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(54) IMPROVEMENTS IN OR RELATING TO A CONNECTOR DEVICE FOR SUBSEA WELL INSTALLATIONS

(71) We, SOCIÉTÉ NATIONALE ELF AQUITAINE (PRODUCTION), of Tour Aquitaine, 92400 Courbevoie, France, 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:—

This invention relates to a flowline connector device for subsea well operations.

In subsea well installations, a longitudinal extending flowline has an end which is brought into axial alignment with another flowline or fluid conducting pipe for inter-connection of such lines and for providing a fluid tight seal connection. In some installations, one or both of the fluid conducting lines are axially movable relative to the other to bring the ends of the lines into close proximity, coupling the ends together, and providing a fluid tight seal at the coupling. In some underwater conditions, it is often difficult to move a flowline laid on the sea floor in an axial direction to bring its connector end into proximity with the connector end of a line to which it is to be connected because of the weight of the flowline, possible embedment of the flowline in the sea floor, or frictional resistance of the flowline with the sea floor. In subsea stations, end to end positioning of fluid conducting lines with precise axial alignment is often difficult to achieve; out of axial alignment conditions may prevent proper coupling and fluid tight sealing at the coupling.

Prior proposed fluid conducting line connecting devices have been actuated by fluid pressure and the fluid pressure has been relied upon to maintain the sealed relation of the coupling or connection. In the event fluid pressure was not maintained or there was a partial failure of the desired pressure, the connecting device may leak at the sealing surfaces. Leakage of production or hydrocarbon fluids into the sea water is undesirable not only because of loss of production fluid, but also because of environmental pollution.

A flowline pipe end provided with a rotatable connector member has been moved laterally onto a support and then mechanical gear means associated therewith to move the rotatable connector axially into sealed relationship with a surface on a wellhead. See U.S. Patents 3,502,354 and 3,593,408.

In accordance with the present invention there is provided a flowline connector device comprising a first connector means arranged to be secured to an end of the flowline, a second connector means arranged to be secured to a subsea installation, each said connector means having a sealing surface, the first and second connector means being inter-engageable by moving one said connector means relatively to the other in a plane perpendicular to the axis of said other connector means to bring said sealing surfaces into juxtaposition, and one of said connector means including fluid actuable means for moving said sealing surfaces into mutual sealing engagement.

Preferably said second connector means includes an elongate connector body member having an axially extending chamber, said fluid actuable means comprising a mandrel movable within said chamber by fluid pressure and having a said sealing surface at one end thereof, fluid operable locking means arranged to lock the mandrel in a predetermined axial position relative to the body member; and means on said connector body arranged to receive said second connector member by movement in said plane perpendicular to the axis of the body member and to axially align the sealing surface of said second connector member with that on the mandrel.

A presently preferred embodiment of the invention is described in detail below, by way of example, with reference to the accompanying drawings, in which:

FIGURE 1 is a fragmentary perspective view of a flowline connector device embodying this invention and showing a connector means secured to a subsea station and a fragmentary end of a connector

means provided on the end of a flowline, the latter connector means being separated from the subsea station connector means;

FIGURE 2 is an enlarged fragmentary sectional view taken in a longitudinal plane bisecting the connector device of Fig. 1, the view showing the connector device with the connector means of the flowline and the connector means on the subsea station in locked and sealed relation;

FIGURE 3 is a fragmentary, generally quarter sectional view of the locking device shown in Fig. 2 showing actuation of the fluid locking device toward an unlocked position;

FIGURE 4 is a fragmentary sectional view similar to Fig. 3 showing the fluid locking device in unlocked position;

FIGURE 5 is a fragmentary, generally quarter sectional view of the locking device shown in Fig. 2, the locking device being shown in both hydraulically unlocked position and mechanically unlocked position; and

FIGURE 6 is a transverse sectional view taken in the plane indicated by line VI-VI of Fig. 2 showing the mechanical lock in locked position, the pressure fluid conducting tube of Fig. 2 being omitted for purposes of clarity.

In the drawings there is shown a flowline connector device, generally indicated at 10, which includes a flowline connector means 11 and a second connector means 12 adapted to be secured to a subsea installation in suitable manner. Flowline connector means 11 is fragmentarily shown, it being understood that the connector means 11 is attached to the end of a flowline which may be laid along a sea floor and extend from a subsea well installation to a subsea station carrying connector means 12. In this example, a subsea station is generally indicated at 14, only a portion of which is shown; namely, a pair of upstanding guide posts 15 which may be secured to a subsea station frame structure such as is described in copending application No. 47752/77 (Serial No. 1,576,897). Connector means 12 is located at one end of said subsea station and provides a connection between fluid conducting lines provided on said station and the flowline provided with connector means 11.

Connector means 12 may be fixedly secured and supported in generally horizontal position by laterally extending arms 16 which carry at their ends cylindrical connector sleeves 17 which receive guide posts 15 for rigidly supporting and positioning the connector means 12 on the subsea station 14.

Flowline connector means 11 includes a cylindrical member 20 having a reduced neck portion 21 extending to a head por-

tion 22 and so forming an annular engagement groove 23. The passage within head portion 22 terminates in an axially directed outwardly flared sealing surface 24.

Connector means 12 includes a connector body member 30 of cylindrical form having means at one end thereof for lateral reception of head 22 of connector means 11. Such reception means includes a yoke portion 31 formed at one end of body member 30 and providing a radially extending slot 32 which leads to a part-cylindrical recess 33. Flowline connector means 11 may be moved laterally with respect to its axis and the axis of body member 20 so that the annular groove 23 and reduced neck portion 21 are received within slot 32 and head 22 is received within the part-cylindrical recess 33. As noted in Figs. 2, 3, 4 and 5, the head 22 and groove 23 fit snugly within the yoke 31, so that relative axial movement of the connector means 11 and 12 is restrained. Connector means 11 may be supported vertically in yoke 31 by suitable means not shown, such means including a supporting member provided on subsea station 14.

Connector means 12 includes body member 30 of cylindrical form with the end somewhat overhanging to form yoke 31 and is provided with an elongate chamber, generally indicated at 35, within which is received an axially movable mandrel 36 and a fluid actuated locking means 37. Mandrel 36 is provided with a throughbore 39 of the same flow area as the throughbore 40 of the connector means 11. Mandrel 36 is arranged to be slidable in but sealed with respect to a portion 42 of chamber 36 at the end adjacent recess 33, said mandrel also being slidable within but sealed at 43 to a body end cap 44. Mandrel 36 extends beyond cap 44 and may be provided with an annular groove 45 defining a locking head 46 suitable for connection to a fluid conducting pipe on the subsea installation.

Between cap 44 and cylindrical chamber portion 42, chamber means 35 receives locking means 37 which includes a locking sleeve member 48, a lock piston member 49 and lock dogs 50 carried by said lock sleeve member 48. Lock sleeve member 48 carries at one end an annular spring retainer 52 secured within the end of member 48 by a suitable lock washer 53. Retainer 52 provides a seat at 54 for one end of a coil spring 55 sleeved over mandrel 36 and having its opposite end seated at 56 against a recessed shoulder 57 provided in lock piston member 49 (Fig. 2).

Movement of mandrel 36 from its unsealed and unlocked position as shown in Fig. 5 to its sealed and locked position shown in Fig. 2 is effected by the introduction of hydraulic pressure fluid from a

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pressure fluid source, not shown, through a fluid conducting line 60 and passageway 61 provided in the cap 44 into the chamber means 35. Fluid pressure fluid at the opposite end of chamber 35 is relieved through passageway 62 and a fluid conducting line 63. Pressure fluid introduced through passageway 61 moves the lock sleeve member 48 toward the opposite end of body member 30 until sloping shoulder 65 of sleeve member 48 abuts a corresponding shoulder 66 provided on the internal surface of body member 30. Also, relief of pressure fluid through passageway 62 facilitates the movement of the lock piston 49 toward the said opposite end of chamber 35 in the body member by the differential hydraulic pressure acting on the ends of piston 49 and by the mechanical action of the compressed coil spring 55. The lock piston member 49 moves axially until its inclined shoulder 67 abuts a correspondingly inclined shoulder 68 provided on the internal surface of lock sleeve member 48. Fig. 2 shows the position of the lock sleeve member 48 and the lock piston 49 in their axially displaced locking position.

In this locking position, it will be noted that the reduced-diameter end portion 70 of the piston member 49 against which locking dogs 50 seat in unlocked position has now, together with the forward end of the lock sleeve member, moved the locking dogs axially until they are opposite the lock dogs recess 71 provided in body member 30. During such movement, lock dogs 50 are also urged radially outwardly by a cam surface 72 provided on the lock sleeve member adjacent to the reduced-diameter end portion 70. It will be noted that lock dogs 60 are carried in lock dog ports 73 provided in the lock sleeve member 48 and are radially movable in these ports. In such locked position of the locking device 37, it may also be noted that the reduced-diameter end portion 70 of the locked piston has moved into the end portion 74 of the lock sleeve member so that both the lock sleeve member 48 and the piston member 49 are positively positioned and hold the lock dogs 50 in locking interengagement with the lock dog recesses 71 in the body member 30.

The lock piston member is provided with suitable sealing means 77 and 78 for sliding sealing engagement with the internal surface of the lock sleeve member 48 and with the external surface of mandrel 36.

Movement of mandrel 36 during such locking operation is provided by a split retainer ring 80 seated in an annular groove 81 in mandrel 36 and secured by a suitable ring 82 secured to the split retainer portions by suitable screw bolts 83. In the

locked position, Belleville type spring 84 is held in compression between retainer ring 80 and the end face of the locking sleeve member 48. Thus, when locking dogs are locked in recesses 71 as shown in Fig. 2, Belleville spring 84 urges said mandrel 36 towards flowline connector means 11 which is held against axial movement by the yoke 31. End 86 of mandrel 36 is provided with an outwardly flared sealing surface 87 for sealing relation with a gasket 88 of suitable compressible gasket material retained in the end 86 by a retainer ring 89 carried in an annular groove in the upwardly flaring sealing surface 87. Thus, when mandrel 36 is moved axially into sealing relationship with the sealing surfaces 24 of the flowline connector means 11, gasket 88 will be compressed between said sealing surfaces 87 and 24 to provide a fluid tight seal. As seen in Fig. 2, after fluid pressure has actuated the connector means to the locked position, Belleville spring 84 will exert a spring biasing force on the mandrel to maintain such sealing engagement independently of the pressure fluid. In other words, once the connector is set into its locked position by use of fluid pressure, further fluid pressure is not required to hold such locked position, and the lock dogs are held in the lock dog recesses by the pressure provided by spring 55.

Means are also provided for mechanically locking mandrel 36 in fluid tight sealed relation with the fluid connector means 11, in addition to the hydraulic pressure fluid acting on lock sleeve member 48 and piston 49. It will be understood that unless such means are provided, in the event there should be a failure of pressure fluid in line 60, the sealed relationship of the mandrel end 86 might be relaxed and permit leakage at such sealing surfaces. When the locking device is in the locked position and the sealing surfaces in fluid tight sealing relation, mechanical lock means generally indicated at 90 are placed into a mandrel locked position by a diver, if the depth of water permits, or by a submarine vessel or robot. Mechanical lock means 90 comprises an annular groove 91 in mandrel 36 at a position initially adjacent but outside end cover 44. End cover 44 carries a lock ring 92, which is split, Fig. 6, and extends through less than 360°. Lock ring setting bolts 93 are carried by end cover 44 in diametrically opposite relation and are threaded therein. The inner ends of bolts 93 seat on arcuate portions of lock ring 92 as at 94. As bolts 93 are tightened and threaded radially inwardly, the ends cause deflection of the lock ring 92 into the recess 91 on the mandrel and provide a mechanical interlock with the mandrel which restrains axial movement

thereof relative to the body member 30. Thus, the mechanical lock means 90 will maintain the sealed fluid tight relationship of the sealing surfaces 87 and 24 with respect to the gasket 88.

Unlocking of the locking device 37 to permit separation of the sealed surfaces of the mandrel 36 and the flowline connector 11 is best shown in Figs. 3 and 4. In each figure, the manual lock means 90 is shown in unlocked position, lock bolts 93 having been loosened to permit the split lock ring 92 to expand and to move out of annular groove 91. Locking device 37 is actuated to unlocked position by relief of pressure fluid from pressure line 60 and by introduction of pressure fluid through fluid line 63 into the forward end of the chamber means 35. Pressure fluid in chamber means 35 at the end containing the Belleville spring 84 first acts upon the lock piston 49 to move the piston rearwardly and to compress spring 55. Such movement of lock piston 49 separates cam surface 72 from its actuated position in which it supports lock dog 50 and moves the reduced-diameter end portion 70 of the piston beneath dog 50. Fluid pressure acting against the radially outwardly directed surfaces of the lock dog cause the lock dog to move radially inwardly for seating on the reduced end 70. As fluid pressure continues to act on both lock piston 49 and lock sleeve member 48, both are urged rearwardly until they seat against end cover 44. In this position, lock dogs 50 are fully retracted and are held between end portion 70 and the opposed internal surface of body member 30. In the unlocked position shown in Fig. 4, it should be noted that the Belleville spring 84 has expanded and one end thereof is seated and retained against shoulder 96 provided on mandrel 36. Mandrel 36 is then axially moved or retracted by pressure fluid acting against retainers 80, 82 until it reaches the position shown in Fig. 5 wherein the sealing gasket 88 is withdrawn from the head 22 of the flowline connector means 11. Flowline connector means 11 may then be dropped downwardly for disengagement with the yoke 31.

The advantages of the above described flowline connector device are readily understood. First, the connection allows a flowline connection to be made by lateral relative movement of mating connector means with minimal axial movement; namely, the distance mandrel 36 travels between locked sealed position and unlocked unsealed position. In subsea well operations, such lateral connections are advantageous because relative movement of a flowline in a longitudinal direction with respect to a mating connector is often difficult, requires special equipment, and in some circumstan-

ces such a flowline may be immovable longitudinally.

Second, the flowline connection is made under hydraulic pressure and while the connector means are in locked relation, a mechanical lock means is actuated so that in the event there should be a drop in the pressure fluid which acts to maintain the sealed relationship, the mechanical lock will maintain such sealed relationship. Thus, in subsea operations, a reliable fluid tight sealed condition of the mating connector parts is maintained until the manual lock is released.

Third, the snug interengagement of the level surfaces on yoke 31 with the neck portion 21 of the flowline connector, together with juxtaposed outwardly flaring seal surfaces 24 and 87 with the generally triangular section gasket 88 therebetween assures a fluid tight sealing relationship when the connector device is in pressure locked condition.

From the foregoing, it will be seen that there is described above a flowline connector device for subsea well operations in which a connector means on the end of the flowline is moved laterally into position for connection to a fixed connector means on a subsea station. The connector means on the subsea station includes an axially movable mandrel located within a chamber in a body member, the mandrel having sealing surfaces at one end thereof juxtaposed to sealing surfaces on the flowline connector member when laterally positioned. A fluid pressure actuated locking means moves said sealing surfaces on the mandrel into sealed relationship with the sealing surfaces on the flowline connector member and locks the sealing surfaces in fluid tight sealed relation. A mechanical backup lock means for the mandrel is carried by the connector means on the subsea station for positively and unyieldingly mechanically locking the mandrel in fluid tight sealed relation. In the event of a drop in fluid pressure, leakage at the sealing surfaces is prevented by the mechanical locking device.

WHAT WE CLAIM IS:—

1. A flowline connector device comprising a first connector means arranged to be secured to an end of the flowline, a second connector means arranged to be secured to a subsea installation, each said connector means having a sealing surface, the first and second connector means being inter-engageable by moving one said connector means relatively to the other in a plane perpendicular to the axis of said other connector means to bring said sealing surfaces into juxtaposition, and one of said connector means including fluid actu-

thereof relative to the body member 30. Thus, the mechanical lock means 90 will maintain the sealed fluid tight relationship of the sealing surfaces 87 and 24 with respect to the gasket 88.

Unlocking of the locking device 37 to permit separation of the sealed surfaces of the mandrel 36 and the flowline connector 11 is best shown in Figs. 3 and 4. In each figure, the manual lock means 90 is shown in unlocked position, lock bolts 93 having been loosened to permit the split lock ring 92 to expand and to move out of annular groove 91. Locking device 37 is actuated to unlocked position by relief of pressure fluid from pressure line 60 and by introduction of pressure fluid through fluid line 63 into the forward end of the chamber means 35. Pressure fluid in chamber means 35 at the end containing the Belleville spring 84 first acts upon the lock piston 49 to move the piston rearwardly and to compress spring 55. Such movement of lock piston 49 separates cam surface 72 from its actuated position in which it supports lock dog 50 and moves the reduced-diameter end portion 70 of the piston beneath dog 50. Fluid pressure acting against the radially outwardly directed surfaces of the lock dog cause the lock dog to move radially inwardly for seating on the reduced end 70. As fluid pressure continues to act on both lock piston 49 and lock sleeve member 48, both are urged rearwardly until they seat against end cover 44. In this position, lock dogs 50 are fully retracted and are held between end portion 70 and the opposed internal surface of body member 30. In the unlocked position shown in Fig. 4, it should be noted that the Belleville spring 84 has expanded and one end thereof is seated and retained against shoulder 96 provided on mandrel 36. Mandrel 36 is then axially moved or retracted by pressure fluid acting against retainers 80, 82 until it reaches the position shown in Fig. 5 wherein the sealing gasket 88 is withdrawn from the head 22 of the flowline connector means 11. Flowline connector means 11 may then be dropped downwardly for disengagement with the yoke 31.

The advantages of the above described flowline connector device are readily understood. First, the connection allows a flowline connection to be made by lateral relative movement of mating connector means with minimal axial movement; namely, the distance mandrel 36 travels between locked sealed position and unlocked unsealed position. In subsea well operations, such lateral connections are advantageous because relative movement of a flowline in a longitudinal direction with respect to a mating connector is often difficult, requires special equipment, and in some circumstan-

ces such a flowline may be immovable longitudinally.

Second, the flowline connection is made under hydraulic pressure and while the connector means are in locked relation, a mechanical lock means is actuated so that in the event there should be a drop in the pressure fluid which acts to maintain the sealed relationship, the mechanical lock will maintain such sealed relationship. Thus, in subsea operations, a reliable fluid tight sealed condition of the mating connector parts is maintained until the manual lock is released.

Third, the snug interengagement of the level surfaces on yoke 31 with the neck portion 21 of the flowline connector, together with juxtaposed outwardly flaring seal surfaces 24 and 87 with the generally triangular section gasket 88 therebetween assures a fluid tight sealing relationship when the connector device is in pressure locked condition.

From the foregoing, it will be seen that there is described above a flowline connector device for subsea well operations in which a connector means on the end of the flowline is moved laterally into position for connection to a fixed connector means on a subsea station. The connector means on the subsea station includes an axially movable mandrel located within a chamber in a body member, the mandrel having sealing surfaces at one end thereof juxtaposed to sealing surfaces on the flowline connector member when laterally positioned. A fluid pressure actuated locking means moves said sealing surfaces on the mandrel into sealed relationship with the sealing surfaces on the flowline connector member and locks the sealing surfaces in fluid tight sealed relation. A mechanical backup lock means for the mandrel is carried by the connector means on the subsea station for positively and unyieldingly mechanically locking the mandrel in fluid tight sealed relation. In the event of a drop in fluid pressure, leakage at the sealing surfaces is prevented by the mechanical locking device.

WHAT WE CLAIM IS:—

1. A flowline connector device comprising a first connector means arranged to be secured to an end of the flowline, a second connector means arranged to be secured to a subsea installation, each said connector means having a sealing surface, the first and second connector means being inter-engageable by moving one said connector means relatively to the other in a plane perpendicular to the axis of said other connector means to bring said sealing surfaces into juxtaposition, and one of said connector means including fluid actu-



able means for moving said sealing surfaces into mutual sealing engagement.

2. A flowline connector in accordance with claim 1, wherein said second connector means includes an elongate connector body member having an axially extending chamber, said fluid actuable means comprising a mandrel movable within said chamber by fluid pressure and having a said sealing surface at one end thereof, fluid operable locking means arranged to lock the mandrel in a predetermined axial position relative to the body member; and means on said connector body arranged to receive said second connector member by movement in said plane perpendicular to the axis of the body member and to axially align the sealing surface of said second connector member with that on the mandrel.

3. A connector device as claimed in claim 1 or 2 wherein the piston means includes locking means for locking said first and second connector means against relative movement with said sealing surfaces sealingly engaged.

4. A connector device as claimed in claim 1, 2 or 3 wherein one of said connector means includes locking means for mechanically locking said first and second connector means against relative movement with the sealing surfaces sealingly engaged.

5. A connector device as claimed in claim 4 wherein said mechanical locking means includes a contractable lock ring on one of said connector means, and means for securing said lock ring in contracted position.

6. A connector device as claimed in any one of claims 1 to 5 wherein one connector means includes a body member and a mandrel carried by said body member for movement relative thereto to move one sealing surface into sealing relation with the other sealing surface.

7. A connector device as claimed in claim 6 wherein said mandrel has an annular groove and the body member includes engagement in said groove to hold said mandrel against axial movement.

8. A connector device as claimed in any one of claims 1 to 5 wherein the connector means with the piston and cylinder means comprises a body member, sleeve member in said body member, a piston member within said sleeve member, a dog element carried by said sleeve member and movable radially outwardly with respect thereto by said piston member to engage in a recess in the body member for holding the sleeve member against movement relative to the body member, a mandrel within the piston member and movable axially relative to said body member, and spring means acting between said mandrel and said sleeve member for maintaining sealed relationship of said sealing surfaces.

9. A flowline connector device substantially as herein described with reference to the accompanying drawings.

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