(12)

LINER HANGER WITH BRASS PACKER

The invention relates to an oil well liner hanger which provides a packer between the liner and a surrounding pipe string. More particularly, the invention relates to an erosion-resistant liner hanger for use in wells in which sand control is important.

Liner hangers with packers are described in U.S. patent Nos. 2,328,840; 2,916,092; 3,152,643; 3,342,268 and 3,468,375. As far as Applicant is aware, the previously used packer materials were limited to lead or deformable materials such as rubber-like materials. It is an object of the invention is to provide an improved construction for an erosion-resistant liner hanger.

In accordance with the invention there is provided a liner hanger which is capable of being fluid-tightly wedged within a portion of a pipe string having an inner diameter small enough to engage and hold a tapered sleeve which is small enough to pass through the upper portions of the pipe string, and which comprises:

an upper hanger element comprising an upper tubular member with an upper end portion fluid-tightly connected to a surrounding sleeve which sleeve has brass-like properties and an outer diameter which tapers from a top located maximum to a bottom located minimum so that the sleeve is capable of passing through said pipe string and into, but not through, said smaller inner diameter section;

a plurality of axially aligned slots which extend through the wall of the upper tubular member in a location below the surrounding sleeve;

a lower hanger element comprising a lower tubular member which has an outer diameter substantially equalling that of the upper tubular member and is fluid-tightly connected, near its upper end, to the bottom of a surrounding sleeve, which sleeve (a) has an inner diameter capable of fitting snugly, but slidably, around the lower end of the upper tubular member, and (b) contains, near its mid-portion, a plurality of lugs extending inwardly into the slots in the upper tubular member;

the dimensions of said slots in the upper tubular member and lugs on the sleeve on the lower tubular member being arranged to accommodate to the extent of thermally-induced expansion and contraction of the liner in the well in which it is to be installed; and

means for attaching the hanger to the liner to be installed and a running string for installing the assembly.

The invention will now be explained in more detail with reference to the accompanying drawing, in which:

Figure 1 shows a cross sectional view of the hanger of the present invention.

Figures 2-4 are schematic illustrations of different stages of completing a well containing a liner suspended from a hanger of the present invention.

Figure 5 schematically illustrates preferred means for attaching the present hanger to a liner and a running string.

As shown in Figure 1, the upper element of the hanger comprises a section of tubing 1 which is surrounded by a brass-like tapered sleeve 2 and is provided with a plurality of axially aligned slots 3. The lower element of the hanger is a section of tubing with a similar outer diameter which is fluid-tightly connected to a surrounding sleeve 5. The sleeve 5 has an inner diameter capable of fitting snugly, but slidably, around the outer diameter of the lower portion of the upper element of the hanger. The gap between the inner diameter of the sleeve 5 and outer diameter of the element 1 are preferably machined to a close tolerance providing an opening which is not substantially larger than the perforations in the liner to be hung.

A threaded sleeve section 7 is arranged for connection to a lifting sub so that the hanger can be picked up and raised on the drill floor. The lower element of the hanger is provided with means, such as threaded section 8, adapting the hanger to be connected to the upper end of a liner.

The brass-like sleeve 2 has an outer diameter which tapers to a bottom portion small enough to enter into a reduced inner diameter portion of a pipe string, (such as a casing string). That portion is located so that it becomes positioned within the well at the depth at which the liner and hanger are to be installed.

The outer diameter of the upper portion of the sleeve 2 is arranged to be too large to pass into the reduced inner diameter portion of the surrounding pipe string without being too large to pass through the upper portions of the surrounding pipe string.

Figure 2 shows an early stage in a preferred procedure for installing the present hanger and a liner within a well. As shown, a borehole 10 has been drilled into the earth to a depth near, but above a reservoir interval within which a well liner is to be installed. The casing string 11 has been provided with a reduced inner diameter section 12, an insert for cementing 13, and a cement guide shoe 14. Such a casing string, or other pipe string, can readily be assembled from conventional units. The reduced inner diameter section 12 is preferably a section of pipe having a thicker wall but substantially the equal outer diameter. The insert for cementing and the cement guide shoe can be conventionally available items. Such a casing string can be cemented or otherwise grouted in place by means of materials and procedures which are conventionally known and available.

Figure 3 shows a subsequent stage in which the pipe string has been grouted into the borehole and, preferably, cleaned out by means of running a scraper through the upper portion of the casing and the reduced diameter section 12. In general, a drill string is preferably run in to drill out the cement insert and shoe and extend a borehole section 15 on into a reservoir interval 16 in which the liner is to be located. However, by using a cement basket or the like, where desired, the well can be initially drilled to the depth necessary to accommodate the liner below the casing string.

Figure 4 shows the final stage of installing a well liner suspended from the present liner hanger. The brass-like sleeve 2 is wedged into the reduced diameter portion 12 of the surrounding pipe string 11 and the liner 18 is hung below the expansion joint provided by the sleeve 5 of the lower element of the hanger.

Figure 5 shows a preferred method of connecting the present liner hanger to a running string and the liner for installing the assembly. As shown, a running string 20 comprises a section of drill pipe which is connected below a drill pipe string (not shown). The running string is bottomed by a running tube 21, such as a box on the top of 10 left-handed coarse threads, such as Acme threads, on the bottom of the running tube. The bottom end of the liner is connected to washdown shoe 22 containing internal left-hand threads for receiving those on the bottom of the running string.

Field Test Example

A plurality of liner hangers of the present invention have been installed in an oil field in which the traditional well completion equipment involved a 30 m wire-wrapped liner set on bottom with a lead seal arranged to seal the gap between a liner and a production casing. It was found that when the lead seals became washed or eroded-out, rod pumps became less efficient and centrifugal pumps would shut down completely; necessitating the pulling of the wire wrapped liners and pumps.

A plurality of the present type adapters have been installed and successfully pressure tested. The so-tested hangers were constructed as indicated in Figure 1. In each case, the tapered brass sleeve 2 was constructed of brass composed of 70% copper and 30% zinc. The sleeves were wedged inside of 6 m long casing sections near the bottom of the strings.

The casing strings were run in and cemented as indicated in Figures 2 to 4. The hangers were each connected to a 60 m wire wrapped screen liner. The hangers were sealed (as shown in Figure 4) by pressing the brass tapers into the heavy wall pipe sections with the weight of the drill strings (amounting to about 13,000 kgf). Since the casings were substantially vertical, the vertical force was about 13,000 kgf, and the horizontal force was about 45,000 kgf. The minimum sealing surface was about 32 cm^2, in the form of a metal-to-metal seal ring of about 0.5 cm wide. Even at a corrosion rate of 0.05 cm per year, such a seal should remain intact for about 10 years.

In each of the hangers tested, in the region just above the slots 3, the gap between the outer diameter of the upper hanger element 1 and the sleeve 5 was machined to 0.025 cm $\pm$ 0.012 cm. The openings through the wire wrapped screens were 0.03 cm $\pm$ 0.006 cm. Since experience has indicated that such wire wrapped screens are effective in keeping sand out of the wellbores, the tolerance between the element 1 and the sleeve 5 is expected to prevent the entry of sand between those elements.

Suitable Materials and Techniques

In general, the present hanger can be installed within substantially any metal pipe containing a properly proportioned section of reduced internal diameter and having a strength adequate to withstand the formation of a metal-to-metal seal by an application of downward force on a brass-like sleeve. A preferred arrangement comprises a section of heavy walled casing having an inner diameter smaller than that of the rest of the casing by an amount sufficient to engage and hold a tapered sleeve, where the sleeve is small enough to pass through the rest of the casing and the smaller inner diameter is large enough to avoid blocking cement plugs and the like.

In a particularly preferred installation procedure, an insert for cementing, such as those commercially available, should be put on a 6 m shoe joint below the heavy walled casing section, so the cementing plug can wipe the surface of the heavy walled section cleanly.

The term "brass-like", in relation to the sleeve 2, is used herein to refer to a metal having a combination of ductility, strength and corrosion resistance which is at least substantially as efficient for forming a corrosion resistant metal-to-metal seal as a brass sleeve composed of 70% copper and 30% zinc. In each of the hangers tested as described above, the seal between the brass-like tapered sleeve 2 and the upper element 1 of the hanger was formed by crimp-fitting the sleeve onto a piece of steel pipe. To ensure that the sleeve would not come off, the threaded collar means 7, for the accommodation of a lifting sub, was arranged to lock the sleeve in place.

CLAIMS

1. A liner hanger capable of being fluid-tightly wedged within a portion of a pipe string having an inner diameter small enough to engage and hold a tapered sleeve which is small enough to pass through the upper portions of the pipe string, comprising:

an upper hanger element comprising an upper tubular member with an upper end portion fluid-tightly connected to a surrounding sleeve which sleeve has brass-like properties and an outer diameter which tapers from a top located maximum to a bottom located minimum so that the sleeve is capable of passing through said pipe string and into, but not through, said smaller inner diameter section;

a plurality of axially aligned slots which extend through the wall of the upper tubular member in a location below the surrounding sleeve;

a lower hanger element comprising a lower tubular member which has an outer diameter substantially equalling that of the upper tubular member and is fluid-tightly connected, near its upper end, to the bottom of a surrounding sleeve, which sleeve (a) has an inner diameter capable of fitting snugly, but slidably, around the lower end of the upper tubular member, and (b) contains, near its mid-portion, a plurality of lugs extending inwardly into the slots in the upper tubular member;

the dimensions of said slots in the upper tubular member and lugs on the sleeve on the lower tubular member being arranged to accommodate to the extent of thermally-induced expansion and contraction of the liner in the well in which it is to be installed; and

means for attaching the hanger to the liner to be installed and a running string for installing the assembly.

2. The hanger of claim 1 in which the gap between the outer diameter of a near bottom portion of the upper hanger element and the inner diameter of a near top portion of the sleeve on the lower

(19)

* C L M S *

hanger element is at least about as small as the openings through the wall of the liner to be installed in a well.

3. The apparatus of claim 1 in which the running string comprises a drill string having a weight suitable for wedging the tapered sleeve on the upper hanger element into the portion of the pipe string having a reduced inner diameter.

4. The apparatus of claim 3 in which said lower tubular member of the hanger element is connected to the top of the liner and the drill string is connected to the bottom of the liner.

5. The apparatus of claim 1 in which the sleeve having brass-like properties has a combination of ductility strength and corrosion resistance which is at least substantially as efficient for forming a corrosion-resistant metal-to-metal seal as a brass sleeve composed of 70% copper and 30% zinc.

6. A process for installing a liner within a well comprising:

arranging a pipe string to contain a section which, within the well, will be located near, but above, the depth at which the liner is to be hung, and has an inner diameter small enough to engage and hold a tapered sleeve that is composed of brass-like material and is capable of being run in through the upper portion of the pipe string;

cementing the so-arranged pipe string in a well and, to the extent necessary, extending the well to a depth sufficient to accommodate the liner below the casing string;

running into the pipe string a liner hanger which is connected to a running string and the liner and contains the tapered sleeve of brass-like fluid material attached around a tubular upper liner hanger element containing axially aligned slots which are penetrated by lugs extending inwardly from a sleeve which is (a) fluid-tightly connected around a tubular lower liner hanger element, and (b) arranged to fit snugly, but slidably, over the tubular upper liner hanger element; and

wedging the brass-like tapered sleeve into the pipe string section of reduced diameter by subjecting that sleeve to a downwardly directed force.

* C L M S *

7. The process of claim 6 in which the gap between the tubular lower liner hanger element and the tubular upper liner hanger element is at least substantially as small as the openings in the wall of the liner to be installed.

8. The process of claim 6 in which the pipe string is cemented into a well which is subsequently extended to the extent necessary to accommodate the liner below the pipe string.

9. The process of claim 6 in which the pipe string is a casing string and a drill string is used as the running string.

10. The process of claim 9 in which the assembly comprising the liner hanger and liner are run in with the liner top connected to the hanger and the liner bottom connected to the drill string and the weight of the drill string is applied to that assembly to wedge the brass-like tapered sleeve into the casing string section of reduced inner diameter.

11. A liner hanger according to claim 1 substantially as hereinbefore described with reference to the accompanying drawings.

12. A process for installing a liner within a well according to claim 6 substantially as hereinbefore described with reference to the accompanying drawings.