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(54) IMPROVEMENTS IN OR RELATING TO A LANDING TOOL AND LANDING METHOD FOR OFF-SHORE SUBSEA WELL OPERATIONS

(71) We, SOCIETE NATIONALE ELF AQUITAINE, (PRODUCTION) of Tour Aquitaine—92400 Courbevoie, France a French corporate body do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a landing tool and landing method whereby a tubing hanger is precisely angularly indexed in a subsea wellhead assembly.

In offshore subsea well operations, it is desirable to conduct many of the operations at great depths and without diver assistance. Such well operations at any depth require precise remote control of equipment.

According to the present invention there is provided a landing tool for landing a well tool in a subsea wellhead assembly, said tool comprising a tool body including means to support said well tool in predetermined angular orientation with respect thereto.

a pipe stinger assembly extending from said tool body and including a pipe stinger having mounted thereon by a screw thread a sub assembly provided with swivel means allowing the sub assembly to be rotated while supported against axial movement,

said tool body being provided with engagement means arranged in use to engage vertical slot means in said wellhead assembly and thereby to limit rotation of said tool body in one direction while permitting axial movement thereof relative to said wellhead assembly,

whereby when the weight of said tool is supported by said swivel means rotation of said sub assembly in the direction opposite to said one direction will cause said pipe stinger to move axially with respect to said swivel means thereby to land said well tool in said wellhead assembly.

The invention also provides a method of landing a tubing hanger in a subsea well casing, comprising the steps of lowering said tubing hanger into the well casing by means of a pipe string having attached thereto a landing tool in accordance with the preceding paragraph and including a shear pin which until sheared prevents relative rotation of said sub assembly and said pipe stinger assembly, interposing rams to intercept and support the swivel means of said landing tool prior to landing of said tubing hanger; rotating said tubing hanger by rotating said pipe string in one direction; locking said tubing hanger against rotation with respect to said well casing; shearing said shear pin to permit rotation of said pipe string in said opposite direction; rotating said pipe string in said opposite direction to advance the pipe stinger assembly connected to said tubing hanger below said swivel means and thereby advancing said tubing hanger downwardly without rotation until said tubing hanger is landed.

Use of a landing tool and landing technique of the invention enables a tubing hanger to be precisely positioned in a well casing or wellhead assembly and said landing tool to be readily retrieved therefrom.

Other features and advantages of the invention will become apparent from the following description of a preferred embodiment thereof, by way of example only, with reference to the accompanying drawings, in which:—

Figure 1 is a fragmentary elevational view of a tubing hanger suspended from a pipe string by a landing tool embodying the invention, prior to being landed in a well casing;

Figure 2 is a fragmentary elevational view, partly in section, showing a portion of the landing tool located above the portion of the pipe string shown in Fig. 1;

Figure 3 is a fragmentary enlarged sectional view of the upper portion of the tubing hanger within a well casing in landed

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position and preparatory to retrieving the landing tool;

Figure 4 is an enlarged fragmentary view illustrating another step in the retrieval of the landing tool; and

Figure 5 is an enlarged fragmentary view taken in the plane indicated by line V—V of Fig. 3.

Generally speaking, a landing tool 20 as shown in Figs. 1 and 2 provides a technique for landing a tubing hanger 22 in a well casing 23, Fig. 3, in connection with the completion of a well hole for production. Landing tool 20 may be readily retrieved after completion testing. After such retrieval, the tubing hanger may be connected to a safety tree assembly through an adaptor member as described and claimed in co-pending Patent Application No. 3489/78 (Serial No. 1,591,862) for indexing and aligning fluid conducting passageways on the safety tree assembly and on the tubing hanger in such a manner that tubular nipple members are precisely and accurately guided into proper relationship with the passageways in the upper end of the tubing hanger.

As shown in Figs. 1 and 2, landing tool 20 is adapted to carry a tubing hanger 22 which is provided with suitable fluid conducting passageways therethrough for annulus lines and for fluid control lines. Tubing hanger 22 may include a plurality of circumferentially arranged latches 27 for interlocking engagement with well casing 23 in well-known manner. Upper end of tubing hanger 22 includes a mandrel end 29 which is received within an internally threaded lower skirt 30 of the landing tool 20.

Landing tool 20 includes a landing tool stinger pipe portion 32 which extends upwardly, Fig. 2, for internal threaded engagement with the lower end of a sleeve member 33 initially secured against rotation by a shear pin 34 which interconnects a lower sub 35 which is threaded at 36 to a bearing swivel housing 37 which carries a swivel base 38. Between swivel base 38 and the swivel housing is provided a ball bearing antifriction means 39 to permit relative rotational movement between base 38 and bearing swivel 37. Cap screw 40 holds base 38 in assembly with swivel 37, the inner end of screw 40 being received in annular groove 41 on base 30.

Lower sub 35 is threadedly connected to upper sub 42 which may be connected to pipe string 43 which extends to a vessel having a derrick, not shown, at the water surface. Sleeve member 33 has threaded engagement at 44 with the upper end of lower sub 35 and includes an upwardly directed sleeve extension 45 providing a selected length of external threads 46 to permit axial movement of pipe stinger portion 32 under certain rotational conditions as later described. Below base 38 of the swivel means 37, the landing tool body 50 includes a relief portion 51 which provides a ledge 52 having a recess 53 within which is pivotally mounted a latch 54. Latch 54 is mounted about a vertical axis or an axis parallel to the axis of the landing tool as indicated at 55 and is normally biased outwardly by springs 56. The latch 54 may be retained in recess 53 by a retainer place 57 secured on opposite sides of recess 53 by screw bolts 58. Latch 54 is shaped to limit rotation of the landing tool body in a clockwise direction as shown in Fig. 5 and to allow its rotation in a counterclockwise direction.

In the method of landing a tubing hanger by a landing tool 20 as above described, tubing hanger 22 is threadedly connected to the lower skirt 30 of the landing tool by buttress threads 60 which resist rotation in the presence of tension forces acting on the threaded connection. The landing tool 20 is lowered by pipe string 43 until the swivel base 38 is seated as at 61 on a pair of rams 62 which may be provided on a blow out preventor located adjacent the well hole. Rams 62 embrace pipe string portion 32 with a relatively loose sliding fit. Rams 62 are brought into embracing position after body member 50 of the landing tool 20 has passed therebelow.

In such position of the landing tool and the tubing hanger 22 carried thereby, the tubing hanger is angularly oriented with respect to the landing tool 20 by lock piston means 70 as later described.

After base 38 has landed upon rams 62, the pipe string 43 may be rotated in one direction, for example the clockwise direction, thereby causing the landing tool body 50 to rotate to the right and causing the lock dog 54 to bear against the internal surface 65 of the casing wall 66 until dog 54 engages a vertically extending slot 67 in the casing, dog 54 having been urged thereinto by biasing spring 56. Clockwise rotation of the landing tool body is thereby stopped.

To advance the tubing hanger downwardly into its landed position, shear pin 34 is now sheared by further clockwise rotation of the pipe string, since rotation of the body of landing tool 20 is now prevented by lock dog 54. Once pin 34 has been sheared, the pipe string 43 is rotated in the opposite or anticlockwise direction or towards the left. Such rotation will cause the now non-rotatable landing tool body 50, pipe stinger portion 32 and the extension 45 to be advanced downwardly because of the threaded engagement at 44 with the now rotatable subs 42 and 35. Landing tool 20 advances downwardly until the tubing hanger is landed at 28 and the outwardly

biased latches 27 engage the well casing to lock said tubing hanger in its selected position.

During landing of the tubing hanger and in landed selected position of the tubing hanger, the landing tool 20 is locked to the tubing hanger against relative rotation by means of a ported lock piston 70 which has a lower end 71 extending into the upper enlarged passageway 72 of a passageway for fluid 73 provided in the tubing hanger for control or annulus purposes. Upper end of lock piston 70 extends into an enlarged bore 74 in tool 20, the bore being provided with a lock ring 75 to limit movement of the lock piston 70 in an upward direction under tool retrieval operations. Lock piston 70 includes an upper piston head 77 provided with suitable O rings 78 for sealing engagement with bore 74. A biasing spring 79 normally urges the lock piston 70 upwardly, such upward movement of the lock piston 70 being restrained by a shear pin 80 engaged in an annular groove in the piston head 77.

After conducting certain tests, landing tool 20 is retrieved by the following procedure. It will be noted landing tool 20 includes a slidable sleeve 83 provided in the central throughbore or passageway of the landing tool. Sleeve 83 is provided with a pair of O rings 84 and with an annular groove 85 which is engaged by a shear pin 86 extending through body 50 and having its exterior opening sealed with a plug 87. Shear pin 86 holds sleeve 83 in the position shown in Fig. 3 in which sleeve 83 blocks a port 88 extending between the central passageway in the landing tool and the piston bore 74.

In the landing tool retrieval operation, a dart 90 may be dropped down the pipe string 43 and into the throughbore of the landing tool for final seating in the sleeve 83. Dart 90 may be made of solid material and plugs the opening in sleeve 83 which normally permits passage of fluid through the pipe string. Pressure fluid may now be applied through the central passageway of the pipe string 43 and landing tool 20 to cause the shear pin 86 to shear and release sleeve 83 so that it may slide downwardly into seated position at 92 as shown in Fig. 4. In this seated position of sleeve 83 and dart 90, port 88 is exposed and open to pressure fluid which now enters the lock piston bore 74 below piston head 77. The pressure fluid acts upwardly against the piston head 77 and causes shearing of pin 80 which releases the lock piston which is now biased upwardly until it is seated against the lock ring or retainer 75. In this upper position the lower end 70a of the lock piston is withdrawn from the passageway 73 to thereby permit rotation of the pipe string to cause the threaded sleeve member 33 to be threadedly driven upwardly and thus applying a lifting force to the landing tool 20. Rotation of the landing tool is permitted by the cammed surface of the lock dog 54 and by the disengagement of the lock piston 70 with the tubing hanger. Landing tool 20 may be unthreaded from the mandrel threads 60. The upper end of the landed tubing hanger or the tubing hanger mandrel 29 is accessible and is available for further well operations.

Landing tool 20 provides a means for precise placement and installation of a tubing hanger or similar well tool equipment in a subsea wellhead or well casing in precise preselected angular or azimuth orientation of the tubing hanger in the casing.

WHAT WE CLAIM IS:—

1. A landing tool for landing a well tool in a subsea wellhead assembly, said tool comprising a tool body including means to support said well tool in predetermined angular orientation with respect thereto,

a pipe stinger assembly extending from said tool body and including a pipe stinger having mounted thereon by a screw thread a sub assembly provided with swivel means allowing the sub assembly to be rotated while supported against axial movement,

said tool body being provided with engagement means arranged in use to engage vertical slot means in said wellhead assembly and thereby to limit rotation of said tool body in one direction while permitting axial movement thereof relative to said wellhead assembly,

whereby when the weight of said tool is supported by said swivel means rotation of said sub assembly in the direction opposite to said one direction will cause said pipe stinger to move axially with respect to said swivel means thereby to land said well tool in said wellhead assembly.

2. A landing tool in accordance with claim 1 and including a shear pin which until sheared prevents relative rotation of said sub assembly and said pipe stinger assembly.

3. A landing tool in accordance with claim 1 or claim 2 wherein said tool body has in its lower portion a buttress thread into which said well tool is screwed, whereby rotation of said tool body relative to said well tool is impossible when said well tool is supported by said landing tool.

4. A landing tool substantially as hereinbefore described with reference to Figures 1 to 5 of the accompanying drawings.

5. A method of landing a tubing hanger in a subsea well casing, comprising the steps of lowering said tubing hanger into the well casing by means of a pipe string having

biased latches 27 engage the well casing to lock said tubing hanger in its selected position.

During landing of the tubing hanger and in landed selected position of the tubing hanger, the landing tool 20 is locked to the tubing hanger against relative rotation by means of a ported lock piston 70 which has a lower end 71 extending into the upper enlarged passageway 72 of a passageway for fluid 73 provided in the tubing hanger for control or annulus purposes. Upper end of lock piston 70 extends into an enlarged bore 74 in tool 20, the bore being provided with a lock ring 75 to limit movement of the lock piston 70 in an upward direction under tool retrieval operations. Lock piston 70 includes an upper piston head 77 provided with suitable O rings 78 for sealing engagement with bore 74. A biasing spring 79 normally urges the lock piston 70 upwardly, such upward movement of the lock piston 70 being restrained by a shear pin 80 engaged in an annular groove in the piston head 77.

After conducting certain tests, landing tool 20 is retrieved by the following procedure. It will be noted landing tool 20 includes a slidable sleeve 83 provided in the central throughbore or passageway of the landing tool. Sleeve 83 is provided with a pair of O rings 84 and with an annular groove 85 which is engaged by a shear pin 86 extending through body 50 and having its exterior opening sealed with a plug 87. Shear pin 86 holds sleeve 83 in the position shown in Fig. 3 in which sleeve 83 blocks a port 88 extending between the central passageway in the landing tool and the piston bore 74.

In the landing tool retrieval operation, a dart 90 may be dropped down the pipe string 43 and into the throughbore of the landing tool for final seating in the sleeve 83. Dart 90 may be made of solid material and plugs the opening in sleeve 83 which normally permits passage of fluid through the pipe string. Pressure fluid may now be applied through the central passageway of the pipe string 43 and landing tool 20 to cause the shear pin 86 to shear and release sleeve 83 so that it may slide downwardly into seated position at 92 as shown in Fig. 4. In this seated position of sleeve 83 and dart 90, port 88 is exposed and open to pressure fluid which now enters the lock piston bore 74 below piston head 77. The pressure fluid acts upwardly against the piston head 77 and causes shearing of pin 80 which releases the lock piston which is now biased upwardly until it is seated against the lock ring or retainer 75. In this upper position the lower end 70a of the lock piston is withdrawn from the passageway 73 to thereby permit rotation of the pipe string to cause the threaded sleeve member 33 to be threadedly driven upwardly and thus applying a lifting force to the landing tool 20. Rotation of the landing tool is permitted by the cammed surface of the lock dog 54 and by the disengagement of the lock piston 70 with the tubing hanger. Landing tool 20 may be unthreaded from the mandrel threads 60. The upper end of the landed tubing hanger or the tubing hanger mandrel 29 is accessible and is available for further well operations.

Landing tool 20 provides a means for precise placement and installation of a tubing hanger or similar well tool equipment in a subsea wellhead or well casing in precise preselected angular or azimuth orientation of the tubing hanger in the casing.

WHAT WE CLAIM IS:—

1. A landing tool for landing a well tool in a subsea wellhead assembly, said tool comprising a tool body including means to support said well tool in predetermined angular orientation with respect thereto,

a pipe stinger assembly extending from said tool body and including a pipe stinger having mounted thereon by a screw thread a sub assembly provided with swivel means allowing the sub assembly to be rotated while supported against axial movement,

said tool body being provided with engagement means arranged in use to engage vertical slot means in said wellhead assembly and thereby to limit rotation of said tool body in one direction while permitting axial movement thereof relative to said wellhead assembly,

whereby when the weight of said tool is supported by said swivel means rotation of said sub assembly in the direction opposite to said one direction will cause said pipe stinger to move axially with respect to said swivel means thereby to land said well tool in said wellhead assembly.

2. A landing tool in accordance with claim 1 and including a shear pin which until sheared prevents relative rotation of said sub assembly and said pipe stinger assembly.

3. A landing tool in accordance with claim 1 or claim 2 wherein said tool body has in its lower portion a buttress thread into which said well tool is screwed, whereby rotation of said tool body relative to said well tool is impossible when said well tool is supported by said landing tool.

4. A landing tool substantially as hereinbefore described with reference to Figures 1 to 5 of the accompanying drawings.

5. A method of landing a tubing hanger in a subsea well casing, comprising the steps of lowering said tubing hanger into the well casing by means of a pipe string having

attached thereto a landing tool in accordance with claim 2, interposing rams to intercept and support the swivel means of said landing tool prior to landing of said tubing hanger; rotating said tubing hanger by rotating said pipe string in one direction; locking said tubing hanger against rotation with respect to said well casing; shearing said shear pin to permit rotation of said pipe string in said opposite direction; rotating said pipe string in said opposite direction to advance the pipe stinger assembly connected to said tubing hanger below said swivel means and thereby advancing said tubing hanger downwardly without rotation until said tubing hanger is landed.

6. A method as claimed in claim 5 including restraining said tubing hanger against rotation relative to said pipe string portion whereby said tubing hanger is indexed in an angular position when said tubing hanger is locked against rotation at a selected angular position in the well casing.

7. A method as claimed in claim 5 or claim 6 and including the further steps of:

releasing the tubing hanger from its non-rotative relation with said pipe string portion and retrieving said landing tool.

8. A method of landing a tubing hanger in a subsea wellhead, said tubing hanger being non-rotatively connected to a landing tool, in accordance with claim 2, claim 3 as dependent on claim 2, or claim 4, and said landing tool being initially held in non rotative relation with respect to a pipe string; said method comprising the steps of:

lowering said tubing hanger into proximity with the wellhead; supporting said tubing hanger and landing tool above said wellhead;

rotating said landing tool and tubing hanger in said one direction until said landing tool is locked against rotation in said one direction;

releasing said landing tool and said pipe string from their nonrotative relation by shearing said shear pin;

rotating said pipe string to lower said landing tool and tubing hanger without rotation thereof;

and landing said tubing hanger in said well casing with said tubing hanger and said landing tool in relative nonrotative relation.

9. A method of landing a well tool in a subsea wellhead assembly substantially as hereinbefore described with reference to Figures 1 to 5 of the accompanying drawings.

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