

TOOL FOR SECURING TUBULAR MEMBERS

This invention relates to tools for securing tubular members. Particularly, in one form, the invention relates to a tieback tool for securing a first tubular member or riser pipe suspended from a vessel floating on a body of water to a second tubular member or casing hung in the wellbore in the bottom of the body of water.

In recent years, it has become desirable to use a floating vessel from which to drill wells in marine locations. Many of these structures have been maintained on station by conventional spread catenary mooring lines, or by propulsion thruster units. One system of floating vessel receiving attention for drilling or production of wells in water is the Vertically Moored Platform (VMP), such as described in U.S. Patent 3,648,638, issued March 14, 1972, Kenneth A. Blenkarn, inventor. A key feature of Vertically Moored Platforms is that the floating platform is connected to anchor means in the ocean floor only by elongated parallel members which are preferred to be large diameter conduits, commonly called "riser pipes". These elongated members or riser pipes are held in tension by excess buoyancy of the platform. In this system, it is preferred that there be several concentric casing strings set in the ocean floor and cemented in place. Corresponding concentric riser pipes or casing strings will extend from the ocean floor to the floating vessel. The present invention discloses novel means of connecting the corresponding set casings to the corresponding riser casing strings extending from

the mudline suspension system in the set casings to the floating vessel.

U.K. Patent Application No. 7912425, filed 9th April 1979, entitled "Vertically Moored Platform Anchoring", describes an 5 anchoring system utilizing concentric casing strings set in the ocean floor which are connected to concentric casing strings within the riser pipe extending from the set casings to the floating vessel.

In the past, riser pipes have been connected to the casing by mechanical connectors. To our knowledge, none of these systems teach 10 the particular J-slot connections which we describe and claim. J-slots for lowering and recovering equipment are well known: for example, see U.S. Patent 3,605,414.

The present invention provides a tool for securing a first tubular member (e.g., riser pipe suspended from a vessel floating on a 15 body of water) to a second tubular member (e.g. a casing hung in a wellbore and preferably cemented in the bottom of the body of water) comprising:

a male tubular member;

a female tubular member adapted to fit over said male tubular 20 member;

a first J-slot and a second J-slot on either the interior of said female tubular member or on the exterior of said male tubular member, said J-slots being longitudinally spaced apart along such tubular member, said first J-slot being nearest the end of such 25 tubular member;

a first lug and a second lug on the tubular member not having the J-slots, said lugs being spaced apart longitudinally along such tubular member, the longitudinal distance between the bearing surfaces of said J-slots and the longitudinal distance between the bearing surfaces of said lugs being about equal, said first lug being nearest the end of such tubular member and said first J-slot being nearest the end of said J-slot member; and

said first lug and said second J-slot forming a load-carrying engagement A and said second lug and said first J-slot forming a load-carrying engagement B, the design load carried by A and by B respectively designated F_A and F_B , and in which

$$K_J/K_L = F_A/F_B$$

where

K_L = axial stiffness of said tubular member having said lugs and between the lug-bearing surfaces; and

K_J = axial stiffness of said tubular member having said J-slots and between the J-slot bearing surfaces.

The present invention further provides a tool for securing a first tubular member to a second tubular member comprising:

a male tubular member;

a female tubular member adapted to fit over said male tubular member;

a first J-slot, a middle J-slot, and a third J-slot farthest from the end of the member on either the interior of said female tubular member or the exterior of said male tubular member, said

slots being longitudinally spaced apart and longitudinally spaced apart first lug, second lug, and third lug on the member not having the J-slots, first lug being the one closest to the lug member end, said lugs adapted to engage said J-slots, the longitudinal distance 5 between the bearing surfaces of said lugs and the corresponding longitudinal distance between the J-slot bearing surfaces being about equal and in which

$$\frac{F_B + F_C}{F_A} K_{L1} = K_{J2}, \text{ and}$$

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$$K_{L2} = \frac{F_A + F_B}{F_C} K_{J1}$$

where

F_A = design load carried by engagement "A" formed by first 15 lug and third J-slot;

F_B = design load carried by engagement "B" formed by second lug and second J-slot;

F_C = design load carried by engagement "C" formed by third lug and first J-slot;

20 K_{L1} = axial stiffness of the tubular member having said lugs and between the first lug and the second lug stage;

K_{L2} = axial stiffness of the tubular member having said lugs and between the second lug stage and the third lug stage;

K_{J1} = axial stiffness of the tubular member having said J-slots and between the first J-slot bearing surface and the second J-slot bearing surface; and

K_{J2} = axial stiffness of the tubular member having said 5 J-slots and between the bearing surface of the second J-slot and the bearing surface of the third J-slot.

The invention will now be described in more detail and by way of example with particular reference to the accompanying drawings in which:

10 FIGURE 1 is a schematic view of a Vertically Moored Platform having riser pipes extending from the ocean floor to the floating structure;

FIGURE 2 illustrates schematically the connection between the concentric casing strings set in the bottom of the body of water and 15 the mating concentric tubular strings extending to the floating structure;

FIGURE 3 illustrates an embodiment of a single J-slot and lug arrangement;

FIGURE 4 illustrates an assembly incorporating an embodiment 20 of a tool according to the present invention having a multiple J-slot arrangement;

FIGURE 5 illustrates a preferred form of J-slot arrangement for the assembly of FIGURE 4;

FIGURE 6 is a modification of the J-slot arrangement of 25 FIGURE 3 to provide means for transmitting a compressive force.

Reference is first made to FIGURE 1 which shows an isometric view of a Vertically Moored Platform (VMP) which comprises a floating structure 10 floating on a body of water 12 and connected by vertical riser pipes 14 to casing 16 indicated as being anchored in the soil. Ordinarily, a sufficient number of casings 16 will be set in place in the holes in the ocean bottom and anchored there such as by cementing in order to form a firm anchor. Next, the floating structure such as a VMP will be connected to casings 16 by vertical riser pipes 14. The vertical riser pipes 14 may be anywhere from as little as 180 metres or less to 1525 metres or more in length. In this concept of using riser 14 to drill through, it is necessary to form a good connection between the riser pipes 14 and the set casing 16. This invention discloses a suitable connector. It is also pointed out that each casing 16 in reality has a plurality of concentric casing strings suspended therein; accordingly, the riser pipe indicated as 14 will normally have a plurality of inner concentric casings which are connected to the inner casings hung within casing 16.

FIGURE 2 illustrates schematically various concentric casing strings 16, 16A, 16B, and 16C, which are connected to riser pipe 14 and its inner strings of casings 14A, 14B, and 14C. Outer casing string 16 is hung off at 18 from drive pipe 20. Casing string 16 is cemented in below the mudline landing 18. A J-slot connector 24 connects casing 16 to riser pipe 14. Inner J-slot connectors 24A and 24B likewise connect casing strings 16A and 16B to casing

strings 14A and 14B. Inner string 14C is shown as being continuous but it normally would also be hung off in a manner similar to that for casing string 16A. Drive pipe 20 is supported from template 15. The J-slot connectors illustrated are described in UK Patent

5 Application 7934161 (Publication No. 2032561).

Attention is next directed to FIGURE 3 which illustrates an embodiment of a J-slot. Shown thereon is a lug 36 positioned in locking J-slot 46. It is to be noted that this is a view of the inside of the tubular members being connected and that this configuration of

10 FIGURE 3 takes up slightly over 25 percent of the circumferential view. In other words, there are four lugs 36 and locking slots 46 spaced circumferentially on the same elevation. (There could be any number but four is the normally preferred number.) Load-bearing surface 50 is the lower side of indexing and load-bearing plateau 40 which is wedge-like

15 in shape and has an indexing race 42. Lug 36 has a stabbing surface 48. Various advancing positions of lug 36 are shown starting with 36A which is considerably above the indexing and load-bearing plateau 40. As lug 36 is lowered, it may assume the position 36A and, if not aligned with passage or throat 47 leading to the J-slot, the stabbing surface

20 48B will contact indexing race 42 and cause the lug to be rotated as it is lowered until it is aligned with passage 47. The lug 36 will then assume the various positions indicated by the dotted lines until it reaches a position 36N. When lug 36 reaches an intermediate position 36F, at least a portion of the bearing surface 48B contacts

guiding race 38. This causes the lug and the pipe on which it is connected to be turned by the weight of the string of pipe supporting the lug 36. This continues until lug 36 reaches the position 36N. The upper pipe 14A which supports lug 36 is then lifted until lug 35 is forced against load-bearing surface 50. As a precautionary measure when upward force is applied to casing string 14A, a light torque is also applied to the string so that there is no chance that lug 36 will slip out of its alignment directly beneath the load-bearing surface 50 and within locking slot 46. Indexing plateau 44 aids in maintaining lug 36 in its proper position. The "sharp corners" shown in the drawings would, in construction, be rounded or shaped to reduce concentration of stresses.

A preferred guiding race 38 has two requirements: (1) it must be deep enough so that lug 36 may clear indexing plateau 44 as it is lowered; and (2) it is preferred to have a slope sufficient to cause the lug and its associated string of pipe to rotate as the lug is lowered.

As mentioned above, there is a plurality of circumferentially spaced indexing and load-bearing plateaus 40 having load-bearing surfaces 50. It is important that load-bearing surfaces 50 be at the same longitudinal position of pipe 14A as each of the other circumferentially spaced plateaus. We accomplish that by cutting them simultaneously with a lathe to form a circumferential groove 51.

One form of connector according to the invention is shown in Figures 4 and 5. Figure 4 shows in vertical cross-section a "multiple J-slot" longitudinal arrangement. This concerns means for connecting a lower tubular member 52 to an upper tubular member 54, and includes a lower J-slot system 56 and an upper J-slot system 58. Seals 59 and 60 are provided and the connecting means will provide a seal-tight connection and transmit tension.

Attention is next directed to FIGURE 5 which illustrates a preferred embodiment of the multiple J-slot arrangement shown in FIGURE 4. In FIGURE 5, there is provided an upper lug 66 having an upper bearing surface 66A and a lower lug 62 having an upper bearing surface 62A which fit, respectively, into upper locking slot 67 having a downwardly facing bearing surface 67A and lower locking slot 63 having a downwardly facing bearing surface 63A. Upper locking slot 67 has a mouth 68 which has a vertical or longitudinal dimension L which is greater than L_1 , the vertical dimension of upper lug 66, but less than the vertical dimension L_2 of the lower locking lug 62. The vertical dimension L_2 is less than the vertical dimension L_3 of the mouth of lower locking slot 63. With this relationship between the upper and lower locking lugs 66 and 62 and the opening 68 and the mouth of locking slot 63, it is impossible for the lower lug 62 to go into upper locking slot 67.

We will now briefly discuss how the proper distribution of loading between upper lug 66 and lower lug 62 is obtained. The J-slot 63 and lug 62 form a first load-carrying engagement A and J-slot 67 and lug 66 form a second load-carrying engagement B. That part of the tubular member (having the J-slots) between the load-bearing surfaces of the J-slots can be identified as the J-slot segment. The multiple J-slot design is required when the tensile loads cannot safely be transmitted through a single J-slot connector fitting in the radial clearance. The proper distribution of the loads transferred at the different stages is thus imperative. This is accomplished by adjusting the relative axial flexibility of the two pipes or tubular members between the bearing surfaces of the longitudinally spaced J-slots 63 and 67. The clearance or difference between the axial distances of the lug stages and bearing stages should be minimum. For example, in the case where only two stages are used, and the load-carrying engagements A and B are each to have the same load-carrying capability, the axial stiffness K_L between the two bearing stages of the member having the lugs and the axial stiffness K_J between the two bearing stages of the member having the J-slots should be equal, $K_L = K_J$. If the design load to be carried by load-carrying engagements A and B is respectively designated F_A and F_B , and where A is closer than B to the end of the lug member, then the axial stiffness ratio of the two segments is:

$$K_J/K_L = F_A/F_B$$

In the case of three stages, the axial stiffness should be distributed as follows:

$$\frac{F_B + F_C}{F_A} K_{L1} = K_{J2}; K_{L2} = \frac{F_A + F_B}{F_C} K_{J1}$$

5 where

F_A = design load carried by engagement "A" formed by first lug and third J-slot;

F_B = design load carried by engagement "B" formed by second lug and second J-slot;

10 F_C = design load carried by engagement "C" formed by third lug and first J-slot;

K_{L1} = axial stiffness of the lug member between the middle lug and the lug stage closest to the end of the member;

K_{L2} = axial stiffness of the lug member between the middle
15 lug stage and the lug stage farthest away from the lug member;

K_{J1} = axial stiffness of the J-slot member between the middle bearing stage and the stage closest to the end of the J-slot member; and

K_{J2} = axial stiffness of the J-slot member between the
20 middle bearing stage and the stage farthest from the end of the J-slot member.

In most of the contemplated uses of the J-slot connections described in this specification, the upper section of pipe such as section 54 of FIGURE 4 will be in tension; however, there may be some situations where the upper section of pipe will be under compression. A modification of a J-slot connector which will take care of this compressive force is shown in FIGURE 6. The main difference between this J-slot connector and those of the other figures is in the modification of the indexing plateau 104. Indexing plateau 104 has been modified to have horizontal extension or leg 106 which has an upper facing bearing surface 108. This is designed to mate with a portion of the downwardly facing bearing surface 110 of lug 102. Lug 102 has a vertical dimension so it can be rotated into the vertical space between leg 106 and the lower surface 112 of indexing and load-bearing plateau 100. In operation, the upper string of pipe supporting lug 102 is lowered from an upper position such as 102A downwardly. Indexing and load-bearing plateau 100 causes the pipe to rotate so that the lug 102 is in the vertical passage 114 of the J-slot. Continual lowering of the upper pipe results in the lug eventually reaching the position 102N. Thus far, the operation is similar to that shown in FIGURE 3. When the lug is in position 102N, tension is applied to the upper string of pipe to pull the pipe upward where the lug reaches the position 102M. At this point, proper torque is applied to the pipe supporting

lug 102 to move it into the position shown in FIGURE 6. If desired, a slight torque may be left on the upper section of the pipe to assure that the lug 102 is maintained in the position shown in FIGURE 6. If tension is ever lost on the upper string
5 of pipe, the bearing surface 108 of leg 106 of indexing plateau 104 will resist downward movement.

Our co-pending Application No. 7934161 describes and claims a tieback tool for sealingly securing a tubular member suspended from a vessel floating on a body of water to a casing hung in a wellbore
10 in the bottom of the body of water, comprising:

a male tubular member;

a female tubular member adapted to fit over said male tubular member;

J-slot means on one of said members and co-operating lug means
15 on the other of said members; and

a self-energizing seal between an outwardly facing surface of a portion of one member and an inwardly facing surface of a portion of the other member, said tool being constructed so that for a given internal pressure said one portion has a greater radial expansion than
20 said other portion and the resulting differential radial expansion of the portions causes compression of the seal.

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CLAIMS

1. A tool for securing a first tubular member to a second tubular member comprising:

a male tubular member;

5 a female tubular member adapted to fit over said male tubular member;

a first J-slot and a second J-slot on either the interior of said female tubular member or on the exterior of said male tubular member, said J-slots being longitudinally spaced
10 apart along such tubular member, said first J-slot being nearest the end of such tubular member;

a first lug and a second lug on the tubular member not having the J-slots, said lugs being spaced apart longitudinally along such tubular member, the longitudinal distance between the
15 bearing surfaces of said J-slots and the longitudinal distance between the bearing surfaces of said lugs being about equal, said first lug being nearest the end of such tubular member and said first J-slot being nearest the end of said J-slot member; and

said first lug and said second J-slot forming a load-carrying engagement A and said second lug and said first J-slot
20 forming a load-carrying engagement B, the design load carried by A and by B respectively designated F_A and F_B , and in which

$$K_J/K_L = F_A/F_B$$

where

25 K_L = axial stiffness of said tubular member having said lugs and between the lug-bearing surfaces; and



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K_J = axial stiffness of said tubular member having said J-slots and between the J-slot bearing surfaces.

2. A tool for securing a first tubular member to a second
5 tubular member comprising:

a male tubular member;

a female tubular member adapted to fit over said male
tubular member;

a first J-slot, a middle J-slot, and a third J-slot
10 farthest from the end of the member on either the interior of
said female tubular member or the exterior of said male tubular
member, said slots being longitudinally spaced apart and longitudinally
spaced apart first lug, second lug, and third lug on the member not
having the J-slots, first lug being the one closest to the lug member
15 end, said lugs adapted to engage said J-slots, the longitudinal
distance between the bearing surfaces of said lugs and the
corresponding longitudinal distance between the J-slot bearing
surfaces being about equal and in which

20
$$\frac{F_B + F_C}{F_A} K_{L1} = K_{J2}, \text{ and}$$

$$K_{L2} = \frac{F_A + F_B}{F_C} K_{J1}$$

where

F_A = design load carried by engagement "A" formed by
25 first lug and third J-slot;



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F_B = design load carried by engagement "B" formed by second lug and second J-slot;

F_C = design load carried by engagement "C" formed by third lug and first J-slot;

5 K_{L1} = axial stiffness of the tubular member having said lugs and between the first lug and the second lug stage;

K_{L2} = axial stiffness of the tubular member having said lugs and between the second lug stage and the third lug stage;

K_{J1} = axial stiffness of the tubular member having said
10 J-slots and between the first J-slot bearing surface and the second J-slot bearing surface; and

K_{J2} = axial stiffness of the tubular member having said J-slots and between the bearing surface of the second J-slot and the bearing surface of the third J-slot.

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