

In a “soft hangoff” procedure – which particularly applicable for deep waters – the tensioners and telescopic joint remain active with the tensioners supporting the free-hanging riser weight from the telescopic joint. The telescopic joint and tensioners absorb vertical rig movements, significantly reducing load variations on the riser system.

The result of a riser-seabed disconnect is normally to have the tensioner cylinders at a fully extended or retracted position (retracted for a direct acting tensioner, extended for a wire-line tensioner) At this point the riser, supported by the tensioner system, will have to move together with the rig as the tensioner cylinders are in an endstroke position. The riser will have a fairly large mass, with buoyancy elements. This means that it will not have the ability to fall down in the water as quickly as the rig does. This phenomenon is more applicable as the water depths and riser lengths increase. When the rig heaves downwards with the sea, the riser mass will have to be pushed down in the sea with the result of shallow water buckling of the riser.

In a typical soft hangoff procedure, the tensioner cylinders are normally stroked to a mid-stroke position and the free-hanging riser is allowed to be supported by the tensioners in a passive and somewhat uncontrolled manner. The riser has a large mass/wet weight ratio and can easily buckle when subjected by the large compression loads caused by the riser upper end having to follow the rig motion. Thus, a major concern during a soft hangoff procedure is to avoid overloading the riser caused by large downwards acceleration that could buckle the upper section of it. Another concern is to prevent the tensioner cylinders from hitting endstroke.

The present applicant has devised and embodied this invention to overcome these shortcomings and to obtain further advantages.

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Summary of the invention

The invention is set forth and characterised in the main claim, while the dependent claims describe other characteristics of the invention.

It is therefore provided an apparatus for controlling movements of a free-hanging tubular in a soft hang-off mode suspended via at least a connector element by at least one compensator member which is connected to a buoyant vessel, said tubular extending into a body of water below the vessel, characterised by first sensing means for sensing dynamic and/or spatial parameters of the compensator member and thus that of the vessel; second sensing means for sensing dynamic and/or spatial parameters of the connector element, and thus that of an upper region of the tubular; data processing means for processing data supplied by said first and second sensing means and

determining one or more parameters regarding the movement between the vessel and the upper region of the tubular; and adjusting means for controlling at least the stiffness and dampening of the compensator member; whereby the axial loads which are transferred between the compensator and the tubular may be controlled.

5 In one embodiment, the first sensing means comprises motion sensing means for sensing movements of the compensator member and thus that of the vessel. In one embodiment, the second sensing means comprises position indicator means for sensing the position of the connector element, and thus that of an upper region of the tubular, with respect to the compensator member.

10 In one embodiment, the one or more parameters regarding the movement between the vessel and the upper region of the tubular comprises acceleration.

The compensator member preferably comprises a hydraulic cylinder connected via a first fluid line to an accumulator, and a first valve means for controlling the flow in said first fluid line, and a first pressure sensing means for sensing the pressure of said
15 hydraulic fluid. Preferably, at least one pressure vessel is fluidly connected to the accumulator via a second fluid line and regulator means, and further comprising a second pressure sensing means, whereby the pressure exerted on the hydraulic fluid in the accumulator by a pressurised gas in the pressure vessel may be controlled.

20 In one embodiment, a heat exchanger, with a cooling circuit, is thermally connected to the first fluid line, whereby hydraulic fluid in the first fluid line may be cooled in heat exchange with a cooling fluid.

It is also provided a system for controlling movements of a free-hanging tubular in a soft hang-off mode, wherein a plurality of apparatuses according to the invention are connected to the tubular via respective compensator members arranged in a
25 symmetrical pattern around the tubular, and further comprising a common data processing means and a common user interface, whereby the movements of the free-hanging tubular may be controlled by a selective manipulation of the individual apparatuses.

It is also provided a method of controlling movements of a free-hanging tubular in a soft hang-off mode suspended via a connector element by at least one compensator
30 member which is connected to a buoyant vessel, said tubular extending into a body of water below the vessel, characterised by collecting motion data for the vessel; collecting motion data for the upper region of the tubular with respect to the compensator member; processing said motion data for the vessel and said motion data
35 for the upper region of the tubular and determining one or more parameters regarding the movement between the vessel and the upper region of the tubular and, based on such data, controlling at least the stiffness and dampening of the compensator member;

CLAIMS

1. An apparatus-(1) for controlling movements of a free-hanging tubular-(4) in a soft hang-off mode suspended via at least a connector element-(8) by at least one
5 compensator member-(7) which is connected to a buoyant vessel-(2), said tubular extending into a body of water below the vessel, **characterised by**
 - first sensing means-(36) for sensing dynamic and/or spatial parameters of the compensator member and thus that of the vessel-(2);
 - second sensing means-(21) for sensing dynamic and/or spatial parameters of the
10 connector element-(8), and thus that of an upper region of the tubular;
 - data processing means-(22) for processing data supplied by said first and second sensing means-(36, 21) and determining one or more parameters regarding the movement between the vessel and the upper region of the tubular; and
 - adjusting means-(24a,b, 25, 26, 29, 33a-d) for controlling at least the stiffness and
15 dampening of the compensator member-(7);
whereby the axial loads which are transferred between the compensator and the tubular may be controlled.
2. The apparatus of claim 1, wherein the first sensing means-(36) comprises motion sensing means-(36) for sensing movements of the compensator member and
20 thus that of the vessel-(2).
3. The apparatus of claim 1 of claim 2, wherein the second sensing means-(21) comprises position indicator means-(21) for sensing the position of the connector element-(8), and thus that of an upper region of the tubular, with respect to the compensator member.
- 25 4. The apparatus of any one of the preceding claims, wherein said one or more parameters regarding the movement between the vessel and the upper region of the tubular comprises acceleration.
5. The apparatus of any one of the preceding claims, wherein the compensator member comprises a hydraulic cylinder-(7) connected via a first fluid line-(35) to an
30 accumulator-(26), and a first valve means-(25) for controlling the flow in said first fluid line, and a first pressure sensing means-(27) for sensing the pressure of said hydraulic fluid.
6. The apparatus of claim 5, further comprising at least one pressure vessel (33a-d) fluidly connected to the accumulator-(26) via a second fluid line-(31) and
35 regulator means-(29), and further comprising a second pressure sensing means-(28),

whereby the pressure exerted on the hydraulic fluid in the accumulator by a pressurised gas in the pressure vessel may be controlled.

7. The apparatus of any one of the preceding claims, further comprising a heat exchanger-(15), with a cooling circuit-(16), thermally connected to the first fluid line-(35), whereby hydraulic fluid in the first fluid line may be cooled in heat exchange with a cooling fluid.

8. A system for controlling movements of a free-hanging tubular-(4) in a soft hang-off mode, wherein a plurality of apparatuses-(1) according to any one of claims 1 – 7 are connected to the tubular-(4) via respective compensator members (7) arranged in a symmetrical pattern around the tubular, and further comprising a common data processing means-(22') and a common user interface-(37'), whereby the movements of the free-hanging tubular may be controlled by a selective manipulation of the individual apparatuses-(1).

9. A method of controlling movements of a free-hanging tubular-(4) in a soft hang-off mode suspended via a connector element-(8) by at least one compensator member-(7) which is connected to a buoyant vessel-(2), said tubular extending into a body of water below the vessel, **characterised by** collecting motion data for the vessel-(2); collecting motion data for the upper region of the tubular with respect to the compensator member; processing said motion data for the vessel and said motion data for the upper region of the tubular and determining one or more parameters regarding the movement between the vessel and the upper region of the tubular and, based on such data, controlling at least the stiffness and dampening of the compensator member; whereby the axial loads which are transferred between the compensator and the tubular may be controlled.

10. The method of claim 9, wherein the collecting of motion data for the vessel comprises sensing movements of the vessel-(2).

11. The method of claim 9 or claim 10, wherein the collecting motion data for the upper region of the tubular comprises sensing the position of an upper part of the tubular with respect to the compensator member.

12. The method of claim 11, further comprising the sensing of a first pressure in a hydraulic cylinder-(7) connected between the tubular-(4) and the vessel-(2), said hydraulic cylinder being connected via a first fluid line-(35) to an accumulator-(26), and the sensing of a second pressure in the accumulator exerted by at least one pressure vessel-(33a-d) fluidly connected to the accumulator-(26) via a second fluid line-(31) and regulator means-(29).