

Description

The present invention relates to an improved annular seal which can be used to seal across the annular space between well members. Difficulty has been encountered in the past with annular seals since manufacturing tolerances and deflection of components due to hoop strain creates an extrusion gap and adversely affects the ability to seal, the seal life and for elastomers causes extrusion problems.

Efforts have been made in prior seal assemblies to provide a structure in which the pressure to which the seal is exposed is utilized to cause a lip to move in the direction to provide a sealing engagement with a cylindrical surface against which the seal is to be provided.

US-A-2,007,501 discloses a packing for a pump rod which is rubber or similar material and includes an outer lip and an inner lip with a compression space between the lips. The fluid being pumped is received within the compression space and exerts a pressure against both lips to hold them in sealing engagement with the surfaces against which they are to seal. A plurality of channels through the packing connect the compression space with a recess on the interior of the packing to provide cooling for the reciprocating rod which moves within the packing. A filter is provided at the intersection of the duct and the compression space to prevent the entry of sand and sediment into the rod cooling recess.

US-A-4,742,874 discloses a subsea wellhead seal assembly for sealing between the interior of a wellhead housing and the exterior of a hanger. The seal assembly includes a U-shaped metal seal ring with a pair of interengaged annular wedging members which are forced into the interior of the U-shaped metal seal ring to cause its inner and outer legs to be spread apart into sealing engagement with the walls on the interior of the housing and the exterior of the hanger.

US-A-4,771,828 discloses a wellhead seal which includes an annular sealing member for sealing across the annular space between two wellhead members. The annular sealing member includes a plurality of inner and outer lips which are tapered in a direction toward the surface against which they are to seal and toward the pressure to which they may be exposed. The sealing surfaces of the wellhead members are prepared to provide an undercut on the sealing surfaces so that the pressure to which the seal is exposed can enter the undercut space and urge the undercut portion of the sealing surface in the direction toward the annular sealing member. In this manner the pressure being sealed urges both the seal lips on the annular sealing member and the undercut sealing surface portions

toward each other to provide a positive seal.

US-A-2832223 discloses an annular rubber seal having a U-shape cross section for sealing between two cylindrical members.

US-A-3159302 discloses an annular metal-to-metal seal for sealing against the flow of pressure fluid through an annular space between an outer member having an internal cylindrical sealing surface and an inner member having an external cylindrical sealing surface; and according to the present invention, such a seal is characterised by the seal comprising a first tubular metal ring having a pressure end and an opposite end, a second tubular metal ring separate from and positioned within the first tubular ring and having a pressure end and an opposite end, sealing means on the exterior of the first tubular ring spaced from the opposite end thereof, sealing means on the interior of the second tubular ring spaced from the opposite end thereof, and means securing the rings together in sealed relationship at their opposite ends to block the flow of pressure fluid between the rings so that the pressure in the portion of the passages near the sealed ends will urge the unsealed end of the rings apart.

An object of the present invention is to provide an improved annular pressure seal having a longer active seal life.

Another object is to provide an improved annular pressure seal in which the changes in the annular space being sealed do not alter the effectiveness of the seal.

A further object is to provide an improved annular pressure seal in which the pressure is utilized to allow the seal to accommodate to changes in the annular space across which it is to seal which are caused by manufacturing tolerances and as a result of the pressure to which the annular space is exposed.

Still another object is to provide an improved annular pressure seal in which a pressure responsive element is provided between inner and outer seals to ensure the maintenance of the sealing engagement of the seals with the surfaces against which they are to seal.

In the accompanying drawings:

FIGURE 1 is a partial sectional view of the improved seal of the present invention positioned between well members with facing cylindrical surfaces between which the seal is provided.

FIGURE 2 is another partial sectional view of a modified form of the improved seal of the present invention.

FIGURE 3 is another partial sectional view of another modified form of the improved seal of the present invention which forms the annulus seal in a wellhead.

FIGURE 4 is a partial transverse sectional view of the seal taken along line 4 - 4 in FIGURE 3.

FIGURE 5 is a partial sectional view of a modified form of seal of the present invention.

In FIGURE 1 seal 10 is illustrated within first tubular member 12 having upper bore 14 and counterbore 16 with shoulder 18 therebetween. The surface 20 of counterbore 16 is one of the sealing surfaces against which seal 10 is to seal. Second tubular member 22 has outer sealing surface 24 which is the other of the sealing surfaces against which seal 10 is to seal. In this manner seal 10 provides an annulus seal for sealing between members 12 and 22.

Seal 10 includes outer ring 26, inner ring 28 and intermediate ring 30. As shown, rings 26, 28 and 30 are threadedly engaged with suitable threading and having welding securing and sealing the upper end of rings 26 and 30 and of rings 28 and 30. The welding is at the end of rings 26, 28 and 30 opposite to the pressure end, i. e., the pressure is exerted on seal 10 from below and the non welded ends of the ring are herein termed the pressure end. The welded ends of rings 26, 28 and 30 are positioned against shoulder 18 as shown. Groove 32 in the exterior of outer ring 26 is provided a substantial distance from the welded end of rings 26 and 30 and groove 34 in the interior of inner ring 28 is provided a substantial distance from the welded end of rings 28 and 30. Suitable sealing means is provided within grooves 32 and 34, such as O rings 36 and 38, for sealing against the facing sealing surfaces 20 and 24.

The threaded engagement between ring 26 and ring 30 and between ring 30 and ring 28 is such that the pressure fluid which is exerted on seal from below enters between the rings and urges outer ring outwardly to assist in the sealing of O ring 36 against sealing surface 20 and urges inner ring 28 inwardly to assist in the sealing of O ring 38 against sealing surface 24.

The pressure within the threaded surfaces between the rings creates the force necessary to urge the inner and outer rings 26 and 28 toward their respective sealing surface so that the pressure exerted on the inner and outer tubular members 12 and 22 which may create an extrusion gap between the rings and the sealing surfaces does not occur because of the compensating pressure responsive movement of the rings 26 and 28.

Seal 10 as shown in FIGURE 1 and described above is a simplified seal to illustrate the novel features of the present invention. Other forms of the invention are shown in the drawings but show additional details of the seals.

In the form of the present invention shown in FIGURE 2, an improved annulus seal 40 is shown which includes lower body 42 having shoulder 41

which lands on seat 43, a plurality of bores 45 extending therethrough to transmit pressure from a position below body 42 to a position above body 42 which is between inner seal stack 44 and outer seal stack 46. Since body 42 is annular in shape, inner seal stack 44 includes a stack of sealing elements, anti-extrusion rings and other back-up elements which provide a suitable seal against the exterior of the inner member 48 and outer seal stack 46 includes a stack of sealing elements, anti-extrusion rings and other back-up elements which provide a suitable seal against the interior of outer member 50. Positioned within stacks 44 and 46 are inner ring 52 and outer ring 54. Rings 52 and 54 are secured and sealed together at their upper ends by weld 56. With pressure exerted on seal 40 from below, this pressure is exerted between rings 52 and 54 to cause them to be wedged apart to assist in the sealing forces exerted by stacks 44 and 46 in their sealing function. Suitable means 58 is provided to secure rings 52 and 54 in the desired position within stacks 44 and 46 and means 59 secures rings 52 and 54 to body 42 and cap ring 60. Cap ring 60 is secured to the upper ends of rings 52 and 54 and cap ring 60 is supported on sleeve 62, as shown, for lowering seal 40 into position between members 48 and 50.

Seal 70 shown in FIGURES 3 and 4 is a seal for use as an annulus seal for sealing across the annulus between the exterior of a hanger and the interior of a housing in which the hanger is landed. In sealing an annulus between a housing and a hanger landed therein, two sources of pressure can be encountered. If there is a fault in the cementing of the casing some pressure fluid may move upward in the space around the casing and enter the annulus within the housing to exert a pressure within the housing from a position below the annulus seal. This pressure is exerted to urge the housing outward and to urge the hanger inwardly. There would be no balancing or equalizing pressure within the hanger. In the other case, a pressure pocket could be encountered while drilling through the hanger and a pressure kick would be exerted through the interior of the hanger. To control such pressure kick, the blowout preventers above the hanger would be closed and the pressure would be exerted within the hanger and within the annulus from above. This pressure causes the housing to be urged outwardly and since there is no balancing or equalizing pressure around the major portion of the exterior of the hanger, there is an appreciable net force urging the hanger outward. The seal 70 is an improved seal structure which will maintain a sealing engagement across the annulus under either pressure condition described above.

Seal 70 includes tubular body 72 having central bore 74 and counterbore 76 extending therein from one end and body ring 78 which is positioned within counterbore 76 and is secured therein by welding 80. Grooves 82 in the exterior of body ring 78 provide communication for pressure fluids to enter between body ring 78 and counterbore 76 of body 72. Body 72 is configured on its exterior surface to provide annular seal lips 84 and 86 which are both tapered in a radially outward direction with upper seal lip 84 being directed upwardly and lower seal lip 86 being directed downwardly. Annular seal lips 84 and 86 are designed to seal against the interior of a housing bore. Groove 88 is provided in the interior of body 72 and groove 90 which is similar to groove 88 is provided in the interior of body ring 78. Elastomeric seals 92 and 94 are positioned in grooves 88 and 90 to seal against the exterior of a hanger which forms the interior of the annulus across which seal 70 is to seal.

Seal 70 includes the two main components, i. e., body 72 and body ring 78. It is preferred that body ring 78 be of a high strength metal and body 72 be of a soft material such as mild steel. With this configuration and with the materials suggested body ring 78 being of a high strength material maximizes the amount of stored energy from an interference fit of the interior of body ring 78 with respect to the inner sealing surface of the annulus. Also, the material of body 72 maximizes the ability of the seal lips to seal against scratches and other imperfections in the inner surface of the outer member of the annulus being sealed. The seal 70 also utilizes the pressure in the annulus in which it is positioned to urge body ring 78 inward and the lower portion of body 72 outward to assist in both the internal and external sealing of seal 70. It should be noted that the inner surface 96 upward of groove 88 is slightly smaller in diameter than bore 74 to provide an interference fit when seal 70 is installed around a hanger and similarly surface 98 which is at the other end of the inner surface of body ring 78 has a similar smaller diameter to provide an interference fit with the exterior of the surface against which seal 70 is to seal. With such sealing surfaces as surfaces 96 and 98 it is possible to eliminate the use of the elastomeric seals 92 and 94. Since such seals can be added immediately before the lowering of seal 70 into a well bore to seal around a hanger landed within an annulus, seal 70 can be provided without seals 92 and 94 and they can be added if desired immediately prior to their use.

It is suggested that by varying the relative thickness of body 72 around counterbore 76 and the thickness of body ring 78, the respective movements of each can be adjusted so that they readily

move with the movement of the hanger and the housing responsive to the pressure experienced in the annulus from below.

When the improved seal 70 is in position and subjected to pressure from below in the housing-hanger annulus, the grooves 82 in body ring 78 allow such pressure to be exerted to urge body ring 78 inwardly and tubular body 72 outwardly to thereby at least partially compensate for the action of the pressure on the housing and the hanger. It is not generally felt that pressure from within the hanger which is also felt in the upper end of the annulus requires any similar compensation for the relative movement of the hanger and housing responsive to such pressure since the hanger would not move, having the pressure exerted both on its interior and its exterior and the amount of movement of the housing would be accommodated by the action of the seal lips 84 and 86.

A further advantage of the present invention is that it does allow the pressure from the lower end of the annulus to be exerted between body ring 78 and tubular body 72 through the grooves 82 but this is done without sacrificing the relative strength of the structure so that during the setting of seal lips 84 and 86 with setting sleeves, the total structure of tubular body 72 and body ring 78 resist any inward forces developed during such setting. This results from the groove structure but would not result if there were a complete annular space between tubular body 72 and body ring 78 since in such structure body ring 78 would not contribute to resisting the setting loads of the seal lip setting sleeve.

It should be noted that any suitable sealing means, including O ring seals, may be used to seal the closed end of the opening between rings so long as it maintains the seal under all pressure and other conditions to which it may be exposed. Further, the thickness of the rings may be varied from one end to the other to provide the desired structure for each application, as shown in FIGURE 5 wherein the improved seal S of the present invention is positioned within annulus A between spool B which is secured to housing H and inner string I which is supported within housing H by sealing and supporting assembly 99. Seal S includes two rings 100 and 102 which are suitably supported by snap ring 103 in position in the annulus between inner member 104 and outer member 106. Seal S also includes inner seal 108 which is positioned in groove 110 on the interior of inner ring 100 and adapted to seal against the exterior of inner member 104 and outer seal 112 which is positioned in groove 114 on the exterior of outer ring 102 and adapted to seal against the interior of outer member 106. This structure makes up sealing assembly 116 which seals across the annulus A between

members 104 and 106 and is subjected to pressure which is within inner member 104 and is transmitted into annulus A above sealing assembly 116. Under such conditions pressure is applied from one direction only and the pressure is from within inner member 104 and is exerted both within and around the exterior of inner member 104 above sealing assembly 116. Inner member 104 is thus in equilibrium and will not deflect in the area down to sealing assembly 116 as pressure increases. Outer member 106 which is not in equilibrium will deflect as pressure is applied. A suitable seal is provided between inner ring 100 and outer ring 102 by sealing element 120 which is positioned in groove 122 on the lower interior of ring 102. Ring 100 has a stepped outer surface with upper surface 124 being of a larger diameter than lower surface 126. Shoulder 128 is positioned between surfaces 124 and 126. Ring 102 is provided with an internal configuration including upper surface 130 which is larger in diameter than lower surface 132 and shoulder 134 is positioned between surfaces 130 and 132 as shown. This structure allows the upper portion of ring 102 to be relatively flexible and to easily deflect with pressure between rings 100 and 102. The lower portion of ring 102 being much thicker will not deflect nearly as much because of the relative stiffness of its wall section. Also, at the point of sealing between the two rings 100 and 102, sealing element 120, both rings are relatively thick and will have relatively little deflection which ensures the maintenance of the sealing of element 120 between the members 100 and 102.

Claims

1. An annular metal-to-metal seal for sealing against the flow of pressure fluid through an annular space between an outer member having an internal cylindrical sealing surface and an inner member having an external cylindrical sealing surface characterised by the seal comprising a first tubular metal ring (26,54,72,102) having a pressure end and an opposite end, a second tubular metal ring (28,52,78,100) separate from and positioned within the first tubular ring and having a pressure end and an opposite end, sealing means (36,46,84,86,112) on the exterior of the first tubular ring spaced from the opposite end thereof, sealing means (34,44,92,94,108) on the interior of the second tubular ring spaced from the opposite end thereof, and means (27,29,56,80,103) securing the rings together in sealed relationship at their opposite ends to block the flow of pressure fluid between the rings so that the pressure in the portion of the passages near the sealed

ends will urge the unsealed end of the rings apart.

2. An annular seal according to claim 1, wherein the sealing means includes an internal stack (44) of sealing elements within the second ring (52), and an external stack (46) of sealing elements surrounding the first ring (54).
3. An annular seal according to claim 1, wherein the exterior sealing means includes a pair of diverging rings (84,86) extending outwardly from the first tubular ring (72), the interior sealing means includes a resilient sealing ring (92,94) positioned in an annular groove (88,90) on the interior of the second ring (78).
4. An annular seal according to claim 1, including a third annular ring (30) positioned between the first (26) and second (28) rings having a pressure end and an opposite end, wherein welding (27,29) secures the third ring to the first and second rings at their respective opposite ends.
5. An annular seal according to claim 1, wherein the tubular rings (102,100) have varying thickness axially to accommodate the pressure responses of the internal and external sealing surfaces.

Patentansprüche

1. Metall-Metall-Ringdichtung zur Abdichtung des Flusses von Druckfluid in einen Ringraum zwischen einem äußeren Teil mit einer inneren zylindrischen Dichtungsfläche und einem inneren Teil mit einer äußeren zylindrischen Dichtungsfläche, dadurch gekennzeichnet, daß die Dichtung umfaßt: einen ersten rohrförmigen Metallring (26, 54, 72, 102) mit einem Druckende und einem gegenüberliegenden Ende, einen zweiten rohrförmigen Metallring (28, 52, 78, 100), der innerhalb des ersten rohrförmigen Ringes und getrennt von diesem angeordnet ist, und ein Druckende und ein gegenüberliegendes Ende aufweist, eine Dichtungseinrichtung (36, 46, 84, 86, 112) an der Außenseite des ersten rohrförmigen Ringes, die von dessen gegenüberliegendem Ende beabstandet ist, eine Dichtungseinrichtung (34, 44, 92, 94, 108) an der Innenseite des zweiten rohrförmigen Metallringes, die von dessen gegenüberliegendem Ende beabstandet ist, und Mittel (27, 29, 56, 80, 103), die die Ringe an deren gegenüberliegenden Enden dicht zusammenhalten, um den Fluß des Druckfluides zwischen den Ringen zu blockieren, so daß



members 104 and 106 and is subjected to pressure which is within inner member 104 and is transmitted into annulus A above sealing assembly 116. Under such conditions pressure is applied from one direction only and the pressure is from within inner member 104 and is exerted both within and around the exterior of inner member 104 above sealing assembly 116. Inner member 104 is thus in equilibrium and will not deflect in the area down to sealing assembly 116 as pressure increases. Outer member 106 which is not in equilibrium will deflect as pressure is applied. A suitable seal is provided between inner ring 100 and outer ring 102 by sealing element 120 which is positioned in groove 122 on the lower interior of ring 102. Ring 100 has a stepped outer surface with upper surface 124 being of a larger diameter than lower surface 126. Shoulder 128 is positioned between surfaces 124 and 126. Ring 102 is provided with an internal configuration including upper surface 130 which is larger in diameter than lower surface 132 and shoulder 134 is positioned between surfaces 130 and 132 as shown. This structure allows the upper portion of ring 102 to be relatively flexible and to easily deflect with pressure between rings 100 and 102. The lower portion of ring 102 being much thicker will not deflect nearly as much because of the relative stiffness of its wall section. Also, at the point of sealing between the two rings 100 and 102, sealing element 120, both rings are relatively thick and will have relatively little deflection which ensures the maintenance of the sealing of element 120 between the members 100 and 102.

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1. An annular metal-to-metal seal for sealing against the flow of pressure fluid through an annular space between an outer member having an internal cylindrical sealing surface and an inner member having an external cylindrical sealing surface characterised by the seal comprising a first tubular metal ring (26,54,72,102) having a pressure end and an opposite end, a second tubular metal ring (28,52,78,100) separate from and positioned within the first tubular ring and having a pressure end and an opposite end, sealing means (36,46,84,86,112) on the exterior of the first tubular ring spaced from the opposite end thereof, sealing means (34,44,92,94,108) on the interior of the second tubular ring spaced from the opposite end thereof, and means (27,29,56,80,103) securing the rings together in sealed relationship at their opposite ends to block the flow of pressure fluid between the rings so that the pressure in the portion of the passages near the sealed

ends will urge the unsealed end of the rings apart.

2. An annular seal according to claim 1, wherein the sealing means includes an internal stack (44) of sealing elements within the second ring (52), and an external stack (46) of sealing elements surrounding the first ring (54).
3. An annular seal according to claim 1, wherein the exterior sealing means includes a pair of diverging rings (84,86) extending outwardly from the first tubular ring (72), the interior sealing means includes a resilient sealing ring (92,94) positioned in an annular groove (88,90) on the interior of the second ring (78).
4. An annular seal according to claim 1, including a third annular ring (30) positioned between the first (26) and second (28) rings having a pressure end and an opposite end, wherein welding (27,29) secures the third ring to the first and second rings at their respective opposite ends.
5. An annular seal according to claim 1, wherein the tubular rings (102,100) have varying thickness axially to accommodate the pressure responses of the internal and external sealing surfaces.

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der Druck in dem Teil der Durchlässe nahe den abgedichteten Enden die unabgedichteten Enden der Ringe voneinander wegdrückt.

2. Ringdichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Dichtungseinrichtung eine innere Packung (44) von Dichtungselementen innerhalb des zweiten Ringes (52) umfaßt, und eine äußere Packung (46) von Dichtungselementen den ersten Ring (54) umgibt. 5
3. Ringdichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Dichtungseinrichtung ein Paar von divergierenden Ringen (84, 86) umfaßt, die vom ersten rohrförmigen Ring (72) nach außen vorstehen und die innere Dichtungseinrichtung einen elastischen Dichtungsring (92, 94) aufweist, der in einer ringförmigen Nut (88, 90) an der Innenseite des zweiten Ringes (78) angeordnet ist. 10
4. Ringdichtung nach Anspruch 1, dadurch gekennzeichnet, daß ein dritter ringförmiger Ring (30) zwischen dem ersten (26) und dem zweiten (28) Ring angeordnet ist und ein Druckende und ein gegenüberliegendes Ende aufweist, worin eine Schweißung (27, 29) den dritten Ring mit den ersten und zweiten Ringen an deren entsprechenden entgegengesetzten Enden verbindet. 15
5. Ringdichtung nach Anspruch 1, dadurch gekennzeichnet, daß die rohrförmigen Ringe (102, 100) eine axial veränderliche Dicke aufweisen, um die Druckreaktionen der inneren und der äußeren Dichtungsflächen aufzunehmen. 20

Revendications

1. Joint annulaire métal sur métal destiné à assurer l'étanchéité à l'encontre d'un écoulement de fluide sous pression à travers un espace annulaire existant entre un élément extérieur ayant une surface d'étanchéité cylindrique intérieure et un élément intérieur ayant une surface d'étanchéité cylindrique extérieure, caractérisé en ce que le joint comporte un premier anneau métallique tubulaire (26, 54, 72, 102) ayant une extrémité de pression et une extrémité opposée, un deuxième anneau métallique tubulaire (28, 52, 78, 100) séparé du premier anneau tubulaire et positionné dans celui-ci et ayant une extrémité de pression et une extrémité opposée, des moyens d'étanchéité (36, 46, 84, 86, 112) situés sur l'extérieur du premier anneau tubulaire en étant éloignés de l'extrémité opposée de celui-ci, des moyens 25

d'étanchéité (34, 46, 92, 94, 108) situés à l'extérieur du deuxième anneau tubulaire en étant éloignés de l'extrémité opposée de celui-ci, et des moyens (27, 29, 56, 80, 103) de fixation des anneaux l'un à l'autre en relation d'étanchéité au niveau de leurs extrémités opposées pour bloquer l'écoulement de fluide sous pression entre les anneaux de sorte que la pression existant dans la partie des passages proche des extrémités étanches écarte l'extrémité non-étanche des anneaux.

2. Joint annulaire selon la revendication 1, dans lequel des moyens d'étanchéité comportent un empilage intérieur (44) d'éléments d'étanchéité situé dans le deuxième anneau (52), et un empilage extérieur (46) d'éléments d'étanchéité entourant le premier anneau (54). 30
3. Joint annulaire selon la revendication 1, dans lequel les moyens d'étanchéité extérieure comportent une paire d'anneaux divergents (84, 86) s'étendant vers l'extérieur à partir du premier anneau tubulaire (72), les moyens d'étanchéité intérieurs comportent un anneau d'étanchéité élastique (92, 94) positionné dans une gorge annulaire (88, 90) située sur l'intérieur du deuxième anneau (78). 35
4. Joint annulaire selon la revendication 1, comportant un troisième anneau tubulaire (30) positionné entre le premier (26) et deuxième (28) anneaux ayant une extrémité de pression et une extrémité opposée, dans laquelle une soudure (27, 29) fixe le troisième anneau sur les premier et au deuxième anneaux au niveau de leurs extrémités opposées respectives. 40
5. Joint annulaire selon la revendication 1, dans lequel les anneaux tubulaires (102, 100) ont une épaisseur variant axialement pour engendrer les réponses à la pression des surfaces d'étanchéité intérieure et extérieure. 45