

METAL SEAL WITH SOFT INLAYS

This invention relates to casing seals for wellheads, and in particular to a metal seal for sealing between the casing and the wellhead bore.

In a completed oil or gas well, one or
5 more strings of casing is cemented in the well. A wellhead is located at the surface for supporting the upper end of the casing. The wellhead includes a lower portion through which the casing extends. A casing hanger supports the casing in the lower portion of the
10 wellhead.

In one technique, the casing hanger fits around the casing, and the upper end of the casing will be cut off a selected distance above the wellhead after cementing. A casing seal or packoff will be
15 placed between the casing and the bore of an upper portion of the wellhead. This packoff prevents leakage from the casing bore to the annulus between the casing and the wellhead.

In many wells, the produced fluid will be
20 at a fairly warm temperature as it reaches the surface of the casing. The warm temperature can cause the casing to expand axially. The wellhead, however, will not move axially. This results in a slight amount of axial movement of the casing relative to the wellhead.

25 In the past, elastomeric seals were used as packoffs primarily. These seals would tolerate a slight amount of axial movement of the casing relative to the wellhead. However, metal seals are now preferred for many oil field applications. Metal seals
30 are longer lasting and are not subject to deterioration from certain well fluids to the extent that elastomeric seals may be. However, a metal seal requires a very precise fit in order to accomplish

sealing. Also, axial movement would damage the sealing ability of the metal seal.

In U.S. Patent 4,711,832, Charles D. Bridges, September 20, 1988, a metal seal is
5 illustrated for sealing between casing and the wellhead. The metal seal includes two eccentric rings. These rings can be rotated to accommodate slight misalignment of the axis of the casing relative to the axis of the wellhead. The inner sealing ring has an
10 inner face that seals against the exterior of the casing. This inner face contains bands that are axially spaced apart. The bands are soft enough to deform when the seal ring is pressed into contact with the casing.

15 While this type of arrangement is satisfactory for a static seal, axial movement of the casing relative to the ring can cause problems. It could damage the seal face on the seal bands, destroying the effectiveness of the seal.

20 In this invention, a metal ring is provided with a sealing side that faces the cylindrical member such as the casing. The ring has a plurality of circumferential axially spaced metal bands that protrude from the sealing side. These bands
25 define cavities between them. An inlay of soft metal is located in these cavities.

When the seal is energized into sealing contact with the casing, the bands will deform and flatten. Preferably, the inlay material partially
30 fills the cavities. When the bands flatten, they will become substantially flush with the inlay material. Later, if the casing begins to move axially, the inlay

material will wipe across the bands, maintaining the effectiveness of the seal.

Figure 1 is a partial sectional view illustrating a seal constructed in accordance with this invention.

Figure 2 is an enlarged sectional view of the seal of Figure 1.

Referring to Figure 1, the well has a lower wellhead 11 which has a bore 13. An upper wellhead 15 secures to the lower wellhead 11 by means of flanges (not shown) which bolt together. A seal 17 locates between the faces of the upper and lower wellheads 15, 11. Upper wellhead 15 has a bore 19 that is co-axial with bore 13.

The bore 19 includes an enlarged counterbore 23. The junction between the counterbore 23 and the bore 19 results in a downward facing shoulder 21. Counterbore 23 includes a lower tapered section 25 that diverges in a downward direction.

A wedge ring 27 locates within the counterbore 23. Wedge ring 27 has an upper end that will contact the shoulder 21. Wedge ring 27 has a lower section that is conical both on the inner side 29 and the outer side 31. The taper of the outer side 31 matches that of the counterbore tapered section 25. The upper portion of the wedge ring 27 is cylindrical. A seal ring 33 locates within the inside of the wedge ring 27.

Seal ring 33 will rest on top of a test ring 35. Test ring 35 locates in the upper portion of the lower wellhead 11. Seal ring 33 has a tapered outer side 37. The taper of the outer side 37 matches that of the taper of the inner side 29 of the wedge

ring 27. Seal ring 33 has an inner side 39 that is cylindrical for sealing on the exterior of casing 41. The casing 41 extends substantially coaxial through the bores 13, 19.

5 Referring to Figure 2, a plurality of bands 43 protrude radially inward from the seal ring inner side 39. Bands 43 are circumferential and axially spaced apart even distances. The sealing face or inner side of each band 43 is cylindrical.

10 The bands 43 define cavities 45 between them. An inlay 47 of soft metal partially fills each cavity 45. Prior to energizing, the bands 43 will protrude a slight distance radially inward of the exterior surface of the inlay 47. This results in a
15 slight clearance 48. When the bands 43 first touch the casing 41, the clearance 48 will exist between the inlays 47 and the casing 41. The bands 43 preferably protrude from the cavities 47 about .040 inch^(0.1cm). The clearance 48 between the sealing surface of the bands
20 43 and the exterior surface of the inlay 47 is preferably about .015 to .020 inch. (0.04 to 0.05cm)

The material of the seal ring 33 is softer than the casing 41. Typical casing may have a yield strength of 55,000 to 60,000 psi^(37921 to 41368 kPa). Preferably, the
25 yield strength of the seal ring 33 will be about half of the yield strength of the casing 41. The material of the inlay 47 is much softer than the material of the seal ring 33. It will be a lubricating type material such as a tin indium alloy. Other suitable
30 alloys including cadmium or lead could also be used. The hardness of the inlay 47 will be only about 25 percent of the hardness of the seal ring 33 material.

Preferably, the seal ring 33 and the wedge ring 27 are eccentric and constructed as described in more detail in U.S. Patent 4,771,832, all of which material is hereby incorporated by reference.

5 In operation, the casing 41 will be cemented in place. A casing hanger (not shown) will be then positioned between the casing 41 and the lower wellhead 11 to support the casing. The test ring 35 will be positioned in place. The upper end of the
10 casing 41 will be cut off a selected distance above the lower wellhead 11.

The exterior of the casing 41 above the test ring 35 will be wire brushed and smoothed with emery cloth. The seal ring 33 and wedge ring 27 are
15 placed over the casing 41. Both rings 27 and 33 may be rotated, but normally only one of the rings will be rotated. Rotation will be performed until the centerline of the seal ring 33 coincides with the axis of the lower wellhead 11.

20 Once aligned, the upper wellhead 15 is bolted to the lower wellhead 11. The shoulder 21 bears down on the wedge ring 27. The wedge ring 27 pushes the seal ring 33 inward with great force. This causes the bands 43 to permanently flatten and deform. The
25 bands 43 will flatten until they are substantially flush with the exterior surface of the inlay 47, as shown in Figure 1. The outer side 31 of the wedge ring 27 forms a tight metal seal with the lower tapered section 25. The inner side 29 of wedge ring 27 forms a
30 tight metal seal with the seal ring tapered side 37.

Under certain conditions during production, the casing 41 may move up and down relative to the seal ring 33. The casing 41 may

possibly move as much as one-fourth inch/ in one direction, and .050 inch/ in ^(0.13cm) the reverse direction from the position that the casing 41 first acquired when the ring 33 was set. If this occurs, the inlay 47 will
5 wipe into damaged areas of the seal bands 43. The cavities 45 serve as reservoirs to store up the inlay material 47 for wiping across the faces of the bands 43.

The invention has significant advantages.

10 The metal seal ring will seal on casing that can move slight distances axially. The reservoir of inlay material produces a seal capable of withstanding this axial movement, which is generated by changes in temperature or tension load.

15 While the invention has been shown in only one of its forms, it should be apparent to those skilled in the art that it is not so limited, but is susceptible to various changes without departing from the scope of the invention.

CLAIMS

1. An apparatus for sealing against a cylindrical member, comprising in combination:

5 a metal ring having a sealing side facing the cylindrical member;

a plurality of circumferential axially spaced metal bands protruding radially from the sealing side, defining cavities between the bands;

10 an inlay material of metal softer than the bands located in the cavities; and

means for moving the sealing side into sealing contact with the cylindrical member, the bands being sufficiently soft relative to the cylindrical member to deform when forced into contact with the cylindrical member but allowing slight axial movement of the cylindrical member relative to the ring with the inlay material wiping onto the bands during said axial movement.

20 2. An apparatus for sealing an annular space between a first member inserted within a second member, comprising in combination:

a metal ring having a first sealing side facing the first member and a second sealing side facing the second member;

25 a plurality of circumferential axially spaced metal bands protruding radially from the first sealing side, defining cavities between the bands, each of the bands having a cylindrical sealing surface;

30 an inlay material of metal softer than the bands located in and initially partially filling the cavities, the sealing surfaces of the bands initially



located a selected radial distance past the exterior surfaces of the inlay material; and

means for moving the first sealing side into contact with the first member and for sealingly
5 contacting the second sealing side with the second member, the bands being sufficiently soft relative to the first member to cause the bands to become substantially flush with the exterior surfaces of the inlay material when the ring is forced into contact
10 with the first member, the bands allowing slight axial movement of the first member relative to the ring with the inlay material wiping onto the bands during said axial movement.

3. In a well assembly having a wellhead
15 containing a string of casing supported in the bore, an improved means for sealing against the casing, comprising in combination:

a metal ring having an inner sealing side facing the casing;

20 a plurality of circumferential axially spaced metal bands protruding radially inward from the inner sealing side, defining cavities between the bands, each of the bands having a cylindrical sealing surface;

25 an inlay material of metal softer than the bands located in and initially partially filling the cavities, the sealing surfaces of the bands initially located a selected distance radially inward from the exterior surfaces of the inlay material; and

30 means for moving the inner sealing side into contact with the casing, the bands being sufficiently soft relative to the casing to cause the bands to deform to a position substantially flush with



the exterior surfaces of the inlay material when the ring is forced into contact with the casing, the bands allowing slight axial movement of the casing relative to the ring with the inlay material wiping onto the bands during said axial movement.

4. A method for sealing a cylindrical member, comprising in combination:

providing a metal ring having a sealing side facing the cylindrical member;

10 providing a plurality of circumferential axially spaced metal bands protruding radially from the sealing side, defining cavities between the bands, and providing each of the bands with a cylindrical sealing surface, the bands being softer than the
15 cylindrical member;

partially filling the cavities with an inlay material of metal softer than the bands, with the sealing surfaces of the bands initially located a selected radial distance past the exterior surfaces of
20 the inlay material; and

pushing the sealing side into contact with the cylindrical member, deforming the bands substantially flush with the exterior surfaces of the inlay material, the bands allowing slight axial
25 movement of the cylindrical member relative to the ring with the inlay material wiping onto the bands during said axial movement.
