SOFT STOP FOR MAXIMUM RISER TENSIONER STROKE

FIELD OF THE INVENTION

This invention relates in general to riser tensioners for offshore drilling and production vessels and in particular to a stop mechanism that cushions impact during a maximum riser tensioner stroke.

BACKGROUND OF THE INVENTION

Offshore well operations in deep water may employ a riser extending from subsea well equipment on the sea floor to a vessel or floating platform at the surface. During drilling, a drilling riser is connected to the subsea wellhead and extends to the drilling platform. During well production, production risers might extending from subsea well equipment, such as a subsea tree or manifold, to the surface platform.

Guides are employed between the riser and the opening in the vessel through which the riser passes. Typically a tubular conductor is mounted to and surrounds the riser. Bearing members, normally rollers, are mounted to the vessel and engage the conductor.

It is important to keep tension in these risers as the vessel rises and falls due to wave movement and/or currents. A tensioner assembly having hydro-pneumatic cylinder units is connected between the riser. As the vessel moves toward and away from the subsea wellhead, the cylinder units extend and retract to keep a generally uniform level of tension in the risers. Normally, the waves are not steep enough to cause the cylinder units to reach a maximum stroke position where the pistons bottom out on the cylinders. A possibility exists, however, that such waves could occur during extreme weather, such as hurricanes. If so, damage could occur to the cylinders.

SUMMARY

In this invention, an apparatus is incorporated with the riser and vessel to reduce shock if the tensioner reaches an extreme stroke position. A stop and a shock absorber are used, one adapted to be mounted to the vessel and the other to the conductor. The stop and the shock absorber are axially movable relative to each other in response to waves and/or currents, so that during an extreme stroke position of the riser tensioner, the stop and the shock absorber impact each other for absorbing shock. The impact of the stop and the shock absorber occur before the riser tensioner piston tops out in the cylinder.

In the preferred embodiment, the stop comprises a flange on the conductor, and the shock absorber is adapted to be mounted to the vessel. The flange is preferably on a lower end of the conductor. The shock absorber comprises upper and lower annular frame members that are movable toward and away from each other. At least one resilient member is located between the frame members. In the preferred embodiment, a plurality of resilient members are located between and spaced around the

upper and lower frame members.

Preferably the frame members have central openings larger in diameter than an outer diameter of the flange. A plurality of dogs are mounted to the lower frame member and movable between an installation position, which allows the flange to pass downwardly through the central opening in the lower frame member, and an operational position, which prevents the bottom frame member from passing downwardly past the flange. The dogs preferably pivot between the installation position and the operational position. During a maximum downward movement of the vessel relative to the riser, an upper surface of each of the dogs contacts the frame member and a lower surface of each of the dogs contacts the flange to pass the impact force to the lower frame member.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view, partially sectioned, of a ri ser tensioner having a shock absorber in accordance with the invention and shown during a normal operating position.

FIG. 2 is a side view of the riser tensioner of FIG. 1, shown in a maximum extended position.

FIG. 3 is a side view of the riser tensioner of FIG. 1 shown in a maximum contracted position.

FIG. 4 is an enlarged side view of the lower guide rollers and the shock absorber of FIG. 1, shown during installation of the conductor of the riser tensioner.

FIG. 5 is a further enlarged, partially sectioned view of a portion of the shock absorber of FIG. 1, shown after the conductor has been inserted through the shock absorber.

FIG. 6 is a side view of the lower guides rollers and the shock absorber of FIG. 1, shown with the tensioner in the maximum extended position.

FIG. 7 is a perspective view of the lower guide rollers and the shock absorber of FIG. 1, shown with the riser tensioner near its maximum stroke position.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, riser tensioner assembly **11** is utilized on offshore drilling and/or production floating platforms, and may be one of several on the same platform. Riser tensioner assembly **11** is employed to maintain a desired tension in a riser **13** that extends from the vessel or platform to subsea well equipment **15** on the sea floor. Riser **13** may be a drilling riser for drilling new wells or it may be a production riser for production fluid flow. Subsea well equipment **15** may be a subsea wellhead housing, a subsea tree, a subsea manifold or other type of hydrocarbon recovery equipment. The vessel is subject to vertical and translational movement relative to subsea equipment **15** because of currents and waves.

Riser tensioner assembly **11** is mounted between an upper deck **17** and a lower deck **19** of the vessel. Decks **17**, **19** are a fixed distance apart and move in unison with the vessel. In this embodiment, riser tensioner assembly **11** has two bearing members, which comprise an upper set of

guide rollers **21** mounted to upper deck **17** and a lower set of guide rollers **23** mounted to lower deck **19**. Riser tensioner assembly **11** has a conductor **25**, which is a large diameter pipe that extends through guide rollers **21**, **23** and is stationary relative to riser **13**. Vessel decks **19**, **21** and upper and lower guide rollers **21**, **23** thus move relative to conductor **25**. Conductor **25** has an upper end that is rigidly secured to a top frame **27**. Conductor **25** has a stop that comprises an external flange **29** located at its lower end. Riser **13** extends through conductor **25** and may be centrally supported by a number of centralizers **31**. Alternately, conductor **25** could be mounted to the vessel for movement therewith, and the guide rollers **21**, **23** could be mounted to the riser **13**.

In this embodiment, it is desired to continually maintain tension throughout the length of riser **13**, regardless of movement of decks **17**, **19**. Each riser tensioner assembly **11** has a plurality of hydro-pneumatic cylinders **33** that in this embodiment are mounted to upper deck **17** and extend downward from upper guide rollers **21** to a point above lower deck **17**. A piston shaft **35** extends from each cylinder **33** to top frame **27**. Fluid pressure acts against a piston within each cylinder **33** for extending and retracting each piston shaft **35** and for applying an upward force to top frame **27**. A clamp **37** at top frame **27** clamps riser **13** to top frame **27**.

A shock absorber **39** is mounted to lower guide rollers **23**, thus shock absorber **39** moves in unison with the vessel in this embodiment. While in the normal operating position of FIG. 1, shock absorber **39** is positioned well above flange **29** at the lower end of conductor **25**. FIG. 2 illustrates an extremely low position for the vessel, such as in the trough of a huge wave in a severe hurricane. In this position, shock absorber **39** lands on conductor flange **29** and piston shafts **35** extend to a maximum length stroke to maintain the desired tension in riser **13**. Preferably, the impact of shock absorber **39** on flange **29** occurs before the pistons top out in cylinders **33**. FIG. 3 shows the vessel moving away from subsea well equipment **15**, such as at the peak of a big wave. In this position, piston shafts **35** are fully retracted to avoid over tensioning riser **13**, and shock absorber **39** is located a full stroke distance above conductor external flange **29**. Alternately, shock absorber **39** could be mounted stationarily on conductor **25** and a stop, such as flange **29**, mounted on the vessel.

Referring to FIG. 4, lower guide rollers **23** may be of a variety of types. In this type, guide rollers **23** include an upper plate **41** and a lower plate **43**, each of which extends around conductor **25** in a plane perpendicular to the axis of conductor **25**. Braces **45** extend vertically between plates **41**, **43**, securing them to each other at a fixed distance. A plurality of rollers **47** are mounted between braces **45** for engaging conductor **25**.

Shock absorber **39** comprises a top frame **49** and a bottom frame **51** in this example. Top frame **49** is secured to lower plate **43** of lower guide rollers **23** in any suitable manner, such as by bolts. Frames **49**, **51** comprise circular flat plates similar to plates **41**, **43** of guide rollers **23**. Each frame **49**, **51** has a central hole **52** (FIG. 5) through which conductor **25** extends. Bottom frame **51** is movable vertically a short distance relative to top frame **49**. A number of retaining pins **53** extends between frames **49**, **51** to retain bottom frame **51** with top frame **49**. Each retaining pin **53** is stationarily secured to top frame

49 for movement therewith. Each retaining pin **53** extends through a hole in bottom frame **51**. A nut **55** at the lower end of each retaining pin **53** retains bottom frame **51** while in its lower position relative to top frame **49**, which is the position shown in FIGS. 4 and 7. FIG. 6 shows bottom frame **51** moved upward relative to retaining pins **53** and top frame **49** to an upper position. Alternatively, retaining pins **53** could be mounted stationarily to bottom frame **51** and extend through holes in top frame **49**.

A plurality of dampers or resilient members are located between frames **49** and **51** to dampen upward movement of bottom frame **51** to relative to top frame **49**. In this example, each damper comprises a tubular steel housing **57** containing a flexible spring element **59**. Spring element **59** may comprise an elastomeric member or a coil spring and it initially protrudes from an open end of damper housing **57**. In this example, damper housing **57** is mounted to top frame **49** and damper spring element **59** extends downward and is biased into contact with bottom frame **51**. However, housing **57** and spring element **59** could be inverted, if desired. FIGS. 4 and 7 show spring elements **59** protruding from housings **57** while FIG. 6 shows spring elements **59** fully compressed within their housings **57**.

Referring to FIG. 4, shock absorber **39** also has a plurality of load transfer dogs **61**. Dogs **61** are uniformly spaced around the circumference of bottom frame **51**. In this example, each dog **61** comprises a flat plate that is pivotally mounted to a clevis **63** by a pivot pin **65**. Each clevis **63** is welded or otherwise secured to the lower side of bottom frame **51**. Each dog **61** has a lower edge **67** that when in the operational position of FIGS. 5-7 faces downward for engagement by external flange **29** when tensioner assembly **11** is in the fully extended position of FIG. 2. Each dog **61** has an upper edge **66** that contacts the lower side of bottom frame **51** while in the operational position. An inner edge **71** of each dog **61** is closely spaced to the outer diameter of conductor **25** while in the operational position. Each dog has an upward-facing cam edge **70** located radially outward from pivot pin **65**.

Referring to FIG. 5, for each dog **61**, an adjustment pin **69** is secured to top frame **49** (FIG. 4) and extends downward into a hole **68** in bottom frame **51**. In the assembly position, illustrated by the dotted lines of FIG. 5, the lower end of each adjustment pin **69** is recessed within hole **68**. Adjustment pin **69** has a threaded section that engages a threaded hole in top frame **49** (FIG. 4). When rotated, adjustment pin **69** moves downward against cam edge **70** of dog **61** to cause dog **61** to rotate about pivot pin **65** to the operational position shown by the solid lines of FIG. 5. Adjustment pin **69** is locked in a desired position by tightening a nut **73** (FIG. 4) against top frame **49**.

During assembly of riser tensioner **11** to the vessel, lower guide rollers **23** and shock absorber **39** will be secured to each other and mounted to lower deck **19** (FIG. 1) of the vessel before installation of conductor **25**. In the installation position shown in FIG. 4 and by the dotted lines of FIG. 5, each dog **61** is free to pivot about its pivot pin **65** and will hang downward by its own weight. In this position, the inner diameter circumscribed by the inner edges **71** of dogs **61** is greater than the outer diameter of conductor flange **29**. Conductor **25** is then lowered through upper guide rollers **21** (FIG. 1), lower guide rollers **23** and shock absorber **39**. The freely pivotal dogs **61** allow flange **29** to pass through shock

absorber **39** as conductor **25** is lowered even if flange **29** happens to contact inner edges **71**. After the upper end of conductor **25** lands on tensioner top frame **27** (FIG. 1), the operator rotates adjustment pins **69**, causing each dog **61** to pivot about its pivot point **65**. When upper edge **66** contacts the lower side of bottom frame **51**, the operator will tighten nut **73** (FIG. 4). Dogs **61** will then remain in the operational position of FIGS. 5-7. The inner edges **71** will define an inner diameter that is smaller than the outer diameter of conductor flange **29** and slightly larger than the outer diameter of conductor **25** above flange **29**.

In operation, shock absorber **39** will move in unison with the vessel and its upper and lower decks **17**, **19**, as can be seen by comparing FIGS. 1-3. Downward and upward movement of vessel decks **17**, **19** relative to conductor **25** cause piston shafts **35** to extend and retract to maintain a desired tension in riser **13**. If the downward movement is great enough, it is possible for shock absorber **39** to impact external flange **29** of conductor **25**, as shown in FIG. 2. Referring to FIG. 7, when lower edges **67** of dogs **61** contact external flange **29**, an upward force from flange **29** is transferred through upper edges **66** (FIG. 5), bottom frame **51** and to damper spring elements **59**, which absorb shock and collapse within damper housings **57**. When damper spring elements **59** are fully collapsed (FIG. 6), the upward force passes through damper housings **57**, top frame **49** and lower guide rollers **23** to lower deck **19** (FIG. 2).

As the vessel rises from the trough of the large wave, decks **17**, **19** move upward relative to conductor **25**, as shown by comparing FIGS. 2 and 3, which moves shock absorber **39** above the external flange **29**. Bottom frame **51** moves back down to the lower position (FIG. 7) relative to top frame **49** and damper spring elements **59** protrude from damper housings **57**.

The shock absorber reduces the possibility of damage occurring to the riser tensioner cylinders because it stops extension of the tensioner cylinder units before the pistons top out. The pivotal load transfer dogs facilitate installation of the riser conductor.

While the invention has been shown in only one of its forms, it should be apparent to those skilled in the art that it is not so limited, but is susceptible to various changes without departing from the scope of the invention. For example, although the shock absorber and stop only operation during maximum extension of the tensioner cylinder units, similar arrangements could be used to restrict maximum contraction.

CLAIMS

The invention claimed is:

1. An apparatus for reducing shock to a riser tensioner occurring during an extreme stroke position, the riser tensioner adapted to be connected between a riser that extends from subsea well equipment through an opening in a vessel, the apparatus comprising:

a tubular conductor that is adapted to surround the riser where the riser passes though the opening in the vessel; and

a stop and a shock absorber, one being adapted to be mounted to the vessel and the other to the conductor, the stop and the shock absorber being axially movable relative to each other and relative to the axis of the conductor, so that during an extreme stroke position of the riser tensioner, the stop and the shock absorber impact each other for absorbing shock, wherein the shock absorber comprises:

upper and lower annular frame members that are movable toward and away from each other; and

at least one resilient member between the frame members.

2. The apparatus according to claim 1, wherein the stop comprises a flange on the conductor, and the shock absorber is adapted to be mounted to the vessel.

3. The apparatus according to claim 1, wherein the stop comprises a flange on a lower end of the conductor.

4. An apparatus for reducing shock to a riser tensioner occurring during an extreme stroke position, the riser tensioner adapted to be connected between a riser that extends from subsea well equipment through an opening in a vessel, the apparatus comprising:

a tubular conductor that is adapted to surround the riser where the riser passes though the opening in the vessel; and

a stop and a shock absorber, one being adapted to be mounted to the vessel and the other to the conductor, the stop and the shock absorber being axially movable relative to each other and relative to the axis of the conductor, so that during an extreme stroke position of the riser tensioner, the stop and the shock absorber impact each other for absorbing shock, wherein the shock absorber comprises:

upper and lower annular frame members that are movable toward and away from each other; and

a plurality of shock absorbing cylinders spaced circumferentially around and to one of the frame members, each of the cylinders having a resilient member that engages the other of the frame members.

5. An apparatus for reducing shock to a riser tensioner occurring during an extreme stroke position, the riser tensioner adapted to be connected between a riser that extends from subsea well equipment through an opening in a vessel, the apparatus comprising:

a tubular conductor that is adapted to surround the riser where the riser passes though the opening in the vessel; and

a stop and a shock absorber, one being adapted to be mounted to the vessel and the other to the conductor, the stop and the shock absorber being axially movable relative to each other and relative to the axis of the conductor, so that during an extreme stroke position of the riser tensioner, the stop and the shock absorber impact each other for absorbing shock, wherein:

the stop comprises a flange on a lower end of the conductor; and the shock absorber comprises:

an annular frame member having a central opening larger in diameter than an outer diameter of the flange; and

a plurality of dogs mounted to the frame member and movable between an installation position, which allows the flange to pass downwardly through the central opening in the frame member, and an operational position, which prevents the bottom frame member from passing downwardly past the flange.

6. The apparatus according to claim 5, wherein each of the dogs is pivotally mounted to the frame member and pivots between the installation position and the operational position.

7. The apparatus according to claim 5, wherein while in the operational position and during a maximum downward movement of the vessel relative to the riser, an upper surface of each of the dogs contacts the frame member and a lower surface of each of the dogs contacts the flange.

8. An apparatus for reducing shock to a riser tensioner occurring during an extreme stroke position, the riser tensioner adapted to be connected between a riser that extends from subsea well equipment through an opening in a vessel, the apparatus comprising:

a tubular conductor that is adapted to surround the riser where the riser passes though the opening in the vessel; and

a stop and a shock absorber, one being adapted to be mounted to the vessel and the other to the conductor, the stop and the shock absorber being axially movable relative to each other and

relative to the axis of the conductor, so that during an extreme stroke position of the riser tensioner, the stop and the shock absorber impact each other for absorbing shock, further comprising:

a plurality of rollers mounted to the shock absorber in rolling engagement with the conductor.

9. An apparatus for reducing shock to a riser tensioner occurring during an extreme stroke position, the riser tensioner adapted to be connected between a riser that extends from subsea well equipment through an opening in a vessel, the apparatus comprising:

a tubular conductor that is adapted to surround the riser where the riser passes though the opening in the vessel; and

a stop and a shock absorber, one being adapted to be mounted to the vessel and the other to the conductor, the stop and the shock absorber being axially movable relative to each other and relative to the axis of the conductor, so that during an extreme stroke position of the riser tensioner, the stop and the shock absorber impact each other for absorbing shock, wherein the shock absorber comprises:

upper and lower annular frame members that are movable toward and away from each other, the upper annular frame member adapted to be mounted stationarily to the vessel; and

a plurality of shock absorbing cylinders spaced circumferentially around and between the frame members, each of the cylinders having a resilient member that engages one of the frame members; and the apparatus further comprises:

a set of rollers mounted to the upper frame member and in rolling engagement with the conductor.

10. An apparatus for performing subsea well operations, comprising:

a vessel;

a riser adapted to be connected to subsea well equipment and extending to the vessel;

a tubular conductor mounted stationarily to and around the riser, the conductor passing through an opening in the vessel;

a bearing member mounted to the vessel around the opening for engagement with the conductor as the vessel moves relative to the riser;

a plurality of hydro-pneumatic cylinder units, each having a piston, the cylinder units being connected between the riser and the vessel for applying tension to the riser, the cylinder units being spaced around the conductor;

an external flange on a lower portion of the conductor; and

a shock absorber positioned around the conductor and mounted to the vessel for movement relative to the conductor, the shock absorber having at least one resilient member for absorbing shock when the shock absorber impacts the external flange.

11. The apparatus according to claim 10, wherein the shock absorber comprises:

upper and lower annular frame members that are movable toward and away from each other along a longitudinal axis of the conductor, one of the frame members being rigidly attached to the vessel; and wherein

said at least one resilient member comprises a plurality of resilient members spaced circumferentially around and between the frame members.

12. The apparatus according to claim 10, wherein the shock absorber comprises:

upper and lower annular frame members that are movable toward and away from each

other along a longitudinal axis of the conductor, one of the frame members rigidly attached to the vessel; and wherein

said at least one resilient member comprises a plurality of shock absorbing cylinders spaced circumferentially around and between the frame members.

13. The apparatus according to claim 10, wherein the shock absorber comprises:

an annular bottom frame member having a central opening larger in diameter than an outer diameter of the flange; and

a plurality of dogs mounted to the bottom frame member and movable between an installation position, which allows the flange to pass downwardly through the bottom frame

member, and an operational position, which prevents the bottom frame member from passing downwardly past the flange.

14. The apparatus according to claim 13, wherein while in the operational position and during a maximum stroke of the cylinder units, an upper surface of each of the dogs contacts the bottom frame member and a lower surface of each of the dogs contacts the flange.

15. The apparatus according to claim 13, wherein each of the dogs is pivotally mounted to the bottom frame member and pivots between the installation position and the operational position.

16. The apparatus according to claim 10, wherein the shock absorber is mounted to a lower side of the bearing member.

17. A method for reducing shock to a riser tensioner occurring during an extreme stroke position, the riser tensioner being connected between a riser that extends from subsea well equipment through an opening in a vessel, the riser being surrounded by a tubular conductor where the riser passes through the opening, the method comprising:

providing a stop and a shock absorber and mounting them to the vessel and to the conductor for axial movement relative to each other in response to waves and/or currents, wherein the step of mounting the stop and the shock absorber to the vessel comprises providing a flange on the conductor to serve as the stop and mounting the shock absorber on the vessel, the shock absorber having a central passage with an expanded installation position and a contracted operational position, and wherein during installation the stop is lowered through the passage in the shock absorber while the shock absorber is in the expanded installation position, then the shock absorber is placed in the contracted operational position; and

during an extreme stroke position of the riser tensioner, impacting the stop and the shock absorber and absorbing shock.