

Subsea Intervention System

Field of the Invention

The invention relates to a method for controlling grease injection to a subsea intervention system and an apparatus comprising a housing containing a control unit
5 and a pump for grease.

Background of the Invention

When doing intervention in a hydrocarbon well it is necessary to isolate the well from the environment. Intervention is often carried out using wireline techniques
10 (braided wire, composite cable or slickline). To contain the pressure in the well during operations and avoid hydrocarbons escaping to the environment intervention operations involve the use of a stuffing box which is part of a pressure control head (PCH). The PCH provides a dynamic seal between the cable and the wellbore
15 enclosures to maintain pressure control and prevent wellbore fluids from leaking into the environment. However, because of its braided (wire rope like) exterior, the cable has a bumpy, crevice-filled surface which is difficult for the PCH to seal around as the cable passes through the PCH as it travels into and out of the well. Current practice is to inject grease into the PCH body at a higher pressure than that
20 of the well. In addition grease has to be replenished at some rate to replace grease lost to the surface of the braided cable as it passes through the ends of PCH (going into or out of the well). The grease injection rate is controlled by periodic visual monitoring of the sealing ends of the PCH for leakage and monitoring the grease injection pressure.

25 This operation gets complicated when performing this practice subsea on a subsea well. This involves the use of a subsea riserless light well intervention (RLWI) stack. For RLWI, the PCH is now remote and difficult to monitor; making it difficult to determine when and how much grease needs to be injected. Furthermore, as the stack is run in deeper water, the length of the grease supply line feeding the
30 PCH grows longer, making it increasingly difficult to pump viscous grease down to the PCH at a reasonable surface pressure or pump rate. The long grease lines and viscous grease becomes more problematic as deeper colder environments are encountered.

35 Current practice for subsea grease injection requires the surface deployment of grease lines as shown in US Patent 4821799. This patent discloses the use of an accumulator to enable a better control of injection pressures.

40 There is also a more subtle problem associated with grease injection to a subsea PCH, that of water ingress. Normally the PCH is lowered to the lubricator tube together with the tool. However, in some operations, the PCH is run independently

after the wireline tools, cable, etc. are landed in the RLWI stack's lubricator tube. As the PCH assembly is lowered down to the sea floor, the braided cable passes through the PCH. If grease is not supplied at a sufficient pressure and rate to offset the increase in ambient pressure and loss of grease to the cable passing by, seawater could weep past the seal ends of the PCH into the main cavity. If this occurs, there is an increased risk that the water will help to form a hydrate plug inside the PCH (later exposed to wellbore pressure and fluids) and prevent the cable from freely moving through the PCH.

Summary of the invention

The invention regards a method and a device for controlling grease injection to a subsea intervention system, where there is provided a at site pressure compensated system for providing the grease at a pressure higher than the outside pressure, this being either the well pressure or the pressure of the water around the subsea system or both these pressures.

The invention is according to one aspect suitable in an intervention workover control system (IWOCS) that is all electric or electro-hydraulic that may comprise a processor with the capability to handle information, for example to record outside ambient sea water pressure, pressure inside the PCH and below the PCH (inside the well). As mentioned above, the purpose of the grease and PCH is to create a dynamic seal that generates a slightly higher (grease) pressure inside the PCH than that of the environment above or the well below. To do that requires pumping grease at some empirical rate monitored visually. In subsea situations, the pumping pressure is exacerbated by the length of the grease line going down to the subsea PCH and the rate is a pure guess, often resulting in sending too much down to conservatively compensate for the unknown condition.

The elimination of the grease line is also in keeping with FMC's deepwater RLWI operating philosophy for line management in deepwater (3 line limit). Reduction or elimination of lines from the surface to the subsea RLWI stack greatly simplifies deepwater operations beyond 500 m (1500 ft) water depths. In addition, the invention makes the overall system depth insensitive by eliminating the grease line which has a "finite" length which would otherwise define the system's operating depth.

The benefit of the present invention is that its architecture is depth insensitive, eliminating the pressure flow rate problems associated with pumping viscous grease longer distances (at higher surface pump pressures) and eliminates waste by using environmentally friendly lubricants that are injected at much lower differential

pressures because the injection process is monitored. It also eliminates a line going into the water which is beneficial for better line management; critical for deepwater (> 500m ~ 1500 ft.) operations.

According to an aspect of the present invention, there is provided a method for controlling grease injection to a subsea lubricator, the said lubricator comprising a housing containing a grease supply accumulator, a pump, an electric motor for operating the pump and a control unit for controlling the motor, where the said method comprises the steps of reading an outside pressure from a sensor located outside said housing, receiving signals from said pressure sensor in the control unit and controlling the motor and the pump to deliver grease from the grease accumulator to the lubricator at a level that is above said outside pressure.

According to one aspect the outside pressure sensor may record the ambient, i.e. seawater pressure. According to another aspect the outside pressure sensor may record the wellhead pressure.

In one aspect of the invention the unit in a first mode may be connected to an intervention control system to receive instructions from a control station at the surface and in a second mode may be operating autonomously when being disconnected from an IWOCS. Wherein there in one embodiment the autonomous mode power may be provided by a battery in the housing.

According to another aspect the signals from the pressure sensor may be processed by the intervention control system. According to another aspect the signals from the pressure sensor may be processed by a processor in the module. The grease may be removed from the subsea equipment and returned to the grease supply accumulator according to another aspect of the invention.

The invention also relates to a grease injection device for injecting grease into a subsea intervention system, comprising a housing with an accumulator of grease, a grease injection line towards the system. According to the invention the grease injection device is a self-contained unit attachable to the system and is pressure compensated to deliver a pressure higher than a pressure within the well and or outside the subsea intervention system, and comprises a pump with an electric motor operating the pump, connected to the grease injection line, at least one pressure sensor reading the pressure within the well and or the outside and a control unit operating the different elements to pressure compensate the device.

According to one aspect the device may be pressure compensated by having a passively pressure compensated accumulator. In another aspect the device may comprises a ROV contingency refill in connection with the accumulator. In a further aspect the device may comprise a grease wipe device connected to the subsea system, and a return line for returning the wiped grease back to the device.
5 In another aspect it may comprises a second pump with a second electric motor.

In a further aspect it may comprise two separate injection points towards the subsea system. According to another aspect the device may be connected to the PCH. The housing may be a self-contained unit attached to a pressure control head in another aspect
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The control unit may comprise a processor and data storage unit. The device may comprise a source of electric power, according to another aspect. The power source may be a battery or be an umbilical. In another aspect the device may comprise a workover control module.
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Brief description of the Drawings

20 The invention will now be described with reference to the accompanying drawing where

Fig. 1 shows a sketch of an intervention system on a subsea well

Fig. 2 is a diagram showing the grease injection module in IWOCS mode, and

25 Fig. 3 is a diagram showing the grease injection module in autonomous mode.

Description of the preferred Embodiments

Fig. 1 is a schematic drawing showing a subsea lubricator system 10 according to the invention attached to a subsea well 5. The subsea well 5 extends into a subterranean formation and has a Christmas tree 6 attached to the wellhead and a flowline/umbilical 7 extending to a process facility. The subsea lubricator stack 10 includes a pressure control unit (BOP) 11, a lubricator (pipe) 12 and the pressure control head (PCH) 13.
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35 The lubricator system further comprises the control system (IWOCS) 15 with a separate workover umbilical 17 extending to the surface. The IWOCS controls the system. In prior art operations grease is pumped down the line 17 and further through line 23 to the PCH 13 to maintain a seal between the braided wire or cable and the seawater environment.
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In a first embodiment of the invention shown on Fig. 1 a grease injection module 21 is attached to the PCH 13. In this mode line 23 is an electric cable that connects the grease injection module 21 with the IWOCS 15. With the grease injection module attached to the PCH it can be raised and lowered together with the PCH and be able to operate in an autonomous mode. In another embodiment (not shown) the grease injection module is made as a part of the IWOCS. In this case the line 23 will comprise both electric and fluid lines and grease is supplied to the PCH through this line.

10 The invention proposes the elimination of the grease line to, or from, surface, replaced with a depth compensated bladder or accumulator filled with grease. The grease injection module 21 comprises an accumulator 31 for grease operatively connected via line 33 to a pump 35. The outlet grease line 37 from the pump is connected to the PCH 13. The pump is controlled by an electric motor 36. A first power supply cable 32 connects the IWOCS with the electric motor 36 for the pump 35. The grease line 37 has a one way valve 43, a shut-off valve 44 and a pressure and temperature sensor 45.

In the embodiment shown in Fig. 2 there is also provided a second pump 38 with associated motor 39, having a separate power supply cable 34. A second grease line 41 connects the pump with the PCH. As above, the second grease line 41 includes a one way valve 46, a shut-off valve 47 and a pressure and temperature transmitter 48. The second pump may be added to provide for redundancy in the system, in case of failure of the first pump 35. It will also make it possible for higher grease pumping rates in case of emergency, with both pumps operating together. They may also be used for the rare times when the cable is travelling very quickly through the PCH and may require more grease than one electric motor/pump can supply.

30 As an alternative, grease may be wiped from the cable as it passes out of the PCH and returned to a container in the module. This is shown on Fig. 2 by return grease line 52 that leads to canister 54. In this way no grease will be released to the environment. However, with the present invention the supply of grease can be tightly controlled to minimize the amount used and therefore there will be very small amounts released to sea.

35 In addition, a ROV attachment 22 may be added to periodically replenish the grease in the bladder for long duration jobs.

40 In operation the IWOCS closely monitors the pressure outside, in the PCH and in the well and compensates by periodically turning on the first 35 or both, 35 and 38, grease pumps to pump grease into the PCH. The grease pressure is closely

monitored and the pump(s) are regulated to generate a very small pressure differential between the PCH and the well.

5 The close in-situ monitoring of pressure minimizes the amount of grease needed because the differential pressure can be kept to a minimum, hence the practicality of subsea bladder instead of guessing on a larger volume needed and trying to pump it down a grease line. Keeping the differential pressure to a minimum also lessens the amount of grease working itself past the PCH seal elements into the well and/or the environment. From the two pumps 35 and 38, the grease may be injected into the
10 PCH in two locations (again opening one or two lines to compensate for cable speed – rapid loss of grease). There is also a third grease injection line 51 in a location below the PCH for better control of the differential pressure between the PCH and well, if necessary.

15 In a second embodiment of the invention shown in Fig. 3 the grease injection module is equipped with its own separate control unit 60 configured as an autonomous version of the control system. The autonomous control unit comprises a processor and data storage (not shown) and is preferably powered by a battery 62. Thus the electric control can be separated from the main IWOCS, but retaining the
20 monitoring and injection control features for grease injection into the PCH. This embodiment simplifies the packaging of the PCH assembly by eliminating the need for the subsea electrical connection 23 (Fig. 1) after the PCH is lowered separately and latched to the rest of the intervention (RLWI) stack. However, this autonomous feature adds two new capabilities. First, as the PCH assembly is lowered to the sea
25 floor, it independently monitors the increase in ambient sea water pressure and can adjust by injecting grease into the PCH at just a slightly higher than ambient pressure differential, to keep sea water from entering the PCH cavity, thereby avoiding the hydrate plugging issues. The control is battery powered to maintain its autonomy. Second, in the event that the surface vessel needs to depart and/or the
30 cable is cut somewhere outside of the PCH and the control system is disconnected, the grease injection pressure containment feature of the PCH is maintained even though the rest of the IWOCS is shut-down, for as long as battery power is present.

35 Another issue is the grease itself. Current practice is to use some form of viscous petroleum based grease that has a certain amount of stickiness to adhere to the surface of the PCH seals and the rough exterior of the cable, creating a pseudo smooth surface on the braided cable. However, this creates its own “leakage to the environment” as the grease laden cable emerges out the top of the PCH during wireline retrieval. In addition, the ambient sea water environment may be as low as
40 4 deg. C (39 deg. F), which may lead to a increase in the greases viscosity or lead to a hardening condition. To alleviate this condition, the invention proposes to replace

petroleum grease with a fish-oil based lubricant, significantly lowering viscosity and eliminating hydrocarbon discharge to the environment.

- 5 The invention has now been explained with non-limiting embodiments, and a skilled person will understand that there may be made several alterations and modifications to the embodiments that are within the scope of the invention as defined in the following claims.

CLAIMS

1. Method for controlling grease injection to a subsea lubricator, the said lubricator comprising a housing containing a grease supply accumulator, a pump, an electric motor for operating the pump and a control unit for controlling the motor,
5 where the said method comprises the steps of reading an outside pressure from a sensor located outside said housing, receiving signals from said pressure sensor in the control unit and controlling the motor and the pump to deliver grease from the grease accumulator to the lubricator at a level that is above said outside pressure.
- 10 2. Method according to claim 1, wherein the outside pressure sensor records the ambient, i.e. seawater pressure.
3. Method according to claim 1, wherein the outside pressure sensor records the wellhead pressure.
- 15 4. Method according to claim 1, wherein the unit in a first mode is connected to an intervention control system to receive instructions from a control station at the surface and in a second mode is operating autonomously when being disconnected from an IWOCS.
- 20 5. Method according to claim 4, wherein in autonomous mode power is provided by a battery in the housing.
6. Method according to claim 1, wherein the signals from the pressure sensor
25 is processed by the intervention control system.
7. Method according to claim 1, wherein the signals from the pressure sensor is processed by a processor in the module.
- 30 8. Method according to one of the preceding claims, wherein grease is removed from the subsea equipment and returned to the grease supply accumulator.
- 35 9. Grease injection device for injecting grease into a subsea intervention system, comprising a housing with an accumulator of grease, a grease injection line towards the system, wherein the grease injection device is a self-contained unit attachable to the system and is pressure compensated to deliver a pressure higher than a pressure within the well and or outside the subsea intervention system, and

comprises a pump with an electric motor operating the pump, connected to the grease injection line, at least one pressure sensor reading the pressure within the well and or the outside and a control unit operating the different elements to pressure compensate the device.

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10. Device according to claim 9, wherein it is pressure compensated by having a passively pressure compensated accumulator.

11. Device according to claim 9, wherein it comprises a ROV contingency refill in connection with the accumulator.

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12. Device according to claim 9, wherein it comprises a grease wipe device connected to the subsea system, and a return line for returning the wiped grease back to the device.

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13. Device according to claim 9, wherein it comprises a second pump with a second electric motor.

14. Device according to claim 9, wherein it comprises at least two separate injection points towards the subsea system.

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15. Device according to claim 9, wherein it is connected to the PCH.

16. Device according to claim 9, wherein the housing is a self-contained unit attached to a pressure control head.

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17. Device according to claim 9, wherein the control unit comprises a processor and data storage unit.

18. Device according to claim 9, wherein it comprising a source of electric power.

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19. Device according to claim 18, wherein the power source is a battery.

20. Device according to claim 18, wherein the power source is an umbilical.

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21. Device according to claim 9, wherein it comprising a workover control module.

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22. Device according to claim 9, wherein the lubricant in the device is a fish-oil based grease.