

ADJUSTABLE HANGER SYSTEM AND METHOD

FIELD OF THE INVENTION

5 The present invention relates to an adjustable hanger system for connecting a hanger to a wellhead. More particularly, the adjustable hanger system is used for tensioning a tubular extending downward from the hanger and secured at a lower end in the well.

10 BACKGROUND OF THE INVENTION

 Various types of hanger systems have been devised for tensioning a tubular in a well. Many prior art adjustable hanger systems include numerous components within the wellhead housing which are adjusted to achieve tensioning of the tubular. U.S. Patent 5,176,218 discloses a threaded sleeve
15 which is landed inside the wellhead. The sleeve interfaces with the hanger by rotating the hanger relative to the sleeve. U.S. Patent 5,671,812, 5,255,746 and 5,944,111 utilize various arrangements of an internal load shoulder and a hanger with multiple grooves to achieve adjustability.

 U.S. Patent 6,065,542 discloses another design wherein adjustment for
20 tensioning is achieved within the hanger. U.S. Patent 8,066,764 discloses another technique for making adjustments to the hanger to tension the tubular in the well.

 U.S. Patent 7,040,412 discloses an adjustable hanger system wherein a series of axially spaced groove sets are provided in the wellhead, with the

hanger including a support ring and a lockdown ring each for fitting within one of the sets of axially spaced grooves. The sealing surface between groove sets provides a sealing surface on the wellhead for sealing with the hanger.

Prior art adjustable hanger systems tend to be complicated, which in turn leads to questionable reliability. The system discloses U.S. Patent 7,040,412 is reliable since the hanger is connected directly to in the wellhead. When a selected set of grooves for connection with the hanger create too much or too little tension in the string, the hanger may be axially raised or lowered so that another vertically spaced set of grooves will provide the more appropriate tension desired for the hanger system. This design is particularly intended for very deep wells, and fine adjustment of the hanger relative to grooves in the wellhead is not disclosed.

The disadvantages of the prior art are overcome by the present invention, an improved adjustable hanger system and method are hereinafter disclosed.

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SUMMARY OF THE INVENTION

In one embodiment, an adjustable hanger system is connected to a wellhead such that a tubular extending downward from the hanger and secured at a lower end of the well may be tensioned at a selected level. The hanger system includes a wellhead housing with a plurality of axially spaced grooves, with each groove having a profile to receive a support member therein. The support member may be carried in the well on the hanger. The wellhead housing includes an axially elongated and generally cylindrical sealing surface spaced above the plurality of axially spaced grooves for sealing engagement with a seal element between the wellhead housing and the hanger. The hanger is axially movable relative to the plurality of grooves, and the support member is axially movable into selected ones of a plurality of grooves in the wellhead housing to axially connect the hanger to the wellhead.

According to the method of the invention, the wellhead housing is provided with a plurality of axially spaced grooves to accept the support member, and includes a generally cylindrical sealing surface spaced axially above the plurality of grooves. The support member is positioned in the well on the hanger above selected ones of a plurality of grooves. When the hanger is lowered slightly in the well, the support member moves radially outward into the selected ones of the plurality of grooves, thereby preventing axially downward movement of the hanger with respect to the wellhead. A seal is sealed between the hanger

and a generally cylindrical sealing surface while the support member is within selected ones of the plurality of grooves.

These and further features and advantages of the present invention will become apparent from the following detailed description, wherein reference is
5 made to the figures in the accompanying drawings.

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BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1A and 1B are cross-sectional half views of a wellhead housing, with a hanger connected to the housing at the lower end of the axially spaced grooves in the wellhead housing shown in Figure 1A, and at the upper end of the
5 axially spaced grooves in the wellhead housing shown in Figure 1B.

Figure 2 is a detailed cross-sectional view including a support ring and a lockdown ring each out of mating engagement with the grooves in the wellhead housing.

Figure 3 is a detailed cross-sectional view illustrating the lockdown ring
10 out of mating engagement with the wellhead grooves, and the landing or support ring in mating engagement with the wellhead grooves.

Figure 4 is a cross-sectional view of a top portion of the hanger and a seal lower sleeve between the wellhead and the hanger, and a portion of mandrel radially within the hanger.

15 Figures 5A and 5B are cross-sectional half views of a running tool for moving the support ring into mating engagement with the grooves in the wellhead housing. In Figure 5B, the hanger is not yet engaged with the housing groove, and in Figure 5B the hanger is engaged with the housing grooves.

Figure 6A and 6B are cross-sectional half views of a running tool for
20 setting the seal to seal between the wellhead and the hanger, and for moving the lockdown ring into mating engagement within the grooves in the wellhead

housing. Figure 6A shows the seal installation starting, and Figure 6B shows the seal installed.

Figure 7 is a detailed cross-sectional view showing the support ring in mating engagement with the grooves in the housing, while the lockdown ring is
5 out of engagement with the grooves in the wellhead housing.

Figure 8 illustrates both the lockdown ring and the support ring in engagement with the grooves in the wellhead housing.

Figure 9 illustrates the seal installed between the hanger and the wellhead housing.

10 Figure 10A and 10B are cross-sectional views of the lower seal sleeve setting the lockdown ring in Figure 10A engaging the lower threads on the housing, and the lockdown ring in Figure 10B engaging the upper threads on the housing.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The hanger system disclosed herein provides an axial elongate sealing surface on the interior of the wellhead housing above an axially spaced plurality of grooves on the wellhead housing. Regardless of the position of the hanger
5 with respect to the grooves, a seal will seal between the hanger and the cylindrical sealing surface above the plurality of grooves, and the hanger will be axially secured to the wellhead housing to provide the desired tension in the tubular string supported in the well from the hanger.

The hanger system allows for very fine adjustment of the position of the
10 hanger relative to the wellhead, thereby obtaining fine adjustment of the tension applied to the tubular extending downward from the hanger. For many applications, the axially spacing of the grooves will be one-quarter inch or less. Because the grooves have the same groove profile and axial spacing, the support ring and the lockdown ring will fit within any of the selected grooves,
15 which is contrary to disclosure with U.S. Patent 7,040,412, in which the support ring had a different profile than the lockdown ring, so that each ring fit within its corresponding groove profile.

Figures 1A and 1B disclose a portion of the surface wellhead assembly including a casing head or wellhead housing 10 and a generally tubular shaped
20 hanger 12. One should appreciate that Figure 1A illustrates the hanger in a lower position within the wellhead housing, and Figure 1B depicts the same hanger in an upper position within the wellhead housing. The tubular 14

supported on the hanger extends downwardly from the hanger, and is conventionally secured in the well at or near its lower end. A spacer spool 16 is shown connected to the wellhead housing 10 with a plurality of conventional dogs 17. A series of axially extending grooves 18 are provided on the inner
5 surface in the housing 10. Both the support ring 22 and a lockdown ring 24 discussed subsequently may be moved into engagement with selected ones of the plurality of grooves 18, thereby securing the hanger to the wellhead. Seal 82 may optionally be provided so that the sealed chamber may be tested. One or more conventional gate valves 25 are provided for communication between the
10 annulus about the tubular 14 and the interior of the housing 10.

Figure 2 illustrates a portion of the wellhead 10 and the casing hanger 12, and more clearly illustrates the grooves 18 on the wellhead for receiving both the support ring 22 and the lockdown ring 24. A fluid passageway 26 is provided in the hanger for supplying pressurized fluid to one or more circumferentially
15 spaced pistons 28, which move radially outward as shown in Figure 3 for mating engagement of the support ring with the grooves on the wellhead housing. During radial outward movement of the support ring, the lockdown ring 24 remains in its position out of mating engagement with the grooves 18. Each of the support ring 22 and the lockdown ring 24 may be biased radially inward to its
20 natural or relaxed position.

Figure 4 illustrates the lower sleeve 30 of the seal assembly discussed subsequently inserted between the cylindrical sealing surface 20 on the wellhead

housing and the radially outward surface on the hanger 12. A portion of the running tool 40 used to set to the seal may be sealed to the hanger 12 by one or more seals 42, while seal 44 seals between the lower sleeve 30 and the hanger 12.

5 Referring now to Figures 5A and 5B, a running tool 50 may be used to activate the support ring, and is shown in Figure 5A in its run in position, wherein the support ring 22 is not yet activated. A ball 52 may be dropped on seat 54, thereby increasing the pressure above the ball, which increases pressure in the axially extending passageway 26. With the increase in pressure, the ball 52 may
10 move down with the seat 44 and the sleeve. High fluid pressure will then force the pistons as shown in Figures 2 and 3 to move the support ring 22 radially outward so that its teeth engage the grooves 18 in the wellhead to prohibit downward movement of the tubular string supported on the hanger, as shown in Figure 5B. The support ring 22 may be retained in its radially outward position
15 by support surface 32 on the hanger (see Figure 7) engaging radially inward surface 34 on the support ring 22 to prevent the support ring from moving radially inward.

Figures 6A and 6B illustrate a running tool 60 for running the seal assembly 62 in place, and also for moving the backup ring 24 radially outward.
20 Fluid pressure below the closed BOP above the spacer spool 16 may thus move the tool 60 and the seal ring 62 supported thereon from its upper position as shown in Figure 6A to its lower position as shown in Figure 6B. As shown in

Figure 9, the seal 62 may be positioned on the running tool 60 for reliably sealing between the housing 10 and the hanger 12. As shown in Figures 7 and 8, the lower sleeve 30 attached to seal 62 moves downward with the seal 62 during the seal setting operation, and becomes trapped between the radially outer surface 64 on the hanger 12 and the radially inner surface 66 on the lockdown ring 24, thereby forcing the lockdown sleeve 24 radially outward into engagement with the grooves in the casing hanger, as shown in Figure 8. Figures 10A and 10B illustrate the sleeve 30 in an upper position to actuate the lockdown ring for engaging an upper set of grooves 18 in Figure 10A, and in a lower position in Figure 10B to actuate the lockdown ring to engage a lower set of grooves 18.

The operational sequence for tension a tubular is described below. The riser (or other tubular) is lowered in the well on a running tool and is connected at its lower end to an external tieback connector (not shown). Pressure tests are commonly made by pressurizing the riser through the running tool, and the running tool is then removed.

The hanger passes through the drilling spool and weight is set down onto the inner riser tieback. The riser is rotated to the right and torqued to approximately 5000 foot pounds. The riser is then pulled to obtain the desired riser tension. While holding tension on the riser, a ball is dropped through the drill pipe which lands in a lower sleeve in the clutch tool. Pressure is applied through the drill pipe which moves the shuttle sleeve downward, allowing pressure to communicate with the radial pistons located in the riser hanger to

drive the support ring radially outward. While holding pressure in the drill pipe, the inner riser is slowly lowered by the support ring until the ring snaps into the first set of circumferential grooves located in the housing and the riser load is then transferred to the riser hanger. The pressure in the drill pipe may be released, and approximately 5000 pounds set down on the clutch tool. The clutch tool is then rotated to the left which releases the clutch tool from the inner riser hanger, allowing the tool to be brought back to the surface.

Following installation to the hanger, the riser hanger seal is made up to the seal with the installation running tool. The tool is lowered into the housing while metal seal has landed on the outside of the hanger. The piston seal is formed on the ID of the hanger with the seal running tool. The BOP rams are closed around the drill pipe and the annulus above the hanger is pressurized, which drives the running tool and the seal assembly down onto the inner riser hanger. Pressure in the annulus is then released and the drill pipe is torqued to approximately 5000 foot pounds to lock the metal seal onto the hanger. An external test port adjacent the metal seal may be removed and a hydrostatic test performed to verify pressure integrity of the metal seal to the hanger and the drilling spool. Upon completion of the pressure test, the tool may then be picked up and brought back to the surface.

For the embodiments shown in Figures 1-6, the support member received within the grooves in the wellhead housing is C-shaped support ring member. Similarly, the lockdown member is another C-shaped ring member. In other

embodiments, one or both of the support member and the lockdown member may have a configuration other than being C-shaped, and for example, may comprise circumferentially spaced dogs which move radially into and out of engagement with the grooves in the wellhead housing. These dogs may be
5 biased radially inward, or may be moved radially by various types of dog actuation mechanisms.

Although specific embodiments of the invention have been described herein in some detail, this has been done solely for the purposes of explaining
10 the various aspects of the invention, and is not intended to limit the scope of the invention as defined in the claims which follow. Those skilled in the art will understand that the embodiment shown and described is exemplary, and various other substitutions, alterations and modifications, including but not limited to those design alternatives specifically discussed herein, may be made in the
15 practice of the invention without departing from its scope.

CLAIMS:

1. An adjustable hanger system for connecting a hanger to a wellhead such that a tubular extending downward from the hanger is tensioned at a selected level, and the hanger system comprising:

the wellhead including a housing having a plurality of axially spaced grooves, each groove having a profile to receive a support member therein, the support member being carried in the well by the hanger, wherein each of the plurality of axially spaced grooves has a common groove configuration and each of the grooves is axially spaced from each of the adjacent grooves by a common axial spacing;

said plurality of grooves being configured to receive concurrently the support member and a lockdown member, said lockdown member being carried in the well by the hanger; the support member being received by a first subset of the grooves and the lockdown member being received by a second subset of the grooves;

the wellhead housing further including an axially elongate and generally cylindrical sealing surface spaced axially above the plurality of axially spaced grooves for sealing engagement of a seal element with the cylindrical sealing surface and the hanger; and

the hanger being axially movable relative to the plurality of grooves, the hanger supported by the support member which is radially movable into selected ones of the plurality of axially spaced grooves in the wellhead housing to interconnect the hanger to the wellhead.

2. An adjustable hanger system as defined in Claim 1, wherein:

the lockdown member is radially movable into one or more of the plurality of grooves for securing the hanger to the wellhead to prevent axially upward movement of the hanger relative to the wellhead.

3. An adjustable hanger system as defined in Claim 1, wherein the support member is biased radially inward.

4. An adjustable hanger system as defined in Claim 1, wherein the support member is movable radially outward in response to one or more fluid pressure responsive pistons supported in the well on the hanger.

5. An adjustable hanger system as defined in Claim 1, wherein an exterior stop surface on the hanger prevents the support member from moving radially inward while the support member is in the selected ones of the plurality of grooves, the exterior stop surface moving axially from an unlocked position to a locked position.

6. An adjustable hanger system as defined in Claim 1, wherein the support member is a substantially C-shaped member.

7. An adjustable hanger system as defined in Claim 1, wherein the seal element is sealed between the hanger and the wellhead housing.

8. A method of adjustably connecting a hanger to a wellhead with a tubular suspended in a well from the hanger and secured at its lower end in the well, the method comprising:

providing the wellhead housing with a plurality of axially spaced grooves each configured to accept a support member, wherein each of the plurality of axially spaced grooves has a common groove configuration and each of the grooves is axially spaced from each of the adjacent grooves by a common axial spacing; said plurality of grooves being configured to receive concurrently the support member and a lockdown member, said lockdown member being carried in the well by the hanger; the support member being received by a first subset of the grooves and the lockdown member being received by a second subset of the grooves; the wellhead housing having a generally cylindrical sealing surface spaced axially above the plurality of grooves;

positioning the support member on the hanger;

positioning the support member and hanger in the well on the hanger above selected ones of the plurality of grooves;

thereafter raising or lowering the hanger in the well to achieve a selected tension level in the tubular;

moving the support member radially outward into the selected ones of the plurality of grooves while the tubular is at the selected tension level, thereby preventing axially downward movement in the hanger with respect to the wellhead; and

sealing a seal with the generally cylindrical sealing surface while the support member is within the selected ones of the plurality of grooves.

9. A method as defined Claim 8, further comprising:

increasing fluid pressure to a running tool to move the support member radially outward into the selective ones of the plurality of grooves.

10. A method as defined Claim 8, wherein fluid pressure acts on a plurality of pistons supported on the hanger, such that the fluid pressure responsive pistons move the support member radially outward.

11. A method as defined Claim 8, further comprising:

positioning the lockdown member on the hanger, the lockdown member engaging one or more of the plurality of grooves to prevent upward movement of the hanger with respect to the wellhead housing.

12. A method as defined Claim 8, further comprising:

lowering the seal element on a running tool into the well after the support member has expanded outward into the selected one of a plurality of support grooves; and

axially moving the sealing element to seal between the hanger and the wellhead.

13. A method as defined Claim 8, further comprising:

providing the support member with a generally C-shaped configuration.