A technique for subsea intervention operations incorporates use of a compliant guide that extends between a surface location and a subsea installation. The technique facilitates deployment of tool strings into a subsea well. A dynamic seal can be conveyed through the compliant guide to a desired subsea location. At this location, the dynamic seal is locked into place to provide a subsea dynamic seal that can be used to facilitate the intervention operations.
INTERVENTION SYSTEM WITH DYNAMIC SEAL

TECHNICAL FIELD

[0001] This invention relates to a system for use with a subsea well. More particularly, the invention relates to a system for use with a subsea well which includes a dynamic seal used in a compliant guide or other riser system.

BACKGROUND ART

[0002] The retrieval of desired fluids, such as hydrocarbon based fluids, is pursued in subsea environments. Production and transfer of fluids from subsea wells relies on subsea installations, subsea flow lines and other equipment. Additionally, preparation and servicing of the subsea well relies on the ability to conduct subsea intervention work. A big challenge in subsea intervention work is controlling pressure so that pressurized borehole fluids in the subsea well are contained within the borehole during intervention operations.

[0003] Subsea intervention work involves numerous challenges not normally faced when working on land wells or offshore platforms. In most cases, intervention in subsea wells is performed from a floating platform or ship by extending the borehole to a surface location by a tensioned riser. This approach allows pressurized borehole fluids to move upward to the surface through the riser which can span hundreds or thousands of feet of seawater. The cost of such platforms is high, however, and the availability of vessels capable of adequately performing this type of intervention work is limited.

[0004] In shallow waters, subsea intervention work can be performed with a specially equipped vessel having subsea lubricators, subsea pressure control equipment, and wave motion compensating systems. In most cases, guide wires extending from a wellhead all the way to the vessel combined with the aid of professional divers is required. Additionally, this approach requires that equipment is conveyed and guided from the vessel to the subsea installation through open waters. Once the subsea lubricator is connected to the subsea installation and the tools are inside, the conveyance cable remains exposed to open waters. Additionally, pressure control must be exercised at the seabed. Because existing non-rig intervention capability is limited to shallow water wireline and slickline operations, most intervention on subsea wells is currently performed with expensive and scarce heavy drilling units.

[0005] When performing intervention operations in subsea wells or other installations borehole fluids are maintained in the well by different types of pressure tight seals. It is convenient in many cases to be able to provide a pressure tight, dynamic seal in the vicinity of the seabed, such that a conveyance member, for example, wireline, slickline, coiled tubing or other applicable conveyance, can be moved up and down inside the well or flowline to perform intervention operations. The subsea installation contains pressurized fluids within and must prevent them from moving either into the environment (in the case of riserless operations) or into a tubular conveyance member connected to the subsea installation, such as a rigid riser, a flexible riser, or a spoolable compliant guide.

[0006] In U.S. Pat. No. 4,905,763, for example, separation of borehole fluids is maintained during logging operations by a sealing nipple and a stuffing box assembly. The assembly is lowered down through a riser extending between a platform and a blowout preventer stack. In another application described in U.S. Pat. No. 4,951,745, a hydraulically actuated stuffing box is mounted on top of an underwater lubricator assembly to seal against a line during well service operations.

[0007] It is also convenient to deploy the dynamic seal from a surface vessel to a seabed installation together with the intervention toolstring and conveyance member, as well as being able to retrieve the dynamic seal back to the surface again with the intervention tools and conveyance member. Having a retrievable dynamic seal enables easy and frequent maintenance of the seal itself, while still allowing efficient operations.

[0008] Advantages of the current invention are that it describes a retrievable dynamic seal which locks itself to the intervention toolstring or conveyance, then lands into its seat near the bottom of the compliant guide or riser, and locks itself in place, releases the conveyance member and toolstring, and then enables the activation of a dynamic seal, in order to provide a valid pressure barrier able to withstand differential pressure either from above or below. Once the intervention operation is concluded, the device is able to again capture the intervention toolstring, and then release itself to be retrieved to the surface together with the toolstring.

DISCLOSURE OF INVENTION

[0009] According to one aspect of the present invention there is provided a system for use with a subsea installation, comprising:

[0010] a tubular guide extending between a surface location and a subsea installation;

[0011] a dynamic seal sized for movement through the tubular guide to a desired location, and a locking mechanism to lock the dynamic seal at a desired location.

[0012] The locking mechanism may form part of the dynamic seal, alternatively the locking mechanism may be an external system which when activated locks the seal at the desired location. Preferably the tubular member is a compliant guide or riser although the use of other tubular members connecting the subsea installation to the surface is also contemplated. The system may further comprise a conveyance on which the dynamic seal is transported through the tubular member. The dynamic seal may comprise an attachment mechanism for attaching the dynamic seal to the conveyance. Also, the dynamic seal may seal against the conveyance by means of at least one dynamic seal member, the dynamic seal member being hydraulically operable. The dynamic seal member is operable through a hydraulic activation system. The hydraulic activation system may be used in combination with a hydraulic ram system.

[0013] In one form of the invention the dynamic seal may seal against the conveyance by means of at least one dynamic seal member, the dynamic seal member being hydraulically operable. The dynamic seal member is operable through a hydraulic activation system. The hydraulic activation system may be used in combination with a hydraulic ram system.

[0014] The dynamic seal may include two dynamic seal members. In one form of the invention the two dynamic seal members each have their own hydraulic activation systems and in another form of the invention the two dynamic seal members use the same hydraulic activation systems.

[0015] The desired location of the dynamic seal may vary but preferably is positioned within the lower part of the compliant guide or riser system, and is designed to be positioned in such a manner as to form a sealing contact with the compliant guide or riser system when positioned at the desired location or the dynamic seal may be positionable proximate the lower end of the compliant guide. It should be understood that the tubular member may vary depending on
the particular needs of the application but for instance the compliant guide may be a spoolable compliant guide.

According to a second aspect of the invention there is provided a method for intervening in a subsea installation, comprising:

- coupling a tubular member between a surface location and a subsea installation;
- moving a dynamic seal down through the tubular member to a desired subsea location; and
- locking the dynamic seal into an operative position at the desired subsea location.

The method may further comprise releasing the dynamic seal and then retrieving it through the tubular member following an intervention operation. Moving of the dynamic seal down through the tubular member to a desired subsea location may be accomplished by various means such as for example moving the dynamic seal through the tubular member on a conveyance. Preferably, the conveyance is moved through the dynamic seal in sealing engagement with the dynamic seal. The sealing engagement may be provided by at least one dynamic seal member in the dynamic seal. The locking may be obtained in various ways as well such as by locking the dynamic seal within a lower end of the tubular member. The method may further comprise activating the dynamic seal to seal against the conveyance, opening the subsea well, and delivering an intervention tool into the subsea well via the conveyance. The seal may be adjusted between the conveyance and the dynamic seal by adjusting the differential pressure above and below the dynamic seal, or by adjusting the hydraulic pressure that controls the activation of the dynamic seal.

According to a third aspect of the invention there is provided a method for intervening in a subsea well comprising deploying a dynamic seal through a tubular member with a conveyance, positioning the dynamic seal at a desired subsea location and releasing the conveyance to enable movement of the conveyance through the dynamic seal while retaining a seal between the conveyance and the dynamic seal.

The deployment step may be done by using a cable-type conveyance. Also positioning may include positioning the dynamic seal above a subsea installation or preferably in a lower portion of the compliant guide or riser, or in proximity of the lower portion. The method may further comprise sealing the dynamic seal to the compliant guide, and/or adjusting a differential pressure acting on the dynamic seal. The method also may be practiced under many different possible variations such as including opening the subsea well, delivering an intervention tool into the subsea well, conducting an intervention operation and retrieving the intervention tool to a surface location.

According to a fourth aspect of the invention there is provided a method for intervening in a subsea well is provided the method comprising:

- coupling a spoolable compliant guide between a surface location and a subsea installation;
- delivering a dynamic seal through the spoolable compliant guide via a conveyance; and
- adjusting the seal formed between the conveyance and the dynamic seal.

The method may comprise changing the pressure acting on the dynamic seal for adjusting the seal formed between the conveyance and the dynamic seal. The pressure changing may be accomplished in a couple different ways preferably remotely from a surface location. The coupling step may include coupling the spoolable compliant guide between a surface vessel and the subsea installation. Delivering the dynamic seal through the spoolable guide via the conveyance may include the use of a cable-type conveyance that delivers the dynamic seal through the spoolable compliant guide.

**BRIEF DESCRIPTION OF FIGURES IN THE DRAWINGS**

Certain embodiments of the invention will hereinafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements, and:

**FIG. 1** shows a schematic front elevation view of a subsea intervention system, according to a first embodiment of the present invention;

**FIG. 2** shows a schematic side elevation view of a portion of the subsea intervention system illustrating a dynamic seal, according to the first embodiment of the present invention;

**FIG. 3** shows a schematic side view similar to that of FIG. 2 but showing the intervention tool string conveyance released from the dynamic seal, according to the first embodiment of the present invention;

**FIG. 4** shows a schematic side view similar to that of FIG. 2 but showing the intervention tool string entering a subsea wellbore, according to the first embodiment of the present invention;

**FIG. 5** shows a schematic side view similar to that of FIG. 2 but showing the intervention tool string exiting the subsea wellbore, according to the first embodiment of the present invention; and

**FIG. 6** shows a schematic side view similar to that of FIG. 2 but showing the dynamic seal being retrieved, according to the first embodiment of the present invention.

**FIG. 7** shows a schematic side view of a portion of the subsea intervention system illustrating a dynamic seal, according to a second embodiment of the present invention;

**FIG. 8** shows a schematic side view similar to that of FIG. 7 but showing the sealing member integrated in the lower portion of the dynamic seal, according to the second embodiment of the present invention;

**FIG. 9** shows a schematic side view similar to that of FIG. 7 but showing two sealing members, one integrated in the upper portion of the dynamic seal and one integrated in the lower portion of the dynamic seal, each with its own activation device according to the second embodiment of the present invention;

**FIG. 10** shows a schematic side view similar to that of FIG. 7 but showing two sealing members, one integrated in the upper portion of the dynamic seal and one integrated in the lower portion of the dynamic seal, both sharing an activation device according to the second embodiment of the present invention; and

**FIG. 11** shows a schematic side view similar to that of FIG. 7 but showing one sealing member having hydraulic rams in combination with an activation device, according to the second embodiment of the present invention.

**MODE(S) FOR CARRYING OUT THE INVENTION**

A first embodiment of the invention for a subsea intervention system is illustrated in FIGS. 1 to 6.

Referring generally to FIG. 1, an intervention system 20 is illustrated according to an embodiment of the
In this embodiment, system 20 comprises a compliant guide 22, e.g. a spoolable compliant guide, and a dynamic seal assembly 24, which also can be referred to as a dynamic stuffing box. Compliant guide 22 is coupled between a subsea installation 26 and a surface vessel 28, such as an intervention vessel located at a surface 30 of the sea. Subsea installation 26 may be located on or at a seabed floor 32. The pressure in the compliant guide 22 can be selectively adjusted to assist intervention operations involving, for example, pulling out of the well or running into the well.

Compliant guide 22 is flexible, and dynamic seal 24 is sized for deployment and retrieval along the interior of compliant guide 22. Depending on the specific intervention application, compliant guide 22 may be arranged in a variety of curvilinear shapes extending between a surface location, e.g., intervention vessel 28, and subsea installation 26. Compliant guide 22 also may be constructed as a tubular member formed from a variety of materials that are sufficiently flexible, including metal materials of appropriate cross-section and composite materials. While the system is described with reference to the tubular member being a compliant guide, the system of the invention can encompass any type of riser or guide which can be deployed to connect a surface vessel to a subsea installation. Such tubular guides can include tensioned risers, flexible riser, jointed drillpipe, flowline, and coiled tubing for example.

To control the pressure differential acting on dynamic seal 24, compliant guide 22 may be filled with a buffer fluid 34, such as seawater, introduced into the interior of compliant guide 22. In some applications, other buffer fluids 34 can be used, e.g., environmentally friendly greases for friction reduction or for pressure sealing; fluids designed for hydrate prevention; weighted mud; and other appropriate buffer fluids. The level and pressure of buffer fluid 34 can be controlled from the surface by, for example, standard pressure control equipment 36 that may be mounted on intervention vessel 28.

Once compliant guide 22 is coupled between subsea installation 26 and intervention vessel 28, the dynamic seal assembly 24 may be run down through compliant guide 22 with an intervention tool string 38. The intervention tool string 38 is deployed by a conveyance 40, and dynamic seal 24 is coupled to conveyance 40 for movement to a desired subsea location 42. The dynamic seal 24 is coupled to conveyance 40 until locked into position at the desired subsea location 42. Subsequently, the dynamic seal 24 is released from conveyance 40 but remains sealed against conveyance 40 as the conveyance is moved to deploy and/or retrieve intervention tool string 38. In some applications, the conveyance of dynamic seal 24 down through compliant guide 22 can be assisted by pumping a fluid into the compliant guide so the pumped fluid pushes the dynamic seal down through the compliant guide. A port can be provided at the bottom of the compliant guide for expulsion of displaced fluid. The retrieval of dynamic seal 24 also can be assisted by pumping fluid out of the compliant guide from the surface. In this latter case, fluid can enter through the port and apply hydrostatic pressure against the bottom of the dynamic seal 24. The maximum force applied against the dynamic seal can be controlled by setting a limit on the pressure of the fluid pumped at the surface with hydraulic pressure control equipment 36, for example.

The dynamic seal 24 and compliant guide 22 can accommodate many different types of conveyances 40. For example, conveyance 40 may be a flexible, cable-type conveyance, such as a wireline or slickline. However conveyance 40 also may comprise stiffer mechanisms including coiled tubing and coiled rod. When a cable-type conveyance 40 is used to convey intervention tool string 38, compliant guide 22 can be arranged to facilitate passage of the intervention tool string 38, in some applications, without requiring a pushing force. In other words, the curvilinear configuration of compliant guide 22 is readily adjustable via, for example, locating intervention vessel 28 so as to avoid bends or deviated sections that could interfere with the passage of intervention tool string 38. Thus, in addition to enabling pressure control within the compliant guide 22, the flexibility of compliant guide 22 enables its configuration to be adjusted as necessary by simply moving intervention vessel 28. Dynamic changes can temporarily be made to compliant guide 22 to change the shape of the compliant guide for facilitating the passage of a tool string. By way of further example, the intervention vessel can be turned to orient itself with its bow against the wind, waves, and currents. Furthermore, the desired orientation of the compliant guide may change from one intervention operation to another or during a given intervention operation depending on parameters, such as current, subsea obstacles, surface obstacles and other environmental factors.

Although a variety of subsea installations 26 can be utilized depending on the particular environment and type of intervention operation, one example is illustrated in FIG. 1. In this example, the subsea installation 26 comprises a subsea wellhead 44, which may include a Christmas tree, coupled to a subsea well 46. Dynamic seal 24 may be positioned generally at the bottom of compliant guide 22 to help block intrusion of well fluids into an interior 48 of the compliant guide. In other embodiments, dynamic seal 24 may be positioned proximate compliant guide 22 in, for example, subsea installation 26.

In the embodiment illustrated, dynamic seal 24 is generally positioned above a subsea lubricator 50 of subsea installation 26. As illustrated, subsea installation 26 also may comprise a variety of other components. For example, subsea installation 26 comprises a lubricating valve 52 that may be deployed directly above subsea wellhead 44. Lubricating valve 52 can be used to close the borehole of subsea well 46 during certain intervention operations, such as tool change outs. A blowout preventer 54 may be positioned above lubricating valve 52 and may comprise one or more cut-and-seal rams 56 able to cut through the interior of the subsea installation and seal off the subsea installation during an emergency disconnect. The subsea installation 26 also may comprise a second blowout preventer 58 positioned above blowout preventer 54 and comprising one or more sealing rams 60 able to seal against the conveyance 40. Many other components, e.g., an emergency disconnect device 62, also can be incorporated into intervention system 20 depending on the specific intervention application.

In operation, the subsea dynamic seal 24 is designed to prevent the escape of borehole fluids from subsea well 46. This prevents the mixing of the borehole fluids with buffer fluid 34 within compliant guide 22. The dynamic seal 24 seals against conveyance 40, and may be designed to seal against a variety of conveyances, such as those listed above. The dynamic seal 24 can also be designed with an active system that can be controlled to selectively open and close its sealing element to accommodate the passage of larger tools through the dynamic seal.
Referring generally to FIG. 2, one embodiment of dynamic seal assembly 24 is illustrated as being deployed down through compliant guide 22. In this embodiment, dynamic seal 24 is illustrated as having an upper region 64, a central region 66 and a lower region 68, however the dynamic seal can be formed in a variety of shapes and configurations. Furthermore, dynamic seal 24 can be formed with a variety of features and components that facilitate its deployment, retrieval and use in the intervention operations. For example, dynamic seal 24 may comprise a sealing element 70, such as a compressible rubber element, that can be compressed to form a seal around conveyance 40. A squeezing element 72 may be positioned proximate sealing element 70 to enable selective compression of the sealing element which, in turn, allows control to be exerted over the force with which sealing element 70 engages conveyance 40. The squeezing element 72 may be controlled via pressures established in compliant guide 22, differential pressures across dynamic seal 24, by direct hydraulic control via a dedicated control line, or by other appropriate control mechanisms. By way of example, sealing element 70 and squeezing element 72 may be positioned in upper dynamic seal region 64. Upper region 64 also may comprise a fishing neck 74 to allow engagement of a fishing tool if necessary. The upper region 64 also may comprise other elements, such as a grease injection system to provide a more efficient seal against conveyance 40 in case of high differential pressures across dynamic seal 24.

Dynamic seal 24 also may comprise a variety of other components, such as an external sealing device 76 that enables formation of a seal between dynamic seal 24 and compliant guide 22, or other surrounding structure, once the dynamic seal 24 reaches its desired subsea location 42. The combination of sealing against the conveyance and sealing against the internal surface of the compliant guide helps prevents well fluids from escaping the well during an intervention operation. External sealing device 76 may comprise a variety of seal technologies, including those used in swab cups, traveling pigs, and other seal technologies able to form a sufficient seal. The dynamic sealing assembly 24 and external sealing device 76 also can be designed to seal against specifically designed surfaces separate from the internal surfaces of the compliant guide 22.

A locking mechanism 78 is designed to lock dynamic seal 24 in position once it reaches desired subsea location 42. A variety of locking mechanisms can be utilized. However, one embodiment of locking mechanism 78 comprises one or more locking dogs or pins 80 that are spring biased via one or more springs 82 for engagement with corresponding receptacles 84 once dynamic seal 24 reaches desired subsea location 42. The dynamic seal 24 also may be designed with a weak point for releasing the dynamic seal when a predefined differential pressure or pulling force is applied. Additionally, a central sealing device 86 may be provided to automatically seal off the opening through which conveyance 40 normally extends in the event conveyance 40 is removed. By way of example, sealing device 76, locking mechanism 78 and central sealing device 86 may be generally positioned in central region 66.

Other dynamic seal features may comprise an appropriate attachment mechanism 88 by which dynamic seal 24 is selectively attached to conveyance 40 during deployment and the retrieval of the dynamic seal. Attachment mechanism 88 may be a clamping member designed to clamp onto conveyance 40 with sufficient force to secure dynamic seal 24 to the conveyance during transfer. The engagement of attachment mechanism 88 as well as the disengagement of locking mechanism 78 may be initiated mechanically by, for example, movement of intervention tool string 38 into engagement with a tool catcher 90 of dynamic seal 24, as illustrated in FIG. 2. However, a variety of mechanical, hydraulic, electrical or other control mechanisms can be used to engage and disengage both attachment mechanism 88 and locking mechanism 78. By way of example, attachment mechanism 88 may be positioned in lower dynamic seal region 68. However, the position, configuration and arrangement of the dynamic seal components can change depending on the dynamic seal design parameters, environment and intervention operations anticipated.

The dynamic seal may also comprise a check valve system. The check valve system is designed to seal the cavity through which the conveyance passes in the event of the conveyance breaking and being forced out of the dynamic seal, such that the conveyance is no longer presence the cavity. The check valve system seals the passage when the conveyance is not presence and against differential pressure in both directions.

In FIG. 2, the dynamic seal assembly 24 is illustrated as attached to conveyance 40 as it is moved down through compliant guide 22 to the desired subsea location 42. Movement of dynamic seal 24 can be aided by pumping a fluid, e.g. water, into compliant guide 22 above dynamic seal 24 and applying downward pressure as indicated by arrows 92. Pumping fluid into compliant guide 22 and applying pressure to an upper side of dynamic seal 24 also can facilitate movement of the dynamic seal 24 through the bends and deviated sections of compliant guide 22. Fluid in the lower dynamic seal 24 can escape through an exit port 94 and is released to the sea, brought back to the surface, or injected into the well.

In some applications of the present invention the retrievable dynamic seal does not present a seal between it’s body and the internal surfaces of the compliant guide, and it moves attached to the conveyance without the need to apply pressure and to have a way of escape for the fluid in the compliant guide below the retrievable dynamic seal.

Regardless of whether pressure is applied via fluid above dynamic seal 24, the dynamic seal 24 is ultimately moved to desired subsea location 42 where it is landed on a landing mechanism 96 and locked into position by locking mechanism 78, as best illustrated in FIG. 3.

Once dynamic seal 24 is landed, conveyance 40 is released by releasing attachment mechanism 88. This allows conveyance 40 to move down and/or up with respect to dynamic seal 24. In some embodiments, control over the differential pressure above and below dynamic seal 24 can be used to apply a greater or lesser squeezing force against conveyance 40 via sealing element 70. For example, the pressure of buffer fluid 34 in compliant guide 22 can be increased to activate sealing element 70 via squeezing element 72. When sealing element 70 of dynamic seal 24 is appropriately activated to form a sufficient seal against conveyance 40, the pressure of the buffer fluid 34 can be substantially equalized with the pressure of borehole fluid 98 and the well can be opened.

When the well is opened, tool string 38 can be deployed into the subsea well 46 for performance of the desired intervention work, as illustrated in FIG. 4. Pressure of the borehole fluid 98 can be monitored from the surface, and
the pressure of buffer fluid 34 in compliant guide 22 can be adjusted from the surface via pressure control equipment 36 to maintain the desired differential pressure. The subsea well 46 is opened by opening an appropriate wellbore seal 100 which may be part of existing subsea installation components or combinations of components. For example, the subsea well 46 can be opened for deployment of intervention tool string 38 by opening lubricating valve 52, opening blowout preventer rams, or opening other wellbore seal components or combinations of components.

Upon completion of the intervention operation, the intervention tool string 38 is pulled back to a position above wellbore seal 100, as illustrated in FIG. 5. The wellbore seal 100 is then closed to isolate compliant guide 22 from subsea well 46. Borehole fluid may be replaced by clean fluid between dynamic seal 24 and wellbore seal 100. The buffer fluid pressure in compliant guide 22 is then released so that dynamic seal 24 can be retrieved to the surface. Intervention tool string 38 is pulled up against dynamic seal assembly 24 and into engagement with tool catcher 90, as illustrated in FIG. 6. In this embodiment, the top or head of intervention tool string 38 mechanically releases locking mechanism 78 and engages attachment mechanism 88. Conveyance 40 is then pulled upwardly to retrieve dynamic seal 24 and intervention tool string 38 to the surface. In some applications, fluid is pumped from the interior of compliant guide 22, and clean fluid is allowed to enter beneath dynamic seal 24 through a port, such as port 94. While retrieving dynamic seal assembly 24, buffer fluid 34 can be flushed to the surface for recovery and reconditioning if necessary.

The use of compliant guide 22 and retrievable dynamic seal assembly 24 facilitates deployment and retrieval of intervention tool string 38. This system and methodology simplifies and increases the efficiency with which intervention tool strings can be interchanged. Additionally, the ability to quickly and efficiently retrieve dynamic seal enables its easy maintenance and replacement of the dynamic sealing elements, which are subject to wear when the conveyance moves up and down in the well.

Intervention system 20 also may include or be combined with other components and features. For example, the dynamic seal 24 may comprise an automatic locking release that can be actuated by, for example, a pre-defined differential pressure to enable fluid to be pumped through the dynamic seal. The system 20 also can be designed to provide a grease injection sealing system having a grease reservoir to enable grease injection under a specified differential pressure. The grease injection system can be designed for use when pressure control is lost at the surface. For example, if pressure in the compliant guide drops and the differential pressure across dynamic seal 24 becomes too great, it may become desirable or necessary to inject grease to maintain the seal. The (automatic) grease injection can be triggered by, for example, relatively higher pressure above dynamic seal 24, relatively higher pressure below dynamic seal 24, or a specific differential pressure in either direction.

Intervention system 20 facilitates deployment of many types of tool strings in a dependable and efficient manner. The compliant guide 22 provides a protected environment through which dynamic seal 24 is readily transported to an operative position. The overall design enables use of a relatively simple dynamic seal while maintaining system adaptability and providing an efficient way of deploying and retrieving intervention tool strings, while minimizing the size and weight of the sealing equipment to be deployed.

A second embodiment of the invention for a subsea intervention system is illustrated in FIGS. 7 to 11. Similar numbering to those used to illustrate the first embodiment has been used to illustrate similar parts in the second embodiment shown in FIGS. 7 to 11.

In FIG. 7 a retrievable dynamic seal 24 is located in compliant guide 22 and is shown to include a dynamic sealing member 102 integrated into the upper portion 104 of dynamic seal 24. In FIG. 8 dynamic sealing member 102 is shown integrated into the lower portion 105 of dynamic seal 24. It is possible to convey the retrievable dynamic seal 24 together with the intervention toolstring 38 through open waters in the case of riserless operations, or through a rigid riser, flexible riser, drillpipe, tubing, spoolable compliant guide or any other suitable tubular conduit connecting the subsea installation to a surface moving vessel.

The retrievable dynamic seal 24 can be temporarily locked to the top of the intervention toolstring 38 by means of a mechanical locking system 106 in the form of tool catching fingers, which prevents the body of the retrievable dynamic seal 24 from sliding up on the conveyance 40 during the descent towards the subsea installation.

The retrievable dynamic seal 24 can land into a dedicated sealing surface and lock itself in place by means of a mechanical locking system 106, or it can be locked in place by activating an external system, like for example the rams 110 shown in FIG. 11, which can both hold the dynamic seal 24 in place and seal against its body at the same time.

Once the retrievable dynamic seal 24 is locked in place, an automatic system well known to the person skilled in the art will release the locking system 106 holding the toolstring 38, and the toolstring 38 attached to the conveyance 40 will be able to move up and down through the retrievable dynamic seal 24 to perform the required intervention operations.

When the retrievable dynamic seal 24 lands in its seat, communication is established between a hydraulic activation circuit 112 and the chamber 114 below an activation piston 116 of the dynamic seal member 102. The hydraulic pressure is contained also by the elastomeric seals 118 or by the sealing/locking rams 110. Applying hydraulic pressure to the fluid contained in the activation circuit 112 through the conduit 119 in the rams 110 will push the dynamic seal activation piston 116 in the direction of compressing the dynamic seal element 102, activating in this way the dynamic seal 24 against the conveyance 40, and creating a valid pressure barrier which can hold differential pressure between the upper and lower sides of the dynamic seal element 102.

Once the intervention operation is completed and the toolstring 38 is ready to be retrieved to surface, the intervention toolstring 38 is pushed up against the body of the retrievable dynamic seal 24. This action activates the mechanism 106 that locks the head of the intervention toolstring 38 in the retrievable dynamic seal body, activates an equalization system that equalizes the pressure above and below the retrievable dynamic seal 24, unlocks the locking system 108 and allows the retrievable dynamic seal 24 to be retrieved towards the surface together with the intervention toolstring 38.

FIG. 9 represents an alternative configuration of the second embodiment of the invention, where two independent dynamic seal members 102 are integrated into the same
retrievable dynamic seal 24, one in the upper portion 104 and the other in the lower portion 105, each of the dynamic seal members 102 having its own hydraulic activation circuit 112. In this configuration the two dynamic seal members 102 can either be activated at the same time, or one can act as a backup dynamic seal member to the other one, and be activated only in case of failure of the other dynamic seal member 102. The dynamic seal can also have a fail-safe mode whereby in the case of a loss of control of the activating signal, the dynamic seal will lock into position and the dynamic seal will be activated to create a seal around the conveyance.

[0071] FIG. 10 represents yet another alternative configuration of the second embodiment of the invention, where two dynamic seal members 102 are embedded into the same retrievable dynamic seal 24, and both seal members 102 are activated by the same hydraulic activation circuit 112. In this configuration the lower dynamic seal 102 in the lower portion 105 has been turned upside down, and is in this case activated from above rather than from below as it was in the previous cases. In this configuration the two dynamic seal member activation pistons 116 include between them a tubular sliding link 120 which allows the variation of the distance between the two activation pistons 116 by means of an elastomer seal between the extremities of the sliding link 120 and the bodies of the activation pistons 116. At the same time the tubular sliding link 120 has the function of containing the hydraulic activation pressurized fluid from escaping along the conveyance 40 in between the two activation pistons 116.

[0072] In an even further configuration of the invention it is conceivable to use viscous grease in the hydraulic activation circuit, in order to improve the sealing performance of the dynamic seal sealing element 102 and extend its operating range even to the highest differential pressures and in presence of gas.

[0073] Other changes can be made while staying within the scope of the invention. Although only a few embodiments of the present invention have been described in detail above, those of ordinary skill in the art will readily appreciate that many modifications are possible without materially departing from the teachings of this invention. Accordingly, such modifications are intended to be included within the scope of this invention as defined in the claims.

1. A system for use with a subsea well comprising:
a tubular member extending between a surface location and a subsea installation;
a dynamic seal sized for movement through the tubular member to a desired location; and
a locking mechanism to lock the dynamic seal at a desired location.
2. A system as claimed in claim 1, wherein dynamic seal comprises the locking mechanism.
3. A system as claimed in claim 1, wherein the tubular member is a compliant guide extending between a surface location and a subsea installation.
4. A system as claimed in claims 1, which further comprises a conveyance on which the dynamic seal is transported through the tubular member.
5. A system as claimed in claim 4, which further comprises an attachment mechanism for attaching the dynamic seal to the conveyance.
6. A system as claimed in claim 4, wherein the dynamic seal seals against the conveyance during movement of the conveyance through the dynamic seal.
7. A system as claimed in claim 6, wherein the dynamic seal seals against the conveyance by means of at least one dynamic seal member, the dynamic seal member being hydraulically openable.
8. A system as claimed in claim 7, wherein the dynamic seal member is operable through a hydraulic activation system.
9. A system as claimed in claim 8, wherein the hydraulic activation system is used in combination with a hydraulic ram system.
10. A system as claimed in any one of claims 7, wherein the dynamic seal includes two dynamic seal members.
11. A system as claimed in claim 10, wherein the two dynamic seal members each have their own hydraulic activation system.
12. A system as claimed in claim 10 wherein the two dynamic seal members use the same hydraulic activation system.
13. A system as claimed in claim 1, wherein the dynamic seal is positionable within a lower end of the tubular member so as to form a sealing contact with the tubular member when positioned at the desired location.
14. A system as claimed in claim 1 wherein the dynamic seal is positionable vicinity the lower end of the tubular member.
15. A method for intervening in a subsea installation, comprising:
coupling a tubular member between a surface location and a subsea installation;
moving a dynamic seal down through the compliant guide to a desired subsea location; and
locking the dynamic seal into an operative position at the desired subsea location.
16. A method as claimed in claim 15, which further comprises releasing the dynamic seal and then retrieving it through the tubular member following an intervention operation.
17. A method as claimed in claim 15, wherein moving of the dynamic seal down through the tubular member to a desired subsea location is accomplished by moving the dynamic seal through the tubular member on a conveyance.
18. A method as claimed in claim 17, wherein the conveyance is moved through the dynamic seal in sealing engagement with the dynamic seal.
19. A method as claimed in claim 17, wherein the sealing engagement is provided by at least one dynamic seal member in the dynamic seal.
20. A method as claimed in claim 15, wherein the locking is obtained by locking the dynamic seal within a lower end of the tubular member.
21. A method as claimed in claim 15, which further comprises activating the dynamic seal to seal against the conveyance, opening the subsea well, and delivering an intervention tool into the subsea well via the conveyance.
22. A method as claimed in claim 15 wherein the seal is adjusted between the conveyance and the dynamic seal by adjusting the differential pressure above and below the dynamic seal.
23. A method as claimed in claim 15 wherein the seal is adjusted between the conveyance and the dynamic seal by adjusting the hydraulic pressure that controls the activation of the dynamic seal.
24. A method for intervening in a subsea well comprising deploying a dynamic seal through a tubular member with a
conveyance, positioning the dynamic seal at a desired subsea location and releasing the conveyance to enable movement of the conveyance through the dynamic seal while retaining a seal between the conveyance and the dynamic seal.

25. A method as claimed in claim 24, wherein the deployment step is done by using a cable-type conveyance.

26. A method as claimed in claim 24, wherein positioning includes positioning the dynamic seal above a subsea installation.

27. A method as claimed in claim 24, wherein positioning includes positioning the dynamic seal in a lower portion of the tubular member.

28. A method as claimed in claim 24, which further comprises sealing the dynamic seal to the tubular member.

29. A method as claimed in claim 24, which further comprises adjusting a differential pressure acting on the dynamic seal.

30. A method as claimed in claim 24, which further comprises opening the subsea well, delivering an intervention tool into the subsea well, conducting an intervention operation and retrieving the intervention tool to a surface location.

31. A method for intervening in a subsea well comprising: coupling a spoolable compliant guide between a surface location and a subsea installation; delivering a dynamic seal through the spoolable compliant guide via a conveyance; and adjusting the seal formed between the conveyance and the dynamic seal.

32. A method as claimed in claim 31, which comprises changing the pressure acting on the dynamic seal for adjusting the seal formed between the conveyance and the dynamic seal.

33. A method as claimed in claim 32, wherein the pressure changing is accomplished remotely from a surface location.

34. A method as claimed in claim 31, wherein the coupling step includes coupling the spoolable compliant guide between a surface vessel and the subsea installation.

35. A method as claimed claim 31, wherein delivering the dynamic seal through the spoolable guide via the conveyance includes the use of a cable-type conveyance that delivers the dynamic seal through the spoolable compliant guide.

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