

ARCTIC RAPID DISCONNECT AND RECONNECT FLOATING DRILLER

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims the benefit of U.S. Provisional Application No. 61/891,134, filed October 15, 2013, the entire contents of which are hereby incorporated by reference.

TECHNOLOGICAL FIELD

[0002] The following description generally pertains to a floating drilling unit, and more particularly pertains to disconnection/reconnection of a riser to the drilling unit.

BACKGROUND

[0003] This section is intended to introduce various aspects of the art. This discussion is believed to assist in providing a framework to facilitate a better understanding of particular aspects of the present technological advancement. Accordingly, it should be understood that this section should be read in this light, and not necessarily as admissions of prior art.

[0004] A sizable portion of the Arctic Ocean has water depth greater than 100 m (Figure 1a). Moving floating drilling units into deeper arctic waters faces increased difficulties as it merges arctic and deep-water frontiers.

[0005] Fig. 1b shows an example of a Concrete Island Drilling Structure (CIDS). This shallow-water mobile offshore drilling unit (MODU) was designed by Global Marine to withstand about 59,000 tonnes of ice load in around 17 meter deep water (Wetmore, 1984). The boundary at which bottom-founded structures become unfeasible in the high-Arctic is generally accepted at approximately 100 m (Paulin, 2008).

[0006] Floating systems, such as Hoover-Diana (Fig. 1c), are held in place with a mooring system that has capacity in the range of 1,000-2,000 tonnes (API RP2SK, 2005). Unfortunately, this capacity pales in comparison with potential ice load magnitude (Fig. 1b), not to mention iceberg loads (Fig. 1d).

[0007] Fig. 2 depicts an axi-symmetric drilling vessel 200, such as the Kulluk. Fig. 3 depicts a ship-shaped arctic drilling vessel 300. Arctic drill vessels 200 or 300 rely on either mooring lines 202 (Fig. 2) or azimuthing thrusters and dynamic positioning (Fig. 3) to

maintain station. Unfortunately, the station-keeping capacity of either system pales in the face of threatening ice floes (an expanse of floating ice).

[0008] Subsea developments may be a viable concept for arctic deep-water development, but some operations still need to be conducted at the surface: i.e., a drilling vessel drilling a subsea well, a tanker loading crude, etc. With conventional technology, offshore operations would have to rely on open water seasons. In higher arctic regions, the open water season exhibits a scarcity and a variance of weeks over the years. For example, in the Canadian Beaufort Ajurak block, the open water season varies between 0 and 24 weeks, with a median of about 9 weeks (Fig. 1e). Fig. 4 shows open water season in the Russian Arctic Seas, the timing of which is no better than what is shown in Fig. 1e. As depicted in Fig. 4, the season median in the N. Barents, N. Kara and Laptev Seas is about 8 weeks, precisely zero in the E. Siberia Sea and about 6 weeks in the Chuckchi Sea.

[0009] Open water season, therefore, may simply not be sufficient to drill oil and gas well in deep water arctic regions. Other means, such as ice management, can play a role to extend the operational season, and to protect operations against ice floe intrusions during the open water season itself. Icebreakers would have to manage a threatening ice floe into sizes small enough not to threaten the station-keeping capacity of the floating vessel. Unfortunately, in some cases, unmanageable multi-year ice inclusions may be present in the invading ice floe. The inclusions can be so small to go undetected yet be threatening, hence leading to the possibility of a rapid or even an emergency disconnection of the riser from the floating drill unit.

SUMMARY

[0010] A system, including: a floating drilling unit; a buoyancy hull plug releasably connected to the floating drilling unit; mooring lines with first ends secured to a seafloor and second ends secured to the buoyancy hull plug; and a riser that is collapsible through a water column, wherein the buoyancy hull plug supports the riser and the mooring lines while disconnected from the floating drilling unit.

[0011] In the system, a combination of the riser and buoyancy hull plug, while disconnected from the floating drilling unit, has sufficient buoyancy to descend to a depth that clears at least a keel of the floating drilling unit.

- [0012] In the system, the riser includes at least one telescoping joint that enables the riser to collapse through the water column.
- [0013] In the system, at least one telescoping joint is disposed below the buoyancy hull plug
- [0014] In the system, the riser includes a plurality of flex joints that enable the riser to collapse.
- [0015] In the system, the flex joints are disposed beneath the buoyancy hull plug.
- [0016] In the system, the buoyancy hull plug has an adjustable buoyancy.
- [0017] In the system, the buoyancy hull plug is a variable depth buoyancy hull plug.
- [0018] In the system, the floating drilling unit is a ship-shaped arctic drilling vessel.
- [0019] In the system, the floating drilling unit is an axi-symmetric drilling vessel.
- [0020] In the system, a blowout preventer is disposed on the buoyancy hull plug.
- [0021] In the system, a second blowout preventer is disposed on a seafloor.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0022] While the present disclosure is susceptible to various modifications and alternative forms, specific example embodiments thereof have been shown in the drawings and are herein described in detail. It should be understood, however, that the description herein of specific example embodiments is not intended to limit the disclosure to the particular forms disclosed herein, but on the contrary, this disclosure is to cover all modifications and equivalents as defined by the appended claims. It should also be understood that the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating principles of the exemplary embodiments. Moreover, certain dimensions may be exaggerated to help visually convey such principles.
- [0023] Fig. 1a is a map that illustrates water depths in the arctic.
- [0024] Fig. 1b illustrates an example of concrete island drilling structure.

- [0025] Fig. 1c illustrates the Hoover-Diana floating system.
- [0026] Fig. 1d illustrates iceberg loads.
- [0027] Fig. 1e illustrates the length of an open water season.
- [0028] Fig. 2 depicts an example of an axi-symmetric drilling vessel.
- [0029] Fig. 3 depicts an example of a ship-shaped arctic drilling vessel.
- [0030] Fig. 4 illustrates the length of an open water season in the Russian Arctic Seas.
- [0031] Fig. 5 illustrates an exemplary offshore drilling system.
- [0032] Fig. 6 illustrates how mooring lines may interfere with the offshore drilling system of Fig. 5.
- [0033] Figs. 7A and 7B illustrate an offshore drilling system that utilizes a collapsible riser.
- [0034] Fig. 8 illustrates a locking mechanism.
- [0035] Fig. 9 illustrates an offshore drilling system that utilizes a collapsible riser.
- [0036] Fig. 10 illustrates an offshore drilling system that utilizes a collapsible riser.

DETAILED DESCRIPTION

[0037] Non-limiting examples of the present technological advancement are described herein. The invention is not limited to the specific examples described below, but rather, it includes all alternatives, modifications, and equivalents falling within the true spirit and scope of the appended claims.

[0038] Fig. 5 illustrates an exemplary offshore drilling system that is configured to drill wells into the ocean floor. The system can include a floating drilling unit 509 that carries drilling equipment. A riser (501 and 511), which extends from the vessel to a well head at the ocean floor, is attached to the floating vessel. The riser (501 and 511) can enclose a drill string and permit circulation of the drilling mud and fluids. The riser (501 and 511)

may comprise a series of pipe-like elements, which are sealably joined into an elongated conduit. The configuration of the riser is further discussed below.

[0039] In waters subjected to inclusion by ice floes, it will be advantageous to quickly move the floating vessel out the area affected by the ice floe. Arctic drilling can be more successful and profitable if the drilling system has the ability to rapidly disconnect the floating vessel 509 from the sea floor and then quickly reestablish that connection at some later time. Such disconnection can be accomplished by disconnecting the riser (501 and 511) from the sea floor, pulling the entire disconnected riser (501 and 511) up to the floating vessel 509, and then maneuvering the floating vessel out of the way of the ice floe. However, the removal of the entire riser (501 and 511) requires a significant investment in time because of the need to raise the entire riser (501 and 511) to the floating vessel 509 and then reestablish the connection at some later time. Given the short duration of the open water season in some arctic regions, removal of the entire riser (501 and 511) will likely end drilling and production operations until the next available open water season.

[0040] Another option for disconnection is to use a two-part riser. The riser can be split into a lower part 501 and an upper part 511. A buoyancy can 505 can be disposed at the top of the lower part 501 in order to support the lower part. The upper part 511 has a connector at its lower end, which normally keeps it connected to the lower part. The connector may be released to separate the upper riser section 511 from the lower riser section 501, which allows the upper part of the riser to be retrieved and stowed in the floating vessel. The floating vessel 509 can be disconnected from its mooring buoy 507 and may then drift away without interference between the keel of the floating vessel 509 and the buoy 507 and riser 501. This solution saves part of the time needed to retrieve the entire riser up to the platform.

[0041] In Fig. 5, the dashed lines represent that the upper part of the riser has been removed. The lower part of the riser 501 is supported by buoyancy can 505, and floating vessel 509 is free to drift away in the direction of the arrow. The mooring lines 503 anchor mooring buoy 507 to the seafloor while mooring buoy 507 remains above and disconnected from the lower part 501.

[0042] The two-part riser presents several disadvantages. A riser with two parts that separate from each other, with a lower part that remains as a free-standing riser in the water column after disconnection, requires special engineering considerations for motion, stability

and structural design, different from conventional single-part drilling risers. After the upper part of the two-part riser is disconnected from the lower part and removed, the remaining lower part will be below and disconnected from the mooring buoy. Because the lower part of the riser after disconnection has to be below the mooring buoy (to avoid interference between the buoy and the riser during disconnection), and the buoy has to come to rest at a depth sufficient to avoid contact with keels of the floating vessel, ice ridges and/or icebergs, the length of the upper part of the riser, which is retrieved to the floating vessel, may be a substantial portion of the total length of the riser. Thus, the time savings from partial riser retrieval may not be significant when compared to the time required to remove the entire riser. Even if the resting depth of the buoy is above the top of the lower part of the riser, there is potential for interference between the mooring line and the lower part of the riser during disconnection, when the disconnection occurs with the vessel at a significant offset from the wellhead and riser (such as that may result from increasing ice loads on the drilling platform). This is illustrated in Fig. 6, wherein the potential for interference between lower part 501 and the mooring lines 503 exists when a significant offset between the floating vessel 509 and the lower riser part 501 develops. The significant offset can develop in response to increasing ice loads prior to disconnection of the mooring buoy 507.

[0043] The present technological advancement can solve the above-noted problems encountered with removing the entire riser or using a two-part riser. Figs. 7A and 7B illustrate an offshore drilling system that utilizes a collapsible riser. Collapsible, as used herein, means to transform to a more compacted state without causing deleterious effects. The system includes a drilling vessel 701 floatably positioned at the water's surface and an elongated riser adapted to extend from the wellhead and blowout preventer 713 to the drilling vessel 701. The drilling vessel is releasably connected from a buoyancy hull plug 703. When the drilling vessel 701 is disconnected from the buoyancy hull plug 703, the riser 705a will collapse through the water column to the state indicated by 705b, wherein buoyancy hull plug 703 will maintain the riser 705b a predetermined distance above the seafloor. The mooring lines are attached directly to the buoyancy hull plug 703 and not directly to the drilling vessel 701. Once the buoyancy hull plug 703 is disengaged from the drilling vessel 701, the drilling vessel is free to float away from any advancing ice floe 711. Use of the collapsible riser eliminates the need to retrieve any part of the riser when avoiding the advancing ice floe. After the ice flow is cleared, the drilling vessel may return to its station,

use a remotely operated vehicle (ROV) to retrieve the collapsed riser and bring it back up to the drilling vessel where the riser can be reconnected to the equipment on the drilling vessel.

[0044] The riser, in Fig. 7B while in a collapsed state, is depicted in a manner to illustrate the collapse. The riser 705a/b is collapsible through the water column in order to accommodate the descent of the buoyancy hull plug without inducing riser buckling. The riser 705a/b can be made from coiled tubing. The coiled tubing is a length of steel or composite tubing that is flexible enough to collapse like a compressed coil spring. The full length of the riser or a partial length of the riser beneath the buoyancy hull plug can be made from the coiled tubing.

[0045] Figs. 7A/7B shows that blowout preventers 715 and 713 can be disposed on the top of the buoyancy hull plug 703 (which is a variable depth buoyancy hull plug and not a fixed depth buoyancy hull plug) and at the sea floor below the lower end of the riser, respectively (wherein top references the side of the buoyancy hull plug closest to the water surface). While Figs. 7A/7B show two blowout preventers, both are not required. Two, one or zero blowout preventers may be used with the present technological advancement. However, two blowout preventers provide for additional redundancy and safety.

[0046] The blowout preventer 715 disposed at the top of the buoyancy hull plug 703 is essentially a pre-installed capping stack, which is an important advantage for drilling in water depth less than 300 meters. In a blowout situation, the hydrocarbon plume prevents intervention vessels from landing the capping stack from directly above. In shallow water, the angle at which the intervention vessel is forced to land the capping stack may be too shallow and therefore not feasible.

[0047] Disposing blowout preventer 715 on variable depth buoyancy hull plug 703 is advantageous when compared blowout preventers disposed on a fixed mid-depth buoy. With the blowout preventer 715 disposed on variable depth buoyancy hull plug 703, there is no need to remove a portion of the riser, whereas the use of the fixed mid-depth buoy necessitates removal of at least an upper portion of the riser.

[0048] The buoyancy hull plug 703 can be secured directly or indirectly to the drilling vessel 701 via multiple locking mechanisms. Fig. 8 illustrates an example of locking mechanism 801, which can be disposed on a deck of the drilling vessel 701 near the top of

the buoyancy hull plug 703. However, the locking mechanisms 801 could be disposed in other locations as long as it can freely engage/disengage from the buoyancy hull plug 703.

[0049] The locking mechanisms 801 can include a lever arm 803 with a first end 805 pivotably attached to the drilling vessel 701, the first end including an protruding member 807 that engages with a recessed portion 809 of the buoyancy hull plug 703. A second end 811 of the lever arm 803 is connected to a quick release mechanism 813, which can be actuated with a sliding or rotating cam 815/817.

[0050] Buoyancy hull plug may be a gas filled canister or a canister filled with a substance less dense than the water. The size of the buoyancy hull plug may be designed to sink to a predetermined depth, given the weight of the riser 705a/b and mooring lines 707. The ballast and/or buoyancy of the hull plug 703 may be adjusted in order for the predetermined depth to be sufficient to clear a keel of any approaching ice floe 711 and the keel of the drilling vessel 701. The canister can be in communication with the water's surface, wherein buoyancy of the canister is controlled by pumping in air, inert gases, or other suitable fluids from the drilling vessel 701. Alternatively, the buoyancy of the hull plug may be fixed, wherein the buoyancy of the hull plug is achieved with a fixed amount of gas, liquid, foam composition, or other material sufficiently less dense than water.

[0051] Fig. 9 illustrates an exemplary collapsible riser. The riser is collapsible through the water column in order to accommodate the descent of the buoyancy hull plug without inducing riser buckling. The riser can comprise a series of discrete tubular members 901 and 903 arranged to form a telescoping joint. A telescoping joint is a joint formed by slipping one part over another in a lengthwise direction. While Fig. 9 illustrates two tubular members 901 and 903, more could be used. The telescoping joint(s) allow independent motion of tubular member 901 while enabling it to be joined to tubular member 903. The tubular members can be arranged with the topmost tubular member 901 being an innermost barrel and each succeeding tubular member 903 being a successive outer barrel. The telescoping riser is disposed below the buoyancy hull plug 703. The telescoping riser can be supported by riser tensioners 905.

[0052] Fig. 10 illustrates an exemplary collapsible riser. The riser is collapsible through the water column in order to accommodate the descent of the buoyancy hull plug without inducing riser buckling. The riser can comprise a series of discrete tubular members

1001, 1003, and 1005 that are connected to each other via flex joints 1007. The flex joint could be a ball joint that provides some angular displacement of the tubular members from vertical. The flex joint could be a riser hinge that can provide angular displacement of the tubular members from vertical. The flex joints 1007 allow independent motion of tubular members 1001, 1003, and 1005 while enabling them to be joined together. The plurality of joints 1007 are disposed below the buoyancy hull plug.

[0053] The non-limiting examples of the present technological advancement may provide many advantages when compared to conventional technology. The present technological advancement can minimize disconnect and reconnect time between the riser and the drilling vessel to a bare minimum; can eliminate the need to retrieve the riser or the drilling string; and can eliminate the need to retrieve or redeploy the mooring lines. The savings and advantages provided from the present technological advancement can provide for commercially profitable exploration of arctic deepwater reservoirs.

[0054] The following references are hereby incorporated by reference in their entirety:

API (2005), Design and Analysis of Stationkeeping Systems for Floating Structures, *API Recommended Practice 2SK*, Third Edition, October 2005;

Le Blanc (1998), "Free-Standing Drilling Riser Features Robust but Familiar Technology," *Offshore Magazine*, February 1998;

Maddock, B., Bush, A., Wojahn, T., Kokkinis, T., Younan, A. and Hawkins, J. R. (2011), "Advances in Ice Management for Deepwater Drilling in the Beaufort Sea," POAC 11-50, Proceedings of the 21st International Conference on Port and Ocean Engineering under Arctic Conditions, July 10-14, 2011, Montréal, Canada;

Moutrey and Lim (2006), "Cost Efficient Artificial Buoyant Seabed Drilling Solution," Rio Oil & Gas Expo and Conference 2006, September 11-14, Rio de Janeiro, Brazil;

Paulin, M. (2008), "Arctic Offshore Technology Assessment of Exploration and Production Options for Cold Regions of the US Outer Continental Shelf" Unites States Minerals Management Service Technology Assessment and Research Program Project Number 584;

US Patent 4,234,047;

US Patent 5,657,823;

Wetmore, S. B. (1984), "The Concrete Island Drilling System: Super Series (Super CIDS), OTC 4801, *Proc. of the 16th Annual Offshore Technology Conference*, Houston, Texas, May 7-9, 1984; and

WO 2009/099337 A1.

[0055] The present techniques may be susceptible to various modifications and alternative forms, and the exemplary embodiments discussed above have been shown only by way of example. However, the present techniques are not intended to be limited to the particular embodiments disclosed herein. Indeed, the present techniques include all alternatives, modifications, and equivalents falling within the spirit and scope of the appended claims.

CLAIMS

What is claimed is:

1. A system, comprising:
 - a floating drilling unit;
 - a buoyancy hull plug releasably connected to the floating drilling unit;
 - mooring lines with first ends secured to a seafloor and second ends secured to the buoyancy hull plug; and
 - a riser that is collapsible through a water column,wherein the buoyancy hull plug supports the riser and the mooring lines while disconnected from the floating drilling unit.
2. The system of claim 1, wherein a combination of the riser and buoyancy hull plug, while disconnected from the floating drilling unit, has sufficient buoyancy to descend to a depth that clears at least a keel of the floating drilling unit.
3. The system of claim 1 or 2, wherein the riser includes at least one telescoping joint that enables the riser to collapse through the water column.
4. The system of claim 3, wherein the at least one telescoping joint is disposed below the buoyancy hull plug
5. The system of any preceding claim, wherein the riser includes a plurality of flex joints that enable the riser to collapse.
6. The system of claim 5, wherein the plurality of flex joints are disposed beneath the buoyancy hull plug.
7. The system of any preceding claim, wherein the buoyancy hull plug has an adjustable buoyancy.

8. The system of any preceding claim, wherein the buoyancy hull plug is a variable depth buoyancy hull plug.
9. The system of any preceding claim, wherein the floating drilling unit is a ship-shaped arctic drilling vessel.
10. The system of any preceding claim, wherein the floating drilling unit is an axisymmetric drilling vessel.
11. The system of any preceding claim, further comprising a blowout preventer disposed on the buoyancy hull plug.
12. The system of claim 10, further comprising a second blowout preventer disposed on a seafloor.