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# Method For Installing A Hanger

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## Introduction

The present disclosure relates to a hanger running tool for installation of a hanger in a wellbore and a method for installing a hanger in a well.

In the field of subsea oil and gas wells, the installation of a hanger (e.g. a tubing hanger or a casing hanger) is commonplace. The hanger is used in the completion of oil wells and is used to suspend tubing or casing from the wellhead.

Normally, installation or retrieval of a hanger is performed using a tubular riser inside the marine riser and Blow Out Preventer (BOP). Installation and retrieval of a hanger is performed using a hanger running tool, which is able to be connected to the hanger, thereby allowing installation or retrieval.

The control of a Hanger Running Tool (HRT) and associated downhole functions is presently achieved through a hanger umbilical clamped to the tubular (e.g. subsea riser, control riser etc.). Such a setup requires a huge investment to establish, as well as a large amount of rig space and operational expenses. In addition, several activities and processes are required to be carried out during installation, e.g. handling umbilical, clamping umbilical to a riser at regular intervals etc.

With the necessary equipment in place, the HRT is then required to be positioned and controlled in a subsea environment. Using the presently available technology, the HRT is operated by supplying operating fluid via a topside HPU and umbilical or via a subsea control module, both of which require a dedicated power source for providing a supply of hydraulic fluid as necessary for operation. As well as being expensive and sophisticated to install and operate (e.g. due to the equipment involved, and/or the need to separately generate a high pressure source of hydraulic fluid), there is always a risk that the hydraulic line may rupture and leak hydraulic fluid into the subsea environment, or that some other component may fail. Current systems may give rise to environmental concern, and additional measures may need to be taken in order to safeguard against this happening.

There is therefore a requirement for a way to control the installation of a hanger in a subsea environment, which is less cost intensive, requires less complex and sophisticated equipment, and more environmentally friendly than known methods.

Summary

It is an object of the present disclosure to mitigate, alleviate or eliminate one or more of the above-identified deficiencies and disadvantages in the prior art and solve at least the above mentioned problem. According to a first aspect there is provided a hanger running tool for installation of a hanger in a well, comprising: a central bore; a hanger engagement arrangement configurable between an engaged position in which the engagement arrangement is coupled to a hanger, and a disengaged position in which the engagement arrangement is decoupled from a hanger; a pressure-controlled anchoring actuator for actuating an anchoring arrangement, and comprising an actuation surface; the hanger engagement arrangement being configurable to the engaged position in response to an increase in pressure at a first pressure source, being configurable to the disengaged position in response to an increase in pressure inside the central bore, and the anchoring actuator being actuated in response to an increase in pressure on the actuation surface (e.g. an increase in pressure external to the tubing hanger running tool, such as an increase in the pressure in the BOP, below the slick joint) so that the anchoring arrangement anchors the hanger to an anchor point (e.g. which may be located on the wellhead, the Xmas tree, the BOP, or the like).

The hanger running tool may be a running tool for any type of hanger, for example for a tubing hanger, or for a casing hanger.

The first pressure source may be the pressure inside the central bore, or may be an external pressure source located at a surface location. In the case where the pressure source is located at a surface location, the pressure increase may be applied by the external pressure source while the hanger running tool is also located at the surface location. According to a second example, the hanger running tool may be configurable to be located inside at least one of a BOP, a subsea Xmas tree and a wellbore, and the anchoring actuator may be configurable to be actuated in response to an increase in pressure inside the BOP, subsea Xmas tree or wellbore, thereby resulting in an increase in pressure on the actuation surface. The anchoring actuator may be located on an external surface of the tool.

According to a third example, the first pressure source may be generated by a pump or compressor. The first pressure source may be generated while the tool is located at the surface location, and the first pressure source may be connected to the hanger running tool while the hanger running tool is at the surface location

According to a fourth example, the hanger engagement arrangement may be configurable to be disconnected from the first pressure source prior to the hanger running tool being positioned in a well.

According to a fifth example, the hanger engagement arrangement and the anchoring actuator may be located external to and around the periphery of the central bore.

According to a sixth example, the tool may comprise a valve comprising a valve seat located in the central bore, the valve being closeable to increase the pressure inside the hanger running tool.

According to a seventh example, the valve may be at least one of a ball valve or a valve that is activated by an activation object.

According to an eighth example, the valve may be removable from the hanger running tool. In some examples, the valve seat may be removable from the hanger running tool.

According to a ninth example, the hanger engagement arrangement may comprise an actuator comprising a first and a second pressure inlet, the first pressure inlet being in communication with the first pressure source via the first pressure conduit, and the second pressure inlet being open to the pressure in the central bore via the channel.

According to a tenth example, the hanger engagement arrangement may comprise an actuator comprising a piston contained in a hydraulic chamber arrangement divided into an upper hydraulic chamber and a lower hydraulic chamber, both the first pressure source and the central bore being in pressure communication with a hydraulic chamber of the hydraulic chamber arrangement.

According to an eleventh example, the first pressure source may be in pressure communication with the upper hydraulic chamber located at an upper end of the hydraulic chamber arrangement, and the central bore may be in pressure communication with the lower hydraulic chamber located at a lower end of the hydraulic chamber arrangement, such that an increase in pressure from the first pressure source may act to move the piston in a first direction, and such that an increase in pressure from the central bore may act to move the piston in a second direction.

According to a twelfth example, the anchoring actuator may be in the form of an annular piston.

According to a thirteenth example, the tool may comprise an anchoring arrangement comprising an anchor engagement profile, the anchoring actuator configurable to operate the anchoring arrangement to engage the wellbore.

According to a fourteenth example, the tool may comprise a locking arrangement configured to lock the hanger engagement arrangement in the engaged position.

According to a fifteenth example, the tool may be configured to retrieve a hanger from a well.

According to a sixteenth example, the tool may comprise a detachable retrieval module for engaging the tool with a hanger for retrieval, the detachable retrieval module comprising a retrieval profile for engaging a hanger for retrieval.

According to a seventeenth example, the central bore may be configurable to have a retrievable plug run therethrough.

A second aspect relates to a method for installing a hanger in a well, comprising:

providing a hanger running tool comprising a central bore, a hanger engagement arrangement and an anchoring actuator for actuating an anchoring arrangement;

engaging the hanger running tool with a hanger by providing an increase in pressure at a first pressure source to configure the hanger engagement arrangement to the engaged configuration, the increase in pressure being provided with both the hanger running tool and the first pressure source being at a surface location;

positioning the hanger and hanger running tool in a well at a desired location;

engaging the hanger with an anchor point by providing an increase in pressure in the well to actuate the anchoring actuator to engage the anchoring arrangement with the anchor point;

disengaging the hanger running tool from the hanger by providing an increase in pressure in the central bore to configure the hanger engagement arrangement to the disengaged configuration; and

retrieving the hanger running tool from a well.

According to a second example of the second aspect, the desired location in the well may be at least one of a desired location inside a BOP, a desired location inside a subsea Xmas tree and a desired location inside a wellbore.

According to a third example of the second aspect, the method may comprise providing a valve seat in the central bore, and locating an activation object (e.g. a ball or dart) in the valve seat to restrict fluid flow therethrough, and provide an increase in pressure in the central bore.

According to a fourth example of the second aspect, the method may comprise increasing the pressure in the well to move the anchoring actuator from a first to a second position to engage the anchoring arrangement with the anchor point.

According to a fifth example of the second aspect, the method may comprise attaching a detachable retrieval module to the tool, and retrieving the hanger from a well by coupling the detachable retrieval module to the hanger.

According to a sixth example of the second aspect, the method may comprise installing a retrievable plug in the well by running the retrievable plug through the central bore of the tool.

According to a seventh example of the second aspect, the method may comprise performing a well clean-up operation prior to installation of the retrievable plug.

<u>List of the drawings</u>

Figure 1 shows a sectional view of an example of the hanger running tool in an installation configuration.

Figure 2 shows Detail A of the hanger running tool in more detail.

Figure 3 illustrates a hanger running tool in a retrieval configuration having a retrieval module attached.

Figure 4 shows Detail B of the hanger running tool in more detail.

Part list

| Part number | Part name |
|---|---|
| 10 | Hanger running tool |
| 12 | tubular |
| 14 | hanger |
| 16 | slick joint |
| 20 | main body portion |
| 22 | actuation sleeve |
| 24 | anchor engagement profile |
| 26 | hanger engagement arrangement |
| 28 | base component |
| 30 | central bore |
| 32 | first pressure port |
| 32a | first auxiliary port |
| 34 | first pressure conduit |
| 34a | valve |
| 36 | second vent conduit |
| 36a | valve |
| 38 | second pressure port |
| 38a | second auxiliary port |
| 40 | actuation cavity |
| 42 | pressure-controlled anchoring actuator |

| | |
|---|---|
| 42a | actuation surface |
| 44 | sleeve |
| 46 | valve seat |
| 48 | hydraulic chamber arrangement |
| 48a | upper hydraulic chamber |
| 48b | lower hydraulic chamber |
| 50 | upper annular engagement ring |
| 52 | abutment surface |
| 54 | annular piston |
| 54a | thicker end |
| 54b | thinner end |
| 56 | hanger engagement member |
| 58 | lower annular ring |
| 60 | lock key |
| 62 | channel |
| 64 | shear ring |
| 110 | hanger running tool |
| 112 | tubular |
| 114 | hanger |
| 122 | actuation sleeve |
| 126 | hanger engagement arrangement |
| 130 | central bore |

| | |
|---|---|
| 132 | first pressure port |
| 134 | first pressure conduit |
| 136 | second vent conduit |
| 138 | second pressure port |
| 140 | actuation cavity |
| 142 | pressure-controlled anchoring actuator |
| 144 | sleeve |
| 144a | sealing ring |
| 148b | lower hydraulic chamber |
| 154 | annular piston |
| 156 | hanger engagement member |
| 162 | port |
| 163 | detachable retrieval module |
| 166 | biasing member/snap ring |
| 168 | lip |
| 170 | lip |
| 172 | sealing arrangement |
| 174 | sealing arrangement |

## Description

The present description provides an improved hanger running tool for installation of hanger in wellbore and method for installing hanger in well. According to one example there is provided a hanger running tool for installation of a hanger in a well, comprising: a central bore; a hanger engagement arrangement configurable between an engaged position in which the engagement arrangement is coupled to a hanger, and a disengaged position in which the engagement arrangement is decoupled from a hanger; a pressure-controlled anchoring actuator for actuating an anchoring arrangement, and comprising an actuation surface; the hanger engagement arrangement being configurable to the engaged position in response to an increase in pressure at a first pressure source, being configurable to the disengaged position in response to an increase in pressure inside the central bore, and the anchoring actuator being actuated in response to an increase in pressure on the actuation surface (e.g. an increase in pressure external to the tubing hanger running tool, such as an increase in the pressure in the BOP, below the slick joint) so that the anchoring arrangement anchors the hanger to an anchor point (e.g. which may be located on the wellhead, the Xmas tree, the BOP, or the like).

In use, the hanger running tool may be able to be coupled to a hanger, and run into position on a wellhead, a subsea Xmas tree, a wellbore, or the like, and may be run into position for example via a Blowout Preventer (BOP) and a marine riser. Once in the desired position, the pressure inside the BOP, marine riser and/or the wellbore may be increased in order to actuate the hanger running tool and provide engagement between the hanger and a component such as a casing hanger seat or the wellhead. The pressure inside the central bore of the hanger running tool may then be increased in order to configure the hanger engagement arrangement to disengage the hanger from the hanger running tool, thereby permitting the hanger running tool to be retrieved from the wellhead, BOP, wellbore, etc., and leaving the hanger in place. This setup permits the user to install the hanger in a desired position without having to have a hydraulic connection between the hanger running tool and a surface location or a subsea control sub/unit, thereby saving on the time and cost of providing the additional equipment involved, as well as running the additional equipment from the surface location. In addition, the described system functions more simply than known systems, and provides environmental benefits, for example because it removes the risk of there being a leak of hydraulic fluid into the surrounding environment.

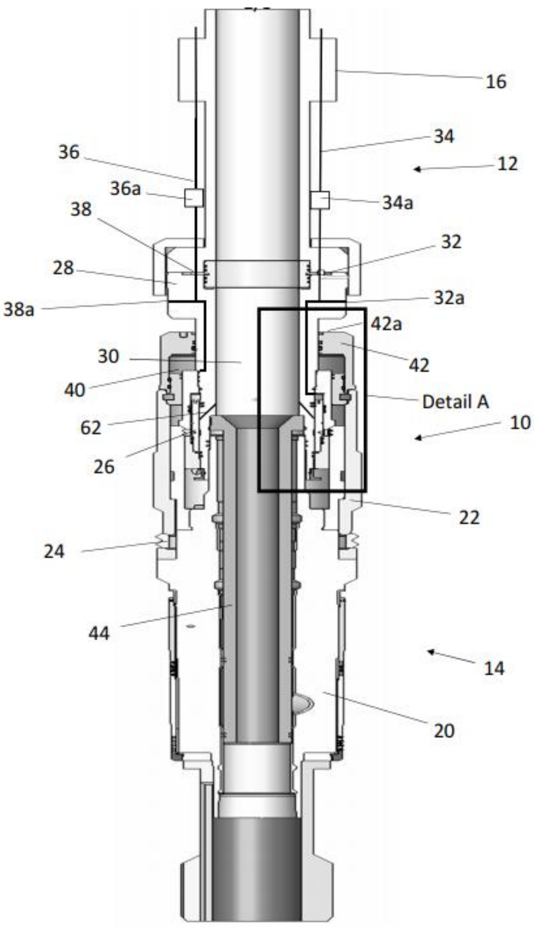



Figure 1

Illustrated in Figure 1 is a cross sectional view of a hanger running tool, showing some internal detail thereof. The hanger running tool is coupled at one end to a tubular, and at another end to a hanger. In this case, the hanger is a tubing hanger, but it should be understood that the hanger running tool may be used to any other type of hanger, such as a casing hanger. Although not illustrated in Figure 1, the hanger running tool may be run onto a wellhead (e.g. a seat in a casing hanger coupled to a wellhead), or into a subsea Xmas tree or wellbore, for example, via a marine riser and Blowout Preventer (BOP).

In this example, the tubular may be coupled to the hanger running tool by any appropriate means, such as by a flanged and bolted connection, via a threaded connection, or the like. Here, the tubular comprises a slick joint which may seal with a ram or BOP annular (not illustrated) and may enable the pressure (e.g. the pressure in the wellbore, BOP, Xmas tree, or the like) to be increased below the slick joint when the ram is in sealing contact therewith.

As will be described in more detail in the following description, the hanger is coupled to the hanger running tool, and in Figure 1 the tubing hanger is illustrated towards the lower portion of the figure. A tubing (not illustrated in Figure 1, and located below the tubing hanger), such as a production tubing, may be hung from the tubing hanger, and the tubing hanger and attached tubing may be run into the desired position in a well with the hanger running tool. The tubing hanger comprises a main body portion from which the tubing may be hung, and an actuation sleeve. In this example, the actuation sleeve comprises an anchor engagement profile, enabling the tubing hanger to engage an anchor point. The anchor point may be located on, for example, a component such as the Xmas tree, wellhead, or a seat in a casing hanger or tubing hanger (not shown).

The hanger running tool, which is located between the tubular and the tubing hanger, functions to engage the tubing hanger and attached tubing, and permits the tubing hanger to be run into a desired position, in relation to a well, such as on a wellhead or Xmas tree. A user may run the hanger running tool into a well through a marine riser and BOP. The hanger running tool is coupled to the tubular via a base component, which also defines a central bore within the hanger running tool.

In order to attach the tubing hanger to the hanger running tool, the hanger running tool comprises a hanger engagement arrangement. The hanger engagement arrangement comprises a number of components, which will be described in more detail in the following paragraphs, and is mounted upon the base component. The hanger engagement arrangement is in pressure communication with a first pressure source via a first pressure port. In this example, the first pressure port is located in the base component, the base component comprising a channel that permits pressure communication between the first pressure port by linking the first pressure port with the hanger engagement arrangement. The first pressure port is, in this example, coupled to a first pressure conduit, and access to the first pressure port is possible by linking the first pressure port and the first pressure conduit. Having access to the first pressure port via the first pressure conduit may provide a user with a degree of flexibility in the provision of pressure at the first pressure port, as the first pressure conduit may be routed however necessary in order to provide easy access via a pressure source. The first pressure conduit may therefore permit communication between a first pressure source (not shown) and the hanger engagement arrangement via the first pressure port.

As can be seen in this example, the first pressure conduit extends from the pressure port on the base component, and through the slick joint, having one end positioned above the slick joint. As such, having the first pressure conduit connected to the pressure port may ensure that, in the case of an increase in pressure below the slick joint, the first pressure port is not exposed to such a pressure increase. The first pressure conduit may have a valve or closure on an open end thereof, thereby providing selective pressure communication to the first pressure port. In the example of Figure 1, the first pressure conduit comprises a valve (e.g. a pilot valve) positioned along the length thereof. As will be described in greater detail in the following paragraphs, the valve may be used to enable selective venting of a chamber inside the hanger engagement arrangement. Venting through the first pressure conduit may be into the wellbore, or into a BOP, for example.

Although illustrated as a single conduit in Figure 1 extending through the slick joint, the first pressure conduit may be partially defined by the tubular and the slick joint, as is illustrated in Figure 1. Here, the part of the first pressure conduit that is in direct contact with the first pressure port is defined by a channel in the tubular (in particular, of a flange connection of the tubular). The first pressure conduit may be entirely defined by the channel in the tubular, and the channel need not contain any tubing therein. The conduit is then defined by a first section of tubing between the channel defined in the tubular and the slick joint. The slick joint also comprises a channel therein which partially defines the first pressure conduit, and in this example a second section of tubing is connected to the channel in the slick joint to further define the first pressure conduit.

The first pressure source may be located at a surface location, e.g. on the topsides of a vessel, or on a rig. The surface location may be any location that is not downhole. In some examples, the first pressure source may be a pump or compressor, which may be attached to the first pressure conduit to provide an increase in pressure at the first pressure port, and therefore increase the pressure at a location inside the hanger engagement arrangement. The first pressure source may be attached to the first pressure conduit while the hanger running tool is at a surface location, and then disconnected in order to run the hanger running tool into a desired position (e.g. disconnected before running the hanger tool into the desired position).

In addition to the first pressure conduit, in this example there is also illustrated a second vent conduit. The second vent conduit connects to a second pressure port that is also located on an outer surface of the base component (similar to the case with the first pressure port). Again, the base component comprises a channel that provides pressure communication between the hanger engagement arrangement and the second pressure port. The second vent conduit is coupled to the second pressure port and extends from the second pressure port to a location above the slick joint, thereby meaning that the second pressure port is not affected by pressure changes occurring below the slick joint. The second pressure port may function to allow venting of fluid from inside the anchoring actuator. In particular, the second pressure port may permit venting of fluid from inside an actuation cavity of the anchoring actuator. As is the case with the first pressure conduit, the second vent conduit comprises a valve (e.g. a pilot valve), which may assist in the venting of fluid inside the hanger engagement arrangement.

Similar to the first pressure conduit, the second vent conduit may be partially defined by sections of tubing, partially defined by the slick joint, and partially defined by the tubular. For the sake of brevity, a detailed description will not be repeated.

Illustrated in the example of Figure 1 is a first auxiliary port and a second auxiliary port. Unlike the first pressure port, the first auxiliary port does not comprise a conduit connected thereto or in communication therewith. In use, the first auxiliary port may serve only as a testing port, for example to perform pressure tests when the hanger running tool is located at a surface location. Once in a downhole location, the first auxiliary port may be sealed or blocked, and may no longer function. This is similarly the case for the second auxiliary port, which may also serve only as a testing port, and may also be sealed, blocked, plugged during normal operation such that it no longer functions.

In some cases there may be a valve arrangement or removable plug in, or adjacent either or both of the first and second auxiliary ports, to permit quick access to the port if required. This access component (e.g. a valve or a removable plug, or an arrangement comprising a plurality of either or both) may be situated in or between the relevant fluid port and the relevant conduit.

Additionally illustrated in Figure 1 is a pressure-controlled anchoring actuator for actuating an anchoring arrangement. As can be seen in Figure 1, the pressure-controlled anchoring actuator is located on an exterior surface of the hanger running tool, peripheral to the central bore, and is therefore open to the pressure external to the hanger running tool. The pressure external to the hanger running tool may be the pressure of the wellbore, where the hanger running tool is located in or adjacent the wellbore and/or wellhead, or may be the pressure inside the BOP. By providing a seal at the slick joint, a user may be able to increase the pressure external to the hanger running tool, located below the slick joint, to actuate the pressure-controlled anchoring actuator. In this example, the anchoring arrangement may be considered to comprise at least the anchoring actuator and the actuation sleeve and the engagement profile.

The pressure-controlled anchoring actuator has the shape of an annular piston in this example, and comprises a laterally extending shoulder which defines an actuation surface. The radially and axially extending shoulder and defined actuation surface may function to provide an axially directed force on the pressure controlled anchoring actuator when the pressure in the wellbore, BOP etc. is increased. As illustrated in Figure 1, the axially directed force acts in a downwards direct, towards the tubing hanger, in this example. The pressure controlled anchoring actuator extends along the exterior of one axial end and along part of the length of the hanger running tool, and together with the actuation sleeve of the tubing hanger, may function to provide an outer housing for the hanger running tool.

Illustrated in Figure 1, the anchor engagement profile is in a disengaged position, with the anchoring profile being radially withdrawn, away from an adjacent anchor point, such as a wellhead, BOP, Xmas tree, or the like, and which may comprise an anchor profile to assist in providing an anchored connection therewith. In order to move the anchor engagement profile to an engaged position, the actuation sleeve of the tubing hanger may be axially moveable. In this example, as the actuation sleeve moves in the direction towards the main body of the tubing hanger, part of the actuation sleeve may be forced underneath (e.g. radially inwards relative to) the anchor engagement profile, thereby forcing the anchor engagement profile in a radially outward direction and into engaging contact with the anchor point, thereby holding the tubing hanger in position in the wellbore, BOP, Xmas tree, or the like. In order to facilitate such a movement, the actuation sleeve may comprise a mating profile, such as a wedge-shaped portion, that is located adjacent the anchor engagement profile, such that axial movement of the actuation sleeve provides a force incident on the anchor engagement profile with a force component that is radially outwardly directed. Additionally or alternatively, the anchor engagement profile may comprise a mating profile, such as a corresponding wedge shaped portion, equally to assist in providing a radially outwardly directed force on the anchor engagement profile. In the case where both the actuation sleeve and the anchor engagement profile comprise a wedge shape profile, the profiles may be functional, for example the profiles may function to ensure that the actuation sleeve is able to exert a radially directed force component on the engagement profile, thereby moving the engagement profile to a radially outer position.

The anchor engagement profile and/or sleeve may comprise a surface configured to maximise the level of grip between the anchor engagement profile and the anchor point. For example, the anchor engagement profile may be roughened, or comprise protrusions such as ribs, dimples, teeth or the like.

As illustrated in Figure 1, the actuation sleeve may be in contact with the pressure-controlled anchoring actuator, or may be contactable by the pressure-controlled anchoring actuator. Here, an increase in the external pressure (e.g. the wellbore or BOP pressure) surrounding the hanger running tool may have the effect of moving the actuator in an axially downwards direction as in the illustrated orientation, thereby also moving the actuation sleeve of the tubing hanger, and configuring the anchor engagement profile from the disengaged to the engaged position. In some examples, the actuation sleeve (or at least a part of the actuation sleeve) may form part of the hanger running tool, while the anchor engagement profile forms part of the tubing hanger.

Although not illustrated, the hanger running tool may comprise a sensor or sensor arrangement for identifying whether a piston, actuation sleeve, engagement profile, or the like has performed the desired movement. The sensor may be in the form of a pressure sensor, strain gauge, optical sensor, or any other type of sensor that is appropriate to identify movement of a piston. The sensor or sensor arrangement may be connected to a control arrangement (e.g. by wires extending between the sensors and control arrangement, or by a wireless connection). The control arrangement may be located at a surface location, or on drill string or downhole, and the control arrangement may be connected to a display to alert a user to the status of movement of a (or each) piston in the hanger running tool.

Inside the central bore is illustrated a sleeve, comprising a valve seat, which in this example is partially located inside the hanger running tool and partially located inside the hanger. The sleeve may be run into the well bore with the hanger running tool, or may be positioned separately in the hanger running tool, for example after the hanger running tool has been installed in the desired position. The sleeve may be run in on wireline, for example, and may be able to be replaced if required. In some examples, the sleeve may have a profile different to that illustrated in Figure 1 – for example where the sleeve is run in on wireline into the tool, the profile may be different to cases where the sleeve is preinstalled. In addition, or alternatively, a hanger plug may be run into the tubing hanger, for example to restrict or block pressure surges from below the tubing hanger, by allowing the user to simply run such a plug through the central bore of the hanger running tool. In some examples, it may be possible to preinstall a plug into the tubing hanger, as the tubing hanger is run downhole, thereby removing the need to install the plug once the hanger is in position in the BOP or wellhead.

The sleeve may function to facilitate use of the hanger running tool. By providing a valve seat, the sleeve may be able to provide a seal in the central bore of the hanger running tool, for example by dropping a ball into the hanger running tool. In doing so, a user may be able to provide an increase in pressure inside the central bore of the hanger running tool, above the valve seat in the direction towards the surface. An increase in pressure may be provided by increasing the pressure inside the tubular (e.g. the marine riser, tubular riser, subsea riser, control riser, or the like), to which the hanger running tool and the tubing hanger are connected. In addition, the sleeve may function to block and seal a production port (not illustrated) in the tubing hanger, thereby ensuring that operation of the hanger running tool is not affected by unsealed ports in the tubing hanger, if these ports are not yet in use.

Illustrated in Figure 2 is Detail A of Figure 1, which is a section of internal detail of the hanger engagement arrangement shown in greater detail.

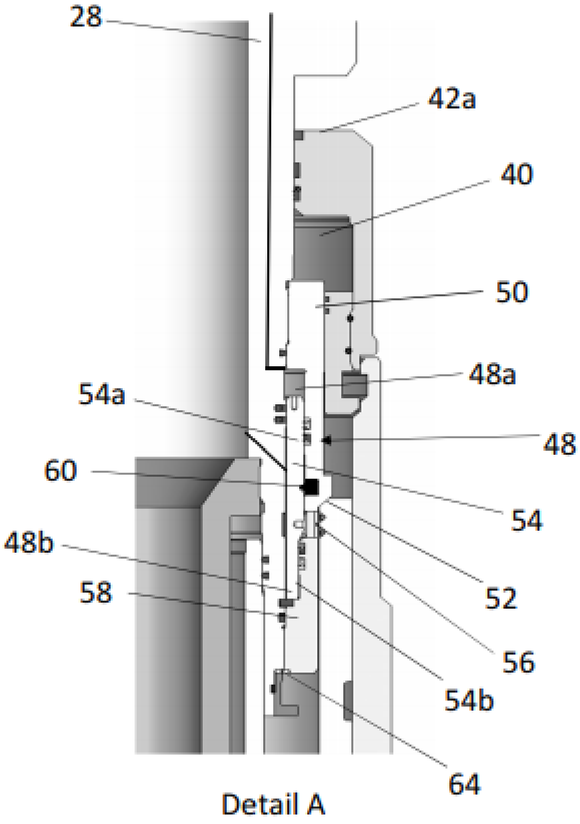



Figure 2

As can be seen in Figures 1 and 2, a channel extends from the first pressure port, and through the base component of the hanger running tool to a location inside the hanger running tool (see also Figure 1). Inside the hanger running tool, a hydraulic chamber arrangement is formed between the base component, a lower annular ring and an upper annular engagement ring, which may comprise an abutment surface for the purposes of engaging and/or locating the hanger running tool relative to the tubing hanger. Inside the hydraulic chamber arrangement is located an annular piston, comprising a thicker end and a thinner end defining two separate (an upper and a lower) hydraulic chambers, inside the hydraulic chamber arrangement. In this example the thicker end is located above the thinner end, such that the thicker end is located in an upper hydraulic chamber, while the thinner end is located in a lower hydraulic chamber. While the annular piston of this example comprises a thicker end and a thinner end, it may be preferable in some examples for the annular piston to be a balanced piston, with the thicker end having the same radial width as the thinner end, and for example with the annular piston having a constant radial width along its length.

Although not illustrated, and similar to as previously described, a sensor or sensor arrangement may be located on or adjacent the annular piston and/or the chamber so as to identify movement of the annular piston, and send information on the positioning of the annular piston to a user.

Located immediately below the upper annular engagement ring is a hanger engagement member, comprising an engagement profile for engaging the hanger running tool with the tubing hanger. The hanger engagement member is held in place by the lower annular ring. In addition, an upper seal arrangement is provided between the thicker end of the annular piston, the base component and the upper annular engagement ring, while a lower seal arrangement is provided between the thinner end of the annular piston, the base component and the lower annular ring. The upper annular engagement ring additionally comprises a lock key, which may be spring loaded, and which may engage with the annular piston in order to lock the annular piston. As shown in Detail A, the annular piston is in a position such that the hanger engagement member is in contact with the tubing hanger, thereby engaging the hanger running tool with the tubing hanger, and locking it in this position.

In use, the hanger running tool may be coupled (e.g. attached, engaged) to the tubing hanger at a surface location, for example on a vessel, a rig, in a warehouse etc.. To do so, a first pressure source, which may be in the form of, or provided by, a pump or compressor, is attached to the first pressure conduit, so as to provide an increase in pressure in the upper chamber– that is, the end of the hydraulic chamber at which the thicker end of the annular piston is located. The increase in pressure on in the upper section of the hydraulic chamber causes the annular piston to move in a downwards direction. As the annular piston moves in a downwards direction, the hanger engagement member changes from being in contact with the thinner end of the annular piston to being in contact with the thicker end thereof, thereby having the effect of moving the hanger engagement member from a disengaged position to an engaged position relative to the tubing hanger.

The hanger engagement member may be biased, for example spring loaded towards the disengaged position, to avoid undesired engagement with the tubing hanger. Once in the engaged position, the lock key may inhibit movement of the piston, thereby preventing the hanger engagement arrangement and the hanger running tool from becoming disengaged from the tubing hanger, for example during handling.

Once the hanger running tool and the tubing hanger have been engaged, both may be run into the desired position in the subsea location (e.g. in the BOP, Xmas tree, wellhead, or the like), for example via a marine riser and BOP. In order to assist with the positioning of the tubing hanger, an arrangement of sensors may be used, for example sensors which are able to convey to a user that the tubing hanger has passed a certain point in the BOP, has come into engagement with the wellhead, for example direct engagement or indirect engagement (e.g. via a seat on the wellhead, via a casing hanger on the wellhead, via a seat in an Xmas tree engaged with the wellhead, or the like), or has reached some other desired position. Additionally or alternatively, the positioning of the tool may be confirmed by hydraulic means, for example by having a tool in the hanger running tool or the tubing hanger that is able to measure pressure buildup around the tool as it is lowered into position, thereby giving the user an indication of the location of the tubing hanger. This information may be passed to a user at a surface location by any appropriate means, for example by communication wires or fibres attached to a marine riser, by wireless transmission or the like.

With the tubing hanger in the desired position, it may then be necessary to install the tubing hanger in this position. Initially, the tubing hanger and the hanger running tool will be in the position shown in Figure 1. In this position, the anchor engagement profile is in a retracted configuration, and is not engaged with the anchor point or any surrounding component of the Xmas tree, BOP, wellhead, or the like. In order to engage the tubing hanger with the anchor point (e.g. of the wellhead, BOP, Xmas tree), it is necessary to configure the tubing hanger and the hanger running tool to the position as shown in Figure 2. Here, the pressure controlled anchoring actuator is moved in a downward direction. As the anchoring actuator is in contact with the actuation sleeve, this has the effect of moving the anchor engagement profile to the engaged, radially expanded, configuration, as previously described, in which it is in engagement with an anchor point. Movement of the anchoring actuator may be enabled by increasing the pressure in the wellbore, the Xmas tree, the BOP, or the like. This may be achieved by moving a ram or BOP annular preventer into sealing contact with the slick joint, and then increasing the pressure below the slick joint.

It can be seen in both Figures 1 and 2 that an actuation cavity exists between the anchoring actuator and the base component. A sealing arrangement may be in place between the anchoring actuator, the base component and the upper annular ring so as to isolate the pressure in the actuation cavity from the rest of the hanger actuation arrangement (e.g. from the hydraulic chamber, as will be described in the following paragraphs).

A sensor or sensor arrangement may be located on or adjacent the anchoring actuator so as to provide an indication of the status thereof. The sensor or sensor arrangement may be located on at least one of the anchoring actuator or tool body (e.g. the base component) adjacent the anchoring actuator. In some examples, the sensor or sensor arrangement may be affixed or connected directly to the actuator, base component etc., while in some other examples, the sensor or sensor arrangement may be provided as a separate component which may be affixed or connected to the actuator, base component, any other adjacent component etc..

As illustrated in both Figure 1 and 2, the second pressure port leads to a channel in the base component, that permits pressure communication between the actuation cavity and second pressure port. Since the second pressure port is coupled to the second vent conduit, the vent conduit extending to a position located above the slick joint, then the pressure in the actuation cavity will be equal to the pressure in the region above the slick joint, which may be equal to the pressure inside the marine riser. Therefore, once the sealing ram is placed in sealing contact with the slick joint, and the pressure below the slick joint is increased, then there will be an unbalanced force acting upon the anchoring actuator, on the laterally extending shoulder and actuation surface thereof, as a result of the pressure differential between the actuation cavity and the region external to the anchoring actuator. This causes the anchoring actuator to move in a downwards direction, causing the anchor engagement profile to engage the anchor point, and the tubing hanger to be installed in the desired position. At the same time, the contents of the actuation cavity may be vented via the vent conduit to a location above the slick joint. The valve in the vent conduit may permit some degree of control over the venting of the actuation cavity. For example, the valve may be operable by a user, to open only when desired by a user. Additionally or alternatively, the valve may automatically open, for example at a set pressure limit.

While the term “above” is used to describe relative terms, this term has been selected to assist the reader in understanding the disclosure in the context of the provided figures. While the described components may be provided in the orientation shown in the Figures, it may also be possible to provide the described components in other configurations, for example rotated by degrees, degrees, or some other angle. Therefore, the reader should understand that in such cases the term “above” (and equally, similarly descriptive relative terms such as “below”, “upwards” and “downwards”) may differ in meaning from what is conventionally understood.

Once the tubing hanger has been installed in the desired position, it may be necessary to unlock the hanger running tool from the tubing hanger for retrieval. To perform this operation, the sleeve (see Figure 1) may be installed (or may be preinstalled) in the hanger running tool, and an activation object such as a ball or dart may be dropped into the valve seat in the sleeve. The ball (not shown) creates a seal with the valve seat, and the pressure inside the hanger running tool may be increased above the valve seat. This may be achieved by increasing the pressure in the tubular attached to the hanger running tool. As can be seen in Figure 1, a bore pressure channel (or a plurality of circumferentially arranged channels) is located in the base component, allowing pressure communication between the central bore and the hydraulic chamber. In particular, the bore pressure channel permits pressure communication between a lower hydraulic chamber that is located below (in this example) the upper seal arrangement. As such, with the activation object (in this example, the ball) engaged in the valve seat, an increase in pressure of the central bore acts on the lower seal arrangement in the lower hydraulic chamber, having the effect of pushing the annular piston therein in an upwards direction, and overcoming the locking force of the lock key, provided by a biasing member such as a spring, biasing the lock key towards the locked configuration. While only one lock key is illustrated in this position, more than one lock key may be present (e.g. there may be a circular array of individual lock keys). A simple profile of the lock key is illustrated in Detail A, although in other examples a differing, more complex profile may be used (e.g. a profile comprising multiple teeth). In this example, the lock key is supported by a spring, such that it is able to disengage upon application of a laterally directed force. Depending on the differing operational conditions (e.g. differing depths or operating pressures at which the tubing hanger running tool is used) the lock key may be differently designed to ensure that accidental unlatching of the tool from the hanger does not happen given the specific operating conditions. For example, more or fewer lock keys may be used, the spring stiffness may be variable, and/or the engagement profile may have a varying shape (e.g. a varying number of teeth). These variables may be able to be controlled to provide an arrangement requiring a desired minimum level of laterally directed force to unlatch.

As a result of the seal arrangements in the hanger running tool, and the pressure balance within cavities/chambers in the tool, the tool may be relatively unaffected by external pressures and/or differential pressures acting across the tool. Additionally, the pressure acting on both ends of the annular piston will be the same (both ends will be open to the pressure surrounding the tool), then this will act to prevent accidental actuation of the tubing hanger running tool during installation.

As the annular piston moves in an upwards direction, the hanger engagement member comes into contact with the thinner end of the piston. As the hanger engagement member is biased towards the disengaged configuration, the hanger engagement member moves towards the disengaged configuration, and the hanger running tool is now disengaged from the tubing hanger. The hanger running tool may then be retrieved.

To further assist in moving the annular piston towards a disengaged position, the valve in the first pressure conduit may be opened, to permit venting of the upper hydraulic chamber.

The tool may also have a secondary means of operation, such that the running tool is able to be released from tubing hanger in the case that the above described process should fail. In the Example of Figures 1 and 2, the hanger running tool may comprise a shear ring. Here, the shear ring is located between the base component and the lower annular ring, and immediately above the shear ring on the base component may be a threaded profile configured to engage with a threaded profile of the lower annular ring.

In order to release the hanger from the running tool, the base component may be rotated. The lower annular ring may be in engagement with the sleeve located radially outwardly thereof (e.g. engaged by a key located therebetween), and therefore may not rotate with the base component, thereby causing the shear ring to shear. Once the shear ring is sheared, then the rotation between the lower annular ring and the base component may cause the lower annular ring to move in a downwards direction, as a result of the threaded connection therebetween, until the lower annular ring and the base component are disengaged. At this point, the base component may be pulled in an upward direction, causing the annular piston to move in an upwards direction and the tool to be disengaged from the hanger, and allowing retrieval thereof. Using this method, the tool may be able to be retrieved should the primary method of hydraulic actuation fail.

Although one means of secondary operation is described, it should be noted that a user should not be restricted specifically to this means of secondary operation. Other means of secondary operation may equally be possible for use in combination with the running tool and hanger as described.

Figures 3 and 4 illustrate a further example of a section of a hanger running tool, which may be the same tool as described in Figures 1 and 2, but in a different configuration as will be described. Detail B illustrates a part of Figure 3 in larger detail. The hanger running tool is substantially similar to that illustrated in Figures 1 and 2, and therefore equivalent numbering will be used for equivalent parts, augmented by.

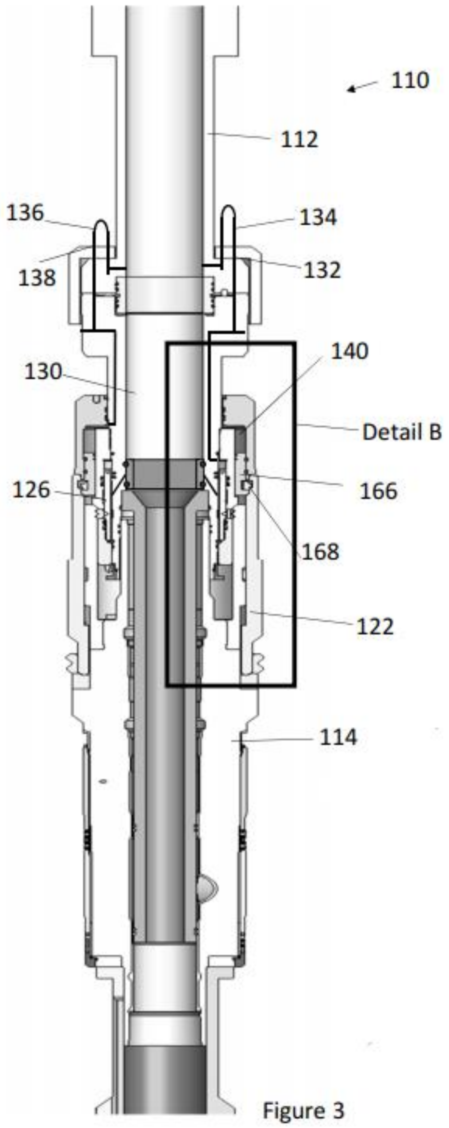
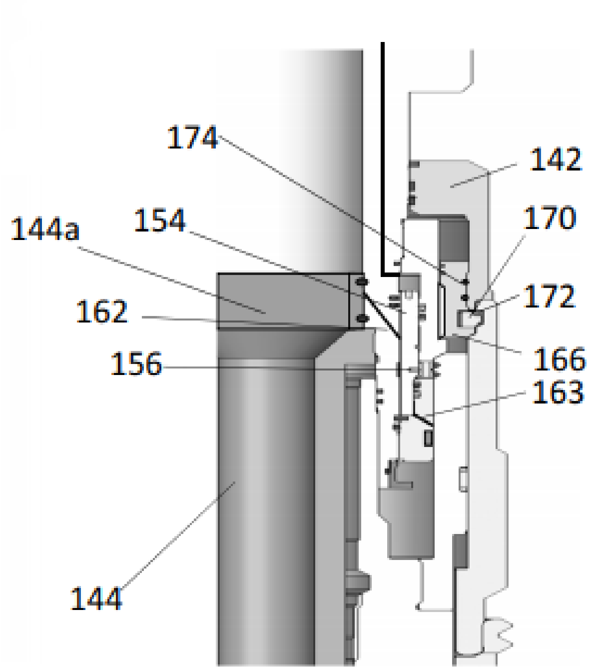



Figure 3

In the example of Figure 3, there is a detachable retrieval module. In this example, the detachable retrieval module is attached to the hanger running tool between the anchoring actuator. The detachable retrieval module may be attached to the hanger running tool before running downhole.

The detachable retrieval tool comprises a biasing member (which may be in the form of a snap ring or of spring loaded keys), which may be moveable between a radially inner position and a radially outer position, and may be biased towards the radially outer position e.g. by a spring member. As can be seen, the snap ring comprises a lip, which is able to engage with a corresponding lip of the actuation sleeve. The hanger running tool may be positioned using electronic or hydraulic sensors, as previously described. As the snap ring can be moved between a radially inner position and a radially outer position, the snap ring may effectively be collapsed and then expanded so as to engage with the lip of the sleeve.

Once engaged with the lip of the sleeve, the hanger running tool may be pulled in an upwards (e.g. upwards relative to the orientation of the figures) direction, thereby completing the disengagement process of the tubing hanger from the anchor point. Before the tubing hanger may be retrieved from the wellbore, the hanger running tool is engaged with the tubing hanger via the hanger engagement member.




Detail B Figure 4

It should be noted that, in the examples of Figure 3 and 4, the first pressure conduit and the second vent conduit have been rerouted, such that they connect the respective part of the hanger engagement arrangement (as described in relation to the previous Figures) to the inside of the tubular, which is in pressure and fluid communication with the central bore of the running tool. As such, the pressure inside the running tool may be increased in order to provide a pressure increase at the first pressure port and the second pressure port, thereby moving the annular piston in a downwards direction and engaging the hanger engagement member with the hanger. Therefore, in this example, there may be no requirement for a dedicated fluid source in order to operate the running tool, as the pressure inside the running tool (or, for example, the BOP) may be increased in order to move piston in a downwards direction. In order to facilitate downwards movement of the annular piston, a port and flowline is illustrated in Detail B of the retrieval tool to allow venting of the lower hydraulic chamber. Similarly, the pressure inside the actuation cavity is increased, causing the anchoring actuator to move in an upwards direction and thereby also assisting to disengage the running tool from the hanger. A sealing arrangement is provided between the detachable retrieval module and the anchoring actuator in order form the pressure sealed actuation cavity, the pressure in which may be increased/decreased via the vent conduit (it should be noted that this sealing arrangement may also be present in the tool in the installation configuration).

Although not illustrated, at least one (or both) of the first pressure conduit and the second vent conduit may comprise a pilot valve, similar to as described in relation to Figure 1.

It should also be noted that the sleeve, when the tool is in the retrieval configuration, comprises an additional sealing ring, which has the effect of isolating the port from the central bore. Therefore, when providing a pressure increase at the ports and, there will not be corresponding pressure increase at the port. The sealing ring may be a separate component or may be integrally formed with the sleeve, or may be a separate component. The sealing ring may be coupled to the sleeve, e.g. via a mating or threaded profile.

Further upwards movement of the tubing hanger may then have the effect of retrieving the tubing hanger from the wellbore.  Having such a retrieval module provides a straightforward way of retrieving the tubing hanger, without the need for use of complex positioning manoeuvres to retrieve the tubing hanger.

Useful examples according to the disclosure are described in the following list:

1) A hanger running tool installation of a hanger in a well, comprising:

a central bore;

a hanger engagement arrangement between an engaged position in which the engagement arrangement coupled to a hanger, and a disengaged position in which the engagement arrangement decoupled from a hanger;

a pressure-controlled anchoring actuator actuating an anchoring arrangement, and comprising an actuation surface;

the hanger engagement arrangement configurable to the engaged position in response to an increase in pressure at a first pressure source, being configurable to the disengaged position in response to an increase in pressure inside the central bore, and the anchoring actuator actuated in response to an increase in pressure on the actuation surface that the anchoring arrangement anchors the hanger an anchor point;

wherein the first pressure source is at least one of:

the pressure inside the central bore, or

an external pressure source located at a surface location, the pressure increase being applied by the external pressure source with the hanger running tool located at a surface location.

2) A hanger running tool installation of a hanger in a well, wherein the hanger running tool configurable to be located inside at least one of a BOP, a subsea Xmas tree and a wellbore, and the anchoring actuator configurable to be actuated in response to an increase in pressure inside the BOP, subsea Xmas tree or wellbore, thereby resulting in an increase in pressure on the actuation surface.

3) A hanger running tool installation of a hanger in a well, wherein the first pressure source is an external pressure source generated by a pump or compressor.

4) A hanger running tool installation of a hanger in a well, wherein the hanger engagement arrangement configurable to be disconnected from the first pressure source prior to the hanger running tool positioned in a well.

5) A hanger running tool installation of a hanger in a well, the hanger engagement arrangement the anchoring actuator located external to and around the periphery of the central bore.

6) A hanger running tool installation of a hanger in a well, comprising a valve a valve seat in the central bore, the valve closeable to increase the pressure inside the hanger running tool.

7) A hanger running tool installation of a hanger in a well, wherein the valve at least one of a ball valve or a valve that is activated by an activation object.

8) A hanger running tool installation of a hanger in a well, wherein the valve removable from the hanger running tool.

9) A hanger running tool installation of a hanger in a well, wherein the hanger engagement arrangement an actuator a first and a second pressure inlet, the first pressure inlet being configurable to be in communication with the first pressure source via the first pressure conduit, and the second pressure inlet being open to the pressure in the central bore via a bore pressure channel.

10) A hanger running tool installation of a hanger in a well, wherein the hanger engagement arrangement an actuator a piston contained in a hydraulic chamber arrangement into an upper hydraulic chamber a lower hydraulic chamber, both the first pressure source and the central bore configurable to be in pressure communication with a hydraulic chamber (48a, 48b) of the hydraulic chamber arrangement.

11) A hanger running tool installation of a hanger in a well, wherein the first pressure source is configurable to be in pressure communication with the upper hydraulic chamber at an upper end of the hydraulic chamber arrangement, and the central bore is configurable to be in pressure communication with the lower hydraulic chamber at a lower end of the hydraulic chamber arrangement, such that an increase in pressure from the first pressure source acts to move the piston in a first direction, and such that an increase in pressure from the central bore to move the piston in a second direction.

12) A hanger running tool installation of a hanger in a well, wherein the anchoring actuator in the form of an annular piston.

13) A hanger running tool installation of a hanger in a well, wherein the anchoring arrangement comprises an anchor engagement profile, the anchoring actuator to operate the anchoring arrangement to engage an anchor point.

14) A hanger running tool installation of a hanger in a well, comprising a locking arrangement to lock the hanger engagement arrangement the engaged position.

15) A hanger running tool installation of a hanger in a well, wherein the tool configured to retrieve a hanger a well.

16) A hanger running tool installation of a hanger in a well, comprising a detachable retrieval module engaging the tool a hanger retrieval, the detachable retrieval module a retrieval profile engaging a hanger retrieval.

17) A hanger running tool installation of a hanger in a well, wherein the central bore configurable to have a retrievable plug run therethrough.

18) A method for installing a hanger a well, comprising:

providing a hanger running tool a central bore, a hanger engagement arrangement an anchoring actuator actuating an anchoring arrangement;

engaging the hanger running tool a hanger providing an increase in pressure at a first pressure source to configure the hanger engagement arrangement the engaged configuration, the increase in pressure being provided with both the hanger running tool the first pressure source being at a surface location;

positioning the hanger hanger running tool a well at a desired location;

engaging the hanger an anchor point by providing an increase in pressure in the well to actuate the anchoring actuator engage the anchoring arrangement with the anchor point;

disengaging the hanger running tool the hanger providing an increase in pressure in the central bore configure the hanger engagement arrangement the disengaged configuration; and

retrieving the hanger running tool a well.

19) A method for installing a hanger a well, wherein the desired location in the well is at least one of a desired location inside a BOP, a desired location inside a subsea Xmas tree and a desired location inside a wellbore.

20) A method for installing a hanger a well, comprising providing a valve seat the central bore, and locating an activation object (e.g. a ball or dart) in the valve seat restrict fluid flow therethrough, and provide an increase in pressure in the central bore.

21) A method for installing a hanger a well, comprising increasing the pressure in the well to move the anchoring actuator a first to a second position to engage the anchoring arrangement with the anchor point.

22) A method for installing a hanger a well, comprising attaching a detachable retrieval module the tool, and retrieving the hanger a well by coupling the detachable retrieval module the hanger.

23) A method for installing a hanger a well, comprising reconfiguring the hanger running tool retrieving the hanger a well such that the first pressure source is the pressure inside the central bore.

24) A method for installing a hanger a well, comprising installing a retrievable plug in the well by running the retrievable plug through the central bore the tool.

25) A method for installing a hanger a well, comprising performing a well clean-up operation prior to installation of the retrievable plug.