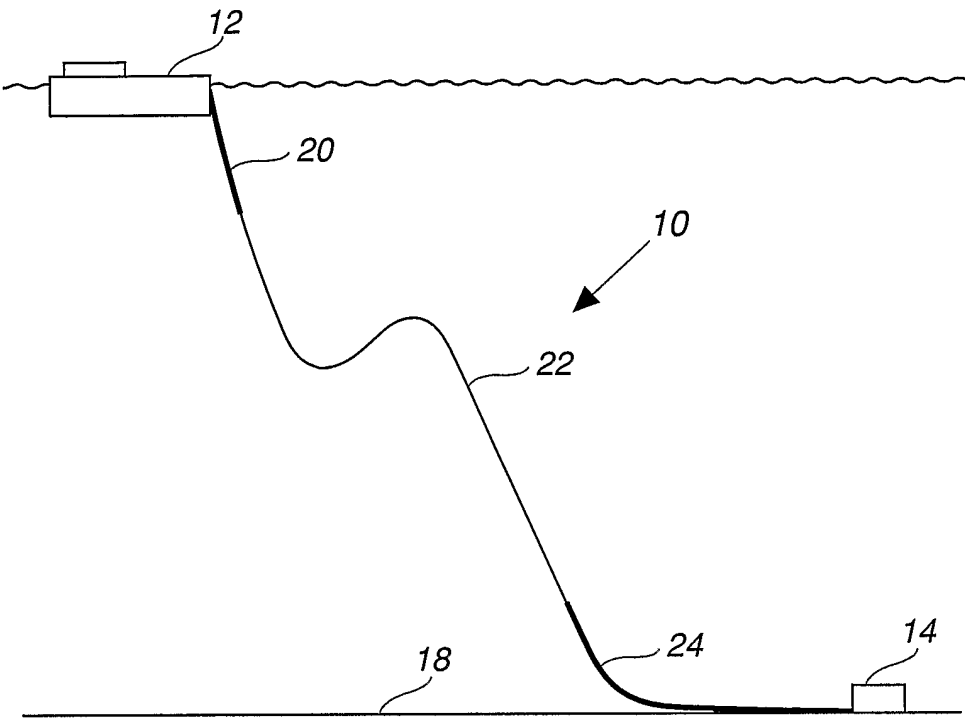


Fig. 1

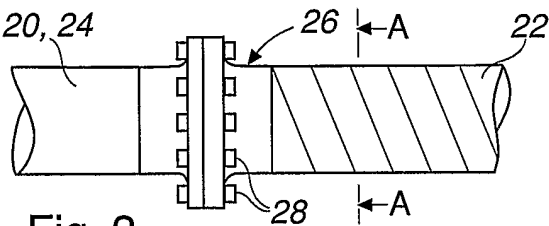


Fig. 2

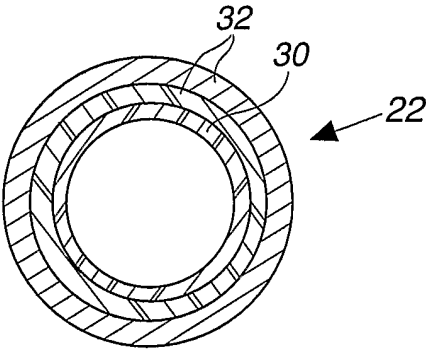


Fig. 3