

PATENT SPECIFICATION (11)

1595993

- 1595993 (21) Application No. 1472/78 (22) Filed 13 Jan. 1978 (19)
(31) Convention Application No. 759030 (32) Filed 13 Jan. 1977 in
(33) United States of America (US)
(44) Complete Specification published 19 Aug. 1981
(51) INT. CL.³ F16L 25/00 E21B 43/013
(52) Index at acceptance
E1H F
E1F JG
E2A 106 414 CAK
F2G 8



(54) METHOD AND APPARATUS FOR CONNECTING A FLOWLINE TO A SUBSEA STATION

(71) We, SOCIETE NATIONALE ELF AQUITAINE (PRODUCTION), 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:—

The present invention relates to a means and method for connecting a flowline to a subsea station by an apparatus remotely controlled and in which the assistance of divers is not required.

Deep sea well operations often require the establishment of a subsea station on the sea floor which may serve as a collecting or assembly point for a plurality of subsea flowlines which connect the subsea installation to remote subsea well heads and also to other locations for distribution of the production fluid. In many prior proposed installations, the connection of flowlines to the subsea station was at water depths which permitted the use of divers. Such prior proposed systems were thereby limited to water depths at which divers could operate.

In still other prior proposed systems, a submarine or diving bell equipped with robot mechanical devices was used for making connections between various well equipment and between a flowline and a subsea installation. Such use of submarines and subsea robots to provide connections at great water depths was time consuming and often difficult to accomplish.

It is an object of the present invention to provide a method and apparatus for making a connection between one end of a flowline and receptacle means on a subsea station, the connection being made under remote control and at any water depth.

According to one aspect of the invention, there is provided apparatus arranged to connect a flowline to a subsea station; the apparatus comprising: a connector receptacle

attachable to the station and intended in use to have its longitudinal axis directed towards the direction of approach of the flowline;

an elongate connector mandrel having one end adapted in use to be attached in flow communication to one end of the flowline and having its other end provided with a coupling head adapted to cooperate with a flowline connector;

a removable assembly positionable on the subsea station and including

an elongate hollow guide having a longitudinal axis which when said assembly is positioned on said subsea station in use is parallel to and spaced from the longitudinal axis of the receptacle,

and a pulling line which in use extends through said hollow guide and is arranged in use to be connected to the flowline adjacent said one end of the mandrel thereby to pull the mandrel towards and into said receptacle, said mandrel extending through said receptacle with said coupling head projecting beyond the end of the receptacle thereby to provide a coupling connection to said mandrel;

and locking means on said receptacle cooperable with said mandrel to lock the mandrel in position in the receptacle,

said mandrel being provided with guide portions cooperating in use with said receptacle to align said mandrel for sliding entry into said receptacle in the direction of the longitudinal axis of the receptacle.

According to another aspect of the invention there is provided a method of connecting a flowline to a subsea station; in which a connector receptacle is attached to the station so as to have its longitudinal axis directed towards the direction of approach of the flowline, one end of an elongate connector mandrel is attached in flow communication to one end of the flowline, the other end of said mandrel being provided with a coupling head adapted to cooperate with a flowline

connector and said mandrel being provided with guide portions cooperating with said receptacle to align said mandrel for sliding entry into said receptacle in the direction of the longitudinal axis of the receptacle, a removable assembly is positioned on the subsea station, said assembly including an elongate hollow guide having a longitudinal axis which is positioned on said subsea station so that the guide axis is parallel to and spaced from the longitudinal axis of the receptacle, a pulling line is passed through said hollow guide and connected to the flowline adjacent said one end of the mandrel, said mandrel and said flowline end are lowered to the sea floor, said mandrel is pulled into said receptacle by pulling said pulling line through said guide so that the mandrel extends through the receptacle with said coupling head projecting beyond the end of the receptacle thereby enabling flow connection to said flowline to be established, and said mandrel is locked in position in the receptacle.

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

FIGURE 1 is a schematic view of a subsea station, a vessel above said station, and a pipe laying vessel carrying a flowline to be connected to the subsea station, and embodying the apparatus and method of this invention;

FIGURE 2 is an enlarged, fragmentary perspective view of a portion of the subsea station having the flowline connector means of this invention;

FIGURE 3 is a perspective view of a removable pulling means being lowered on guide lines to the receptacle means on the subsea station;

FIGURE 4 is a perspective view showing the connection of the pulling means to the subsea station at the receptacle means;

FIGURE 5 is a perspective view similar to Fig. 4 showing the receptacle means, and pulling means at the subsea station and with the lowering pipe string disconnected therefrom;

FIGURE 6 is a schematic view of the mandrel being lowered from the pipe laying vessel with the pulling line attached to the mandrel, fed through the pulling means, and attached to winch drums on the vessel above the subsea station; the view also showing in phantom lines the flowline on the sea floor and being pulled toward the subsea station;

FIGURE 7 is a fragmentary, perspective view illustrating in more detail the approach of the mandrel to the receptacle means on the subsea station;

FIGURE 8 is a perspective view showing

the mandrel and receptacle means in interlocked, latched relation; and

FIGURE 9 is a longitudinal sectional view taken in the plane indicated by line IX—IX of Fig. 8 showing the assembled and latched mandrel and receptacle means.

In the schematic view shown in Fig. 1 illustrating the apparatus and method of this invention, a subsea station 20 is located on the sea floor and may include subsea modules or assemblies for wellhead, production and control operations for a plurality of subsea wells. The wellhead production and control modules are not shown, the subsea station may be of the type shown and described in copending application 3496/78 (Serial No. 1577272). Such a subsea station may serve as a collection point for a plurality of remote subsea wells for transferring production fluid from flowlines on the sea floor to a support vessel thereabove for processing or other disposition. Subsea station 20 is therefore provided with a flowline connector receptacle means 21 for connection to a flowline 22.

Above subsea station 20, a pipe connecting boat or vessel 24 may be equipped with a derrick 25 for raising and lowering a drill pipe string 26 used in the method of making a flowline connection of this invention. Vessel 24 also is equipped with power winches 27 and 28, winch 27 having a pulling cable or line 30 adapted to be connected to flowline 22, which may be carried on a pipe spool or reel 31 provided on pipe laying vessel 32. Flowline 22 carries at its leading end a mandrel 33. Flowline 22 is fed through a flowline pipe straightening means 34 and through brake friction means 35 when flowline 22 is pulled off reel 31.

Also, as shown in Fig. 1, drill pipe string 26 supports and lowers a pulling means or assembly 37 to the subsea station 20 for connection thereto for pulling mandrel 33 into engagement with the receptacle means on the subsea station as described later in detail.

Subsea station 20 is provided, at a suitable location on its frame structure, with spaced, upstanding guide posts 40 rigidly and fixedly supported on brackets 41 to a frame member 42 of the subsea station. Each guide post 40 has an upper end connector means 43 to which a guide line 44 may be attached by suitable remote controlled means such as the Matra (Trade Mark) guide line attachment means or other suitable well-known guide line attachment means. The method of attaching a guide line to the guide post is not part of this invention.

Receptacle means 21, Fig. 2, may comprise an elongated hollow cylindrical body 46 having an outwardly flared mouth 47 to facilitate guiding of mandrel 33 into member 46. Cylindrical member 46 may be seated on

spaced saddles 48, the saddles 48 being welded to the cylindrical member 46 and to frame member 42. Cylindrical member 46 is secured so that its axis, when projected, passes between guide posts 40 and lies in the direction of approach of the mandrel 33.

Transversely disposed with respect to the axis of body member 46 is a movable, in this example pivoted, latch member 49 positionable in a transverse slot 49a formed in the upper part-cylindrical portion of body member 46 above inboard saddle 48. Latch member 49 may be gravity actuated and in down latched (Fig. 9) position, has a lower portion projecting into the hollow member 46 and into and across the path of mandrel 33 to limit and restrict relative axial movement of the mandrel as later described. Latch member 49 may be gravity actuated as in this example or biased downwardly in slot 49a by suitable spring means associated with pivotal mounting for the latch means. Latch member 49 also includes a bail-type latch handle 49b extending across its top to allow grasping thereof by a remotely controlled manipulator for lifting the latch member out of engagement with the mandrel 33 should it be necessary to replace the line.

Mandrel 33 is best seen in Figs. 7, 8 and 9 and may comprise an elongated, tubular member 50 provided at one end with an enlarged head 51 cooperable with a laterally engageable flowline connector means as described and shown in the aforesaid copending application No. 3496/78 (Serial No. 1577272). The opposite end of tubular member 50 is connected to flowline 22 by a suitable coupling 52. Extending along tubular member 50 of mandrel 33 are a plurality of longitudinally extending radially disposed guide ribs or flutes 53, the edges 54 of which lie on a cylindrical surface having a diameter slightly less than the inner diameter of the cylindrical body member 46 of the receptacle means to provide sliding coaxial relationship of the mandrel within the receptacle during assembly. Radial ribs 53 are provided with tapered end edges 56, the end edges 56 spaced inwardly from head 51 serving as a cam means as later described. Spaced at a selected distance from head 51, the guide ribs 53 are interrupted to provide an annular locking recess 57 for latch member 49 carried on body member 46.

Adjacent the other end of radial ribs 53, mandrel 33 is provided with a stop collar 59 having an outer diameter greater than the inner diameter of cylindrical member 46 and serving to abut as at 60 internal surfaces of mouth 47 so as to positively limit longitudinal movement of mandrel 33 within body member 46 to position locking recess 57 opposite latch member 49.

Behind coupling 52, flowline 22 may be provided with a clamp means 63 having a

forwardly extending eye 64 for connection to one end of pulling line 30. Clamp means 63 is loosely mounted on flowline 22 with respect to rotation thereabout and is connected to a preselected buoy and chain to hold clamp means 63 upright and the flowline at a selected height above the sea floor which corresponds to the axis of the body member 46.

Means for pulling mandrel 33 into receptacle means 21 comprises a pulling assembly or means 37 best viewed in Fig. 3. Pulling means 37 may comprise a guide frame generally indicated at 70. Frame 70 may include an upstanding cylindrical pipe member 71 located between laterally spaced guide tubes 72 and connected thereto by vertical plates 73 and forwardly extending triangularly shaped horizontal gusset plates 74 and a vertical gusset plate 75. A forwardly extending guide tube 76 with a guide funnel 77 for pulling line 30 is secured as by welding to longitudinal, parallel edges of triangular plates 74 and 75. Rearwardly of pipe member 71, a 90° segment housing 78 is secured to the lower portion of member 71 and supports a sheave or pulley 79 having its groove in alignment with the axis of tube 76. Housing 78 protects the sheave and also prevents pulling cable 30 from disengagement with sheave 79.

Each guide tube 72 is provided with remotely actuated lock dog means 81 for locking engagement with guide posts 40 to detachably secure guide frame 70 to the guide posts 40 and to the frame of the subsea station.

Pipe member 71 includes a mandrel end 83 for connection to a pipe connector means 84 having laterally extending arms 85 for slidable connection with guide lines 44. Connector means 84 is provided with releasable latch dogs 86 for releasable connection with the pipe member 71. Connector means 84 also provides a connection to a drill string, such as drill string 26, for lowering the pulling means 37 to the subsea installation for cooperable reception of the guide posts 40.

If desired, the drill string may be raised during operation of the pulling assembly as now described.

Referring to Fig. 1, vessel 24 is positioned over subsea station 20 and provides derrick 25 for lowering drill string 26 to which is attached pulling means 37. Before pulling means 37 is lowered into the sea and while it is available on the deck of vessel 24, pulling cable 30 is fed from winch means 27, reaved through pulley 79 and passed through tube 76, and then transferred by suitable means to the pipe laying vessel 32 for connection to mandrel 33. The connection to mandrel 33 may be at the eyelet 64, as previously described.

After the pulling line 30 has been connected to the mandrel 33, the pulling means 37 may be lowered to the subsea station 20 by drill string 26 and during such lowering of pulling means 37, the pulling line 30 is further paid out from the winch means 27 so that the mandrel 33 is not pulled from the pipe laying vessel 32.

Pulling means 37 is guided by guide lines 44 into locked assembly with guide posts 40. In such releasably locked position, tube 76 of the pulling means 37 extends over body member 46 with its axis parallel thereto and with guide funnel 77 positioned above the guide mouth 47.

As shown in Fig. 6, after drill string 26 has been retrieved, the pipe laying vessel 32 moves or lays away from vessel 24. Winch means 27 is locked against rotation and as the vessel 32 moves away on the predetermined course for laying flowline 22, flowline 22, which is spooled upon reel 31, is pulled from reel 31, passed through pipe straighteners 34 for unbending and straightening the flowline 22.

After a preselected length of flowline has been unspooled and a desired length rests upon the sea floor, winch means 27 is unlocked and actuated to take up pulling line 30 and thus move the flowline toward the subsea station 20 and toward the receptacle means 21. As the mandrel 33 approaches the receptacle means 21, the mandrel is drawn into alignment with the body member 46 and the leading end of mandrel 33 is drawn into the guide funnel and into the hollow body member 46. As the leading end of mandrel 33 passes through the hollow body member 46, the tapered rib edges 56 engage latch member 49 and cam the latch member upwardly in slot 49a. For a short distance, the latch member 49 is held in up position by the parallel edges of the guide ribs 53 until locking recess 57 passes beneath the latch member 49 and the latch member falls by gravity into the recess.

Stop collar 59 carried by mandrel 33, at this relative position of the mandrel 33 and body member 46, is brought into abutting engagement with interior surfaces of mouth 47 and prevents longitudinal overtravel of mandrel 33 in the receptacle body member 46 so that latch member 49 is positioned opposite locking recess 57 for interlocking engagement therewith.

The flowline 22, with its mandrel 33, is thus received and retained in receptacle body member 46 against relative longitudinal movement with respect thereto. Head 51 of mandrel 33 projects beyond the inboard end of receptacle body member 46, Fig. 9, and presents a reduced neck portion 51a which is adapted to be laterally engaged by the laterally engageable connector means shown and described in aforesaid copending appli-

tion No. 3496/78 (Serial No 1577272).

After the mandrel 33 is locked within the receptacle means 21, drill string 26 may be reconnected to the pulling means 37. Drill string 26 and its connection to mandrel 33 of pipe member 71 provides pressure actuating fluid for actuating a cable cutting means, not shown, on the pulling means 37 for cutting the cable forwardly of sheave 79. After the pulling line 30 has been so cut, the pressure actuating fluid may also be used for actuating the release mechanisms of the pulling means 37 so that the locks securing the pulling means 37 to the guide posts 40 may be actuated to release position for freeing pulling means 37 from guide posts 44. The drill string 26 may now be retrieved, together with the pulling means 37.

The hydraulic lines for actuating the cable cutting means and the release mechanisms are not shown in this example because the attachment and use of such hydraulic fluid pressure lines is well-known.

From the foregoing it will be seen that there is provided an apparatus and method of connecting a flowline to a subsea station in which such a connection may be remotely controlled and the method employed is independent of water depth. The described flowline connector apparatus includes a receptacle connector supported by a subsea station and has its axis directed toward the approach of the flowline, an elongated connector mandrel on a proximate end of the flowline, pulling means releasably connectible to the subsea station adjacent the connector receptacle, and lock means on the receptacle for interlocking engagement with the mandrel to retain the mandrel in selected longitudinal position relative to the receptacle and with a connector end of the mandrel exposed inboardly thereof.

WHAT WE CLAIM IS:—

1. Apparatus arranged to connect a flowline to a subsea station; the apparatus comprising:

a connector receptacle attachable to the station and intended in use to have its longitudinal axis directed towards the direction of approach of the flowline;

an elongate connector mandrel having one end adapted in use to be attached in flow communication to one end of the flowline and having its other end provided with a coupling head adapted to cooperate with a flow line connector;

a removable assembly positionable on the subsea station and including

an elongate hollow guide having a longitudinal axis which when said assembly is positioned on said subsea station in use is parallel to and spaced from the longitudinal axis of the receptacle,

and a pulling line which in use extends



After the pulling line 30 has been connected to the mandrel 33, the pulling means 37 may be lowered to the subsea station 20 by drill string 26 and during such lowering of pulling means 37, the pulling line 30 is further paid out from the winch means 27 so that the mandrel 33 is not pulled from the pipe laying vessel 32.

Pulling means 37 is guided by guide lines 44 into locked assembly with guide posts 40. In such releasably locked position, tube 76 of the pulling means 37 extends over body member 46 with its axis parallel thereto and with guide funnel 77 positioned above the guide mouth 47.

As shown in Fig. 6, after drill string 26 has been retrieved, the pipe laying vessel 32 moves or lays away from vessel 24. Winch means 27 is locked against rotation and as the vessel 32 moves away on the predetermined course for laying flowline 22, flowline 22, which is spooled upon reel 31, is pulled from reel 31, passed through pipe straighteners 34 for unbending and straightening the flowline 22.

After a preselected length of flowline has been unspooled and a desired length rests upon the sea floor, winch means 27 is unlocked and actuated to take up pulling line 30 and thus move the flowline toward the subsea station 20 and toward the receptacle means 21. As the mandrel 33 approaches the receptacle means 21, the mandrel is drawn into alignment with the body member 46 and the leading end of mandrel 33 is drawn into the guide funnel and into the hollow body member 46. As the leading end of mandrel 33 passes through the hollow body member 46, the tapered rib edges 56 engage latch member 49 and cam the latch member upwardly in slot 49a. For a short distance, the latch member 49 is held in up position by the parallel edges of the guide ribs 53 until locking recess 57 passes beneath the latch member 49 and the latch member falls by gravity into the recess.

Stop collar 59 carried by mandrel 33, at this relative position of the mandrel 33 and body member 46, is brought into abutting engagement with interior surfaces of mouth 47 and prevents longitudinal overtravel of mandrel 33 in the receptacle body member 46 so that latch member 49 is positioned opposite locking recess 57 for interlocking engagement therewith.

The flowline 22, with its mandrel 33, is thus received and retained in receptacle body member 46 against relative longitudinal movement with respect thereto. Head 51 of mandrel 33 projects beyond the inboard end of receptacle body member 46. Fig. 9, and presents a reduced neck portion 51a which is adapted to be laterally engaged by the laterally engageable connector means shown and described in aforesaid copending appli-

tion No. 3496/78 (Serial No 1577272).

After the mandrel 33 is locked within the receptacle means 21, drill string 26 may be reconnected to the pulling means 37. Drill string 26 and its connection to mandrel 83 of pipe member 71 provides pressure actuating fluid for actuating a cable cutting means, not shown, on the pulling means 37 for cutting the cable forwardly of sheave 79. After the pulling line 30 has been so cut, the pressure actuating fluid may also be used for actuating the release mechanisms of the pulling means 37 so that the locks securing the pulling means 37 to the guide posts 40 may be actuated to release position for freeing pulling means 37 from guide posts 44. The drill string 26 may now be retrieved, together with the pulling means 37.

The hydraulic lines for actuating the cable cutting means and the release mechanisms are not shown in this example because the attachment and use of such hydraulic fluid pressure lines is well-known.

From the foregoing it will be seen that there is provided an apparatus and method of connecting a flowline to a subsea station in which such a connection may be remotely controlled and the method employed is independent of water depth. The described flowline connector apparatus includes a receptacle connector supported by a subsea station and has its axis directed toward the approach of the flowline, an elongated connector mandrel on a proximate end of the flowline, pulling means releasably connectible to the subsea station adjacent the connector receptacle, and lock means on the receptacle for interlocking engagement with the mandrel to retain the mandrel in selected longitudinal position relative to the receptacle and with a connector end of the mandrel exposed inboardly thereof.

WHAT WE CLAIM IS:—

1. Apparatus arranged to connect a flowline to a subsea station; the apparatus comprising:

a connector receptacle attachable to the station and intended in use to have its longitudinal axis directed towards the direction of approach of the flowline;

an elongate connector mandrel having one end adapted in use to be attached in flow communication to one end of the flowline and having its other end provided with a coupling head adapted to cooperate with a flow line connector;

a removable assembly positionable on the subsea station and including

an elongate hollow guide having a longitudinal axis which when said assembly is positioned on said subsea station in use is parallel to and spaced from the longitudinal axis of the receptacle.

and a pulling line which in use extends



through said hollow guide and is arranged in use to be connected to the flowline adjacent said one end of the mandrel thereby to pull the mandrel towards and into said receptacle, said mandrel extending through said receptacle with said coupling head projecting beyond the end of the receptacle thereby to provide a coupling connection to said mandrel;

and locking means on said receptacle cooperable with said mandrel to lock the mandrel in position in the receptacle,

said mandrel being provided with guide portions cooperating in use with said receptacle to align said mandrel for sliding entry into said receptacle in the direction of the longitudinal axis of the receptacle.

2. Apparatus as claimed in claim 1, wherein said locking means comprises a movable latch member on said receptacle, said mandrel including a latch member receiving recess, and actuating means on the mandrel arranged to displace the latch member during reception of the mandrel in the receptacle.

3. Apparatus as claimed in claim 2, wherein the actuating means on the mandrel includes longitudinally extending guide fins, having inclined end portions at the leading end of said mandrel for camming said latch member into position for latching engagement with said latch receiving recess.

4. Apparatus as claimed in any of claims 1 to 3, including a stop member adjacent one end of said mandrel engageable with the receptacle to limit relative movement of the mandrel with respect to the receptacle during locking of the locking means.

5. Apparatus as claimed in any of the preceding claims wherein said removable assembly includes a guide frame removably attachable to guide posts on said subsea station and a sheave on said guide frame, and said pulling line being connectible to said mandrel, and in use passing over said sheave, and extending to remote means for pulling said line.

6. Apparatus as claimed in claim 5 including cutting means on said guide frame operable to cut and release said pulling line from said mandrel after the mandrel is in latched engagement with said receptacle.

7. Apparatus as claimed in claim 5 or claim 6 comprising an upstanding member on said frame adapted to be connected to a drill string; and a housing on said member for rotatably mounting said sheave.

8. A method of connecting a flowline to a subsea station; in which a connector receptacle is attached to the station so as to have its longitudinal axis directed towards the direction of approach of the flowline, one end of an elongate connector mandrel is attached in flow communication to one end of the flowline, the other end of said mandrel being

provided with a coupling head adapted to cooperate with a flowline connector and said mandrel being provided with guide portions cooperating with said receptacle to align said mandrel for sliding entry into said receptacle in the direction of the longitudinal axis of the receptacle; a removable assembly is positioned on the subsea station, said assembly including an elongate hollow guide having a longitudinal axis which is positioned on said subsea station so that the guide axis is parallel to and spaced from the longitudinal axis of the receptacle, a pulling line is passed through said hollow guide and connected to the flowline adjacent said one end of the mandrel, said mandrel and said flowline end are lowered to the sea floor, said mandrel is pulled into said receptacle by pulling said pulling line through said guide so that the mandrel extends through the receptacle with said coupling head projecting beyond the end of the receptacle thereby enabling flow connection to said flowline to be established, and said mandrel is locked in position in the receptacle.

9. A method as claimed in claim 8 in which the mandrel is locked in the receptacle by camming a latch member of said receptacle to an unlatched position by the forward end of said mandrel, and said latch member is allowed to fall under gravity into engagement with said mandrel when the mandrel is in a selected position in the receptacle.

10. An apparatus for or method of connecting a flowline to a subsea station substantially as herein described with reference to and as illustrated in the accompanying drawings.

A. A. THORNTON & CO.,
Chartered Patent Agents,
Northumberland House,
303/306 High Holborn,
London WC1V 7LE.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon) Ltd.—1981. Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.