TUBING HANGING SET FOR A SUBMARINE OIL-WELL, RUNNING TOOL FOR ITS PLACING AND HANDLING METHOD.

The present invention refers to an equipment assembly meant to promote the hanging, locking and sealing of a submarine oil-well tubing.

The present invention aims to provide a set of pieces of equipment for the support, locking and sealing of the tubing of a submarine oil-well, the two last functions being performed by a double hydraulic packer (for production), besides establishing a method for the use of the referred set.

To make the oil produced by an oil-well flow it is necessary to perform several operations from the beginning of the drilling until its effective production. Several pipings are installed in the well, by operations which the experts call pipe running (in-hole running).

These pipes carry out the lining of the well, in this case called "casing", or serve to lead the oil to the set of equipments existing on the sea bed, where the wellhead and the Christmas-tree are located.

Simply speaking, the purpose of the wellhead is to support the load of the several hangers where the well casing and the production tubing are fixed on, to provide means of sealing the well to prevent leaks, and also to serve as a support for the set of valves, seals and control devices that enable the connection of the well with the piping which takes the oil to the location of storage or processing. This last set is known in the art as the Christmas-tree. In the case of submarine producing oil-wells these sets are known in the art as "submarine wellhead" and "Wet Christmas-tree".

The operations of preparing an oil-well for production are called "completion". Among the completion operations one in particular, namely the placing of the tubing hanger, is noted for presenting a large amount of failures, causing large losses to the operations. The tubing hanger basically

has the functions of supporting the tubing, locking it against axial movements and, finally, providing the sealing at the casing hanger where it is sustained.

The large amount of failures on the tubing hangers is due to their locking and their sealing being performed by elements with relatively small dimensions as compared to the size of the referred tubing hanger which makes this latter easily subjected to damage. This is made worse by the fact that very often debris from the sea bed settles on the surface of the casing hanger where the tubing hanger will be supported in order to be locked and sealed, making the success of these operations more difficult. The settlement of debris is unavoidable because it results from the turbulence caused by placing the pieces of equipment on the wellhead, which stirs the debris in the vicinity of the well.

Another factor to be taken into consideration is the complexity of the tubing hanger hydraulic running tool, which for its operation needs the use of a complex piece of equipment known as a "completion riser". The hydraulic running tool will need up to four hydraulic functions to place the tubing hanger, which requires a piece of equipment which is difficult to maintain, due to its high number of components.

The above-mentioned problems cause considerable loss of time and, as a consequence, rising costs due to the high number of steps needed to perform the operation of placing the tubing hanger, not to mention the cost of unforeseen extra operations to correct any failures that may occur.

It can therefore be clearly seen that the current art, besides not providing the required safety for the tubing hanger placing operation, frequently leads to an increase in the final costs of the operations due to the necessity of unscheduled operations for correcting problems encountered.

It is the aim of the present invention to provide an equipment set to support the tubing of a submarine oil-well, and also to provide a method for its use, in order to

eliminate the necessity of locking and sealing the tubing hanger on its seat on the casing hanger.

Accordingly one aspect of the present invention provides a tubing hanging set for hanging, locking and sealing a submarine oil-well consisting of a tubing hanger; a connection sleeve; a double hydraulic packer; and first and second extension tubes; wherein the tubing hanger is simply seated on the upper internal part of a connection sleeve, said connection sleeve being seated with its lower external part on the internal upper part of the casing hanger; wherein said tubing hanger has a passageway for connection with said first extension tube which is itself connected to the tubing, and located in the portion below the double hydraulic packer a passageway having internally a valve to block flow from the annulus between tubing and casing; wherein the connection from said passageway and said annulus is made by said second extension tube connected by means of a sleeve to a short tubing of the double hydraulic packer; wherein said double hydraulic packer has grips for locking said tubing hanging set, and at least one packing unit for sealing said tubing hanging set.

A second aspect of the invention provides a running tool for installation of the tubing hanging set of the first aspect, comprising a re-entry mandrel of cylindrical shape, a lower extension provided with a cam, lower tubular elements with coupling terminals, an upper hollow cylindrical extension, a connector to fit to the running string, and a connector for connecting to hydraulic lines.

A further aspect of this invention provides a method of installing a tubing hanging set according to the first aspect comprising:-

(a) before running the whole set, promoting connection and locking of the lower part of said running tool on said tubing hanger by pressing an extension element of the tool against the top of the tubing hanger, thus fitting the cam of tool into the notch of said tubing hanger, thereby

allowing the whole set to rotate for correct placing;

(b) fitting tubular connection elements into the tops of the passageways of said tubing hanger, the fit being sealed by sealing rings of the connection terminals;

(c) fitting the lower part of passageway of said tubing hanger to an extension tube which is connected to a tube passing through the double hydraulic packer, said tubing extending to the oil producing zone;

(d) fitting at the lower part of the passageway of said tubing hanger an extension tube by means of a sleeve to the short tubing of the double hydraulic packer; running by means of a drilling string the whole set together with hydraulic lines and electrical cables connected thereto by way of a connector to the wellhead housing where it is inserted until the tubing hanger seats on said connection sleeve which has been previously seated on said casing hanger; and fixing the double hydraulic packer by applying pressure on said tubing thereby promoting the locking and sealing of the whole tubing hanging set.

The tubing hanger seats on a sleeve that seats itself on the casing hanger. The locking and sealing is done by a double hydraulic packer seated on the casing, slightly below the wellhead.

In order that the present invention may more readily be understood the following description is given, merely by way of example, with reference to the accompanying drawings, in which:-

FIGURE 1 shows a frontal view of a cross-section of a prior art tubing hanger, already seated on the casing hanger;

FIGURE 2 shows a cross-section of a tubing hanger used in the method of the present invention, and the double hydraulic packer used for locking and sealing the tubing;

FIGURE 3 shows a cross-section of a wellhead with the casing hanger already placed;

FIGURE 4 shows a front elevation of the tubing hanger already placed by the method of the present invention;

FIGURE 5 shows an elevation, with partial cross section, of the running tool of the tubing hanger;

FIGURE 6 shows a cross-section of the tool shown in Figure 5; and

FIGURE 7 shows another cross-section of the tool shown in Figure 5.

Before starting the description of the invention, we make reference to Figure 1 showing the prior art tubing hanger 1 seated on the casing hanger 4, which is itself seated on the wellhead housing 2.

The tubing hanger 1 is supported and locked on the casing hanger 4 by means of grips 5, in order to prevent axial movements of the tubing, and the sealing between the two parts is effected by a packing unit 3.

As can easily be seen in Figure 1, either the packing unit 3 or the locking grips have rather reduced dimensions as compared to the size of the tubing hanger 1. As no other points for locking and sealing exist other than the one referred to, one may conclude that locking and sealing of the tubing hanger 1 are precarious. A slight fault in the alignment, or the presence of debris on the surface of the casing hanger 4 where the tubing hanger is seated, is enough to endanger the operation, worsened by the inherent difficulties of an operation performed remotely from the surface.

Figure 2 shows a set of pieces of equipment 10 which shall be referred to herein as a tubing hanging set. The tubing hanging set 10 basically consists of a tubing hanger 11, tubular extensions 20 and 22 and a double hydraulic packer 16.

As compared with the prior art, the tubing hanger 11 is simply seated on the upper interior of a connecting sleeve 13. The lower external portion 60 of the connecting sleeve 13 in its turn seats on the upper internal part of the casing hanger 12 (Figure 3) as suggested by the dotted line Z-Z. It is important to point out that this casing hanger 12 is of the same type as those used by the prior art and does not

need any change for utilization of the tubing hanging set 10 of the present invention.

The locking and fixing of the tubing hanging set 10 is effected by the grips 17 of the double hydraulic packer 16, and the sealing of the tubing hanging set 10 by means of the packing unit 18 of the double hydraulic packer 16. The tubing hanging set 10 duly seated, can be better seen in Figure 4.

As the position of the casing hanger 12 relative to the top of the high pressure wellhead housing 46 varies according to the manufacturer, the connecting sleeve 13 must have its dimension "H" (Figure 4) designed properly to ensure that the top of the tubing 11 keeps a certain length "L" in respect to the top of the high pressure wellhead housing 46, suitable for installation of the wet Christmas-tree which will afterwards be installed on this high pressure wellhead housing 46.

It can be readily seen that the connection sleeve 13 is one of the main features of the present invention, simultaneously playing two roles since, besides promoting the connection between tubing hanger 11 and casing hanger 12, it makes it possible to set easily the position of the top of the tubing hanger 11 in relation to the top of the high pressure wellhead housing 46. It is sufficient for this purpose that the connecting sleeve 13 have its dimensions selected so as to ensure that the final assembly of the set will be effected as desired, viz. that, for each high pressure wellhead housing 46 supporting any casing hanger 12, it will be always possible to seat the top of the tubing hanger 11 as required by the Christmas-tree to be installed. The only requirement is that the connecting sleeve 13 will have been dimensioned appropriately.

The tubing hanger 11 has (i) a passageway 15 for connection with the extension 20, which in turn is connected to the tubing 14, and also (ii) a passageway 25. In the portion located below the double hydraulic packer 16, for the

purpose of installation, there is a valve for blocking the flow coming from the annulus between the tubing 14 and the casing 19. The juncture from passageway 25 to this annulus is effected by the extension 22, which is connected by means of the sleeve 23 to the short tubing 21 of the double hydraulic packer 16, as shown in Figures 2 and 4.

The tubing hanger 11 also has passageways for hydraulic lines, not shown in the drawings, which lead to the subsurface safety valve. Other technical details needed for the operation, which are also found in the prior art hangers, are not mentioned in this specification, since they are largely known in the art and do not pertain to the scope of the present invention, although they have to be considered at the time of design and fabrication.

As already mentioned, the double hydraulic packer 16 is the one responsible for locking and sealing of the tubing hanging set 10, and for this purpose it is provided with grips 17 for locking and with at least one sealing unit 18. The double hydraulic packer is largely known equipment used, for instance, for completion of wells in multi-production zones. In the present invention, as already seen, it is used for a different function.

The placement of the tubing hanging set 10 of the present invention is effected by means of a running tool 27, shown in Figure 5, and which is a feature of the present invention.

The tool 27 comprises a lengthened body with an enlarged part 28 of cylindrical shape, usually known as a re-entry mandrel. As shown in Figure 5, the eccentricity of the tubular elements that form the tool 27 ends in the re-entry mandrel 28.

Below the re-entry mandrel 28 there are two tubular elements 29 and 31 used for direct connection with the tubing hanger 11. The tubular connection elements 29 and 31 are provided at their lower ends with coupling terminals 30 and 32, respectively, which are provided with elastomeric sealing

rings confined inside suitable grooves.

As will be explained in detail together with the description of operation, such coupling terminals fit into passageways 15 and 25 on the tubing hanger 11, their upper parts entering in such a way that this coupling remains secure and leak tight.

The tubular extension 33 above the re-entry mandrel 28 is a cylindrical pipe vertically aligned/lingtened which has on its upper end a connection 34 for connection to the lowering string of the tool 27. Also, the connector 34 is provided with fittings for connection of hydraulic lines 36 for installation and control of operation.

The tubular extension 33 is a hollow cylinder with a certain wall thickness. As shown in Figures 6 and 7, several longitudinal bores are formed in its wall for passageways of the hydraulic control lines. Thus, Figure 5 shows that on the upper tubular extension 33, at an intermediate height, there are holes provided with filters 37 which allow the communication between the inside of the tool and the exterior.

Figures 6 and 7 show cross-sections taken at two levels of the hollow tubular extension 33 (section A-A and section B-B) to show these holes which are, for example, holes 40 and 41 defining passageways for subsurface safety valve control lines and operation lines, the tubular holes 38 and 39 being meant for the passageway of the locking- and unlocking control pipes for the connections to be made. The holes 43 are meant for lines that give access to the annulus in the casing 19.

Before continuing with the description, it must be made clear that the quantity and disposal of the different passageway holes for remote control and operation lines are given only in order to exemplify the possibility of their use in the present invention, and the invention is not in any way to be limited to the arrangement. Furthermore, none of the locations or quantities of elements is final; they are only

representative of one actual possibility.

On the lower part of the tubing hanger installation tool 27, there can be seen an extension 44 of the re-entry mandrel, the dimension of which allows its introduction into the upper part of the tubing hanger 11. This extension has a cam 45 that fits into the notch 26 on the top of the tubing hanger 11 when coupling the tool 27 to the tubing hanger 11, enabling torque to be applied for orientation of the tubing hanger 11.

Another characteristic of the tool 27 is the fact that its tubular extension 33 may, in case of any emergency, be sheared off by a special shear valve of the submarine blow out preventer.

A considerable advantage of the present invention is the fact that the running string 35 of the tool 27 is nothing other than the proper drilling string, viz. that tool 27 replaces a complex equipment called "completion risers", which are used in the prior art placing operations for tubing hangers.

The method for installing the tubing hanging set 10 consists in, before running the assembly, coupling the bottom part of the tool 27 to the tubing hanger 11 and locking this bottom part of the tool 27 by pressing its extension 44 against the top of the tubing hanger 11, fitting its cam 45 into the notch 26 on the top of tubing hanger 11, so that the assembly can rotate for coupling in an exact positioning.

At this point, the tubular connection elements 29 and 31 of the tool 27 shall be duly fitted in the passageways 15 and 25 of the tubing hanger 11 and properly sealed by means of the sealing rings of the fitting terminals 30 and 32, respectively.

The double hydraulic packer 16 will be run coupled to the bottom part of the tubing 14, and connected at its upper part to the tubular extensions 20 and 22, that connect to passageways 15 and 25 respectively.

The described above assembly, together with the

hydraulic lines and necessary cables already connected via connector 34, is run to the wellhead housing 46 where it is inserted so that the tubing hanger 11 seats on the connecting sleeve 13 which has previously been fitted to seat on the casing hanger 12.

Then the double hydraulic packer 16 is hydraulically fixed by means of pressure applied in tubing 14, promoting this way sealing and locking of the whole assembly in a safer way than the prior art manner.

Thus, functionally speaking, the tubing hanging set 10 of the present invention comprises all components from the tubing hanger 11 to the double hydraulic packer 16, leaving to the tubing hanger 11 only the function of supporting the weight of the tubing, while the double hydraulic packer 16 serves for locking and sealing the assembly.

Once more it must be clear that the described devices are disclosed in a general manner and the construction details illustrated should not in any way be considered as restricting the invention, since they serve only to give notice to the skilled person in the art how the different parts are combined to achieve the desired result.

The installation tool for the assembly, which is also a feature of the present invention, may not be limited by specific details of construction, but should be considered as a whole assembly as one conception of practical use. Various modifications are possible within the scope of the claims.

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1. A tubing hanging set for hanging, locking and sealing a submarine oil-well consisting of a tubing hanger; a connection sleeve; a double hydraulic packer; and first and second extension tubes; wherein the tubing hanger is simply seated on the upper internal part of a connection sleeve, said connection sleeve being seated with its lower external part on the internal upper part of the casing hanger; wherein said tubing hanger has a passageway for connection with said first extension tube which is itself connected to the tubing, and located in the portion below the double hydraulic packer a passageway having internally a valve to block flow from the annulus between tubing and casing; wherein the connection from said passageway and said annulus is made by said second extension tube connected by means of a sleeve to a short tubing of the double hydraulic packer; wherein said double hydraulic packer has grips for locking said tubing hanging set, and at least one packing unit for sealing said tubing hanging set.

2. A running tool for installation of a tubing hanging set according to claim 1, comprising a re-entry mandrel of cylindrical shape, a lower extension provided with a cam, lower tubular elements with coupling terminals, an upper hollow cylindrical extension, a connector to fit to the running string, and a connector for connecting to hydraulic lines.

3. A tubing hanging set according to claim 1 wherein said connection sleeve has its external lower portion designed as to seat on the internal upper part of a casing hanger, and its internal upper part designed to brace the tubing hanger, promoting the connection between said tubing hanger and a casing hanger of any kind.

4. A tubing hanging set according to claim 3, wherein said connection sleeve is designed in such a manner

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that the top of the tubing hanger maintains a certain length "L" relative to the top of the wellhead housing for installation of a Wet Christmas-Tree which is to be installed later on top of this wellhead housing.

5. A method of installing a tubing hanging set according to any one of claims 1 to 4, by using a running tool comprising:-

(a) before running the whole set, promoting connection and locking of the lower part of said running tool on said tubing hanger by pressing an extension element of the tool against the top of the tubing hanger, thus fitting the cam of tool into the notch of said tubing hanger, thereby allowing the whole set to rotate for correct placing;

(b) fitting tubular connection elements into the tops of the passageways of said tubing hanger, the fit being sealed by sealing rings of the connection terminals;

(c) fitting the lower part of passageway of said tubing hanger to an extension tube which is connected to a tube passing through the double hydraulic packer, said tubing extending to the oil producing zone;

(d) fitting at the lower part of the passageway of said tubing hanger an extension tube by means of a sleeve to the short tubing of the double hydraulic packer; running by means of a drilling string the whole set together with hydraulic lines and electrical cables connected thereto by way of a connector to the wellhead housing where it is inserted until the tubing hanger seats on said connection sleeve which has been previously seated on said casing hanger; and fixing the double hydraulic packer by applying pressure on said tubing thereby promoting the locking and sealing of the whole tubing hanging set.

6. A tubing hanging set for hanging, locking and sealing a submarine oil-well constructed and adapted to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

7. A running tool for a tubing hanging set for

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hanging, locking and sealing a submarine oil-well constructed and adapted to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

8. A method of installing a tubing hanging set, substantially as hereinbefore described with reference to the accompanying drawings.