BI-DIRECTIONAL SEAL ASSEMBLY

BACKGROUND OF THE INVENTION

The present invention is directed to a bi-directional seal assembly for sealing the annulus between an inner tubular member and an outer tubular member. In particular, the invention is directed to a seal assembly which includes an annular metal seal that in cross section comprises two generally U-shaped portions which enable the seal to be pressure energized from both above and below the seal assembly. The seal can be installed as an interference fit between the tubular members or mechanically energized into sealing engagement with the tubular members after it is installed.

Packoffs are commonly used in hydrocarbon production wells to seal the annulus between a wellhead and, e.g., a casing hanger which is landed in the wellhead. These prior art packoffs often include one or more metal seals which are supported on a packoff body that is locked in place between the casing hanger and the wellhead. Either during or after installation of the packoff, the seals are either mechanically or pressure energized into sealing engagement with both the wellhead and the casing hanger.

Many prior art packoffs have only one metal seal and are uni-directional, that is, they are designed to seal in only one direction. This poses difficulties when it is desired to pressure test the packoff from a port external to the wellhead. Some packoffs include elastomer seals for purposes of pressure testing. However, over time the elastomer can fail and the ability to test the packoff is consequently lost.

Therefore, a need exists for a packoff seal which is bi-directional, that is, which is capable of sealing from both above and below. In addition, a need exists for a bi-directional packoff seal whose pressure reliability in both directions can be proved by pressure testing the packoff from only one direction.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention, there is provided a seal assembly for sealing an annulus between an inner tubular member and an outer tubular member, the seal assembly comprising: an annular first seal which sealingly divides the annulus into first and second parts and which in cross section includes: a generally U-shaped first portion which comprises a radially inner first leg and a radially outer second leg, the first and second legs defining a first cavity;a generally U-shaped second portion which is located radially outwardly of the first portion and

which comprises a radially inner third leg and a radially outer fourth leg, the third and fourth legs defining a second cavity; wherein the second and third legs are joined together between the first and fourth legs such that the first cavity faces the first part of the annulus and the second cavity faces the second part of the annulus.

According to a second aspect of the present invention, there is provided a seal assembly for sealing an annulus between an inner tubular member and an outer tubular member, the seal assembly comprising: an annular first seal which is positioned in the annulus and which in cross section includes: a generally U-shaped first portion which comprises a radially inner first leg and a radially outer second leg, the first and second legs defining a first cavity; a generally U-shaped second portion which is located radially outwardly of the first portion and which comprises a radially inner third leg and a radially outer fourth leg, the third and fourth legs defining a second cavity; wherein the first and second portions are separate members and are oriented such that the first and second cavities face in opposite directions; and wherein the second and third legs are sealed against each other between the first and fourth legs.

In accordance with embodiments of the present invention, a bi-directional seal assembly is provided for sealing between an inner tubular member and an outer tubular member. The seal assembly comprises an annular seal which is positioned in the annulus and which in cross section includes a generally U-shaped first portion which comprises a radially inner first leg and a radially outer second leg, the first and second legs defining a first cavity; and a generally U-shaped second portion

cavity and a second support ring which is positioned in the second cavity. The first support ring causes the first leg to remain engaged with the inner tubular member under the influence of pressure in the second part of the annulus and the second support ring causes the fourth leg to remain engaged with the outer tubular member under the influence of pressure in the second part of the annulus. Also, pressure in the second part of the annulus forces the second leg radially inwardly to thereby urge the first leg into sealing engagement with the inner tubular member and forces the third leg radially outwardly to thereby urge the fourth leg into sealing engagement with the outer tubular member.

In accordance with yet another embodiment of the invention, the seal assembly further comprises a third support ring which is positioned in the third cavity. The third support ring causes the first and fourth legs to remain engaged with the inner and outer tubular members, respectively, under the influence of pressure in the first part of the annulus.

In accordance with a further embodiment of the invention, when the seal is in a relaxed condition the third support ring forms an interference fit with the third cavity such that, when the third support ring is inserted into the third cavity, the third support ring will force the second and third legs toward the inner and outer tubular members, respectively, to thereby urge the first and fourth legs into sealing engagement with the inner and outer tubular members, respectively.

~~The~~Embodiments of the present invention are~~is~~ also directed to a packoff which is positioned in an annulus between a wellhead and a tubular hanger which is landed in the wellhead. The packoff comprises an upper packoff body; a first seal which is positioned below the upper packoff body; and a lower packoff body which is positioned below the first seal and which is supported on one of the tubular hanger or the wellhead. In cross section, the first seal includes a generally U-shaped first portion which comprises a radially inner first leg and a radially outer second leg, the first and second legs defining a first cavity; and a generally U-shaped second portion which comprises a radially inner third leg and a radially outer fourth leg, the third and fourth legs defining a second cavity. The second and third legs are joined together between the first and fourth legs. Also, the first leg engages the tubular hanger and the fourth leg engages the wellhead to thereby sealingly divide the annulus into a first part located above the first seal and a second part located below the first seal.

Thus, embodiments of the present invention provides a bi-directional seal assembly which effectively seals from both above and below. Consequently, additional seals do not need to be employed in conjunction with the seal assembly. In addition, pressure testing of the seal assembly from one direction will establish that the seal assembly is cable of effectively sealing from both directions.

These and other embodimentsobjects and advantages of the present invention will be made apparent from the following detailed description, with reference to the accompanying drawings. In the drawings, the same reference numbers may be used to denote similar components in the various embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cross sectional representation of one embodiment of the seal assembly of the present invention showing the seal component of the invention prior to being energized by an exemplary support ring;

Figure 2 is a cross sectional representation of the seal component shown in Figure 1;

Figure 3 is a cross sectional representation of the seal assembly of Figure 1 showing the seal component after being energized by the support ring;

Figure 4 is a cross sectional representation of a second embodiment of the seal assembly of the present invention;

Figure 5 is a cross sectional representation of a third embodiment of the seal assembly of the present invention;

Figure 6 is a cross sectional representation of a fourth embodiment of the seal assembly of the present invention showing the seal component of the invention prior to being energized by another exemplary support ring;

Figure 7 is a cross sectional representation of the seal component shown in Figure 6;

Figure 8 is a cross sectional representation of an embodiment of the seal assembly of the present invention being used as an annulus packoff;

Figure 9 is a cross sectional representation of a second embodiment of the seal assembly of the present invention shown being used as an annulus packoff;

Figure 10 is a cross sectional representation of a third embodiment of the seal assembly of the present invention shown being used as an annulus packoff;

Figure 11 is a cross sectional representation of a fourth embodiment of the seal assembly of the present invention shown being used as an annulus packoff;