What is claimed is:

1. A subsea wellhead assembly comprising:

a subsea wellhead (13) defining a bore having a shoulder (12);

a casing hanger (11) landed on the shoulder (12) within the bore of the subsea wellhead (13) and defining an annulus (15) between the subsea wellhead (13) and the casing hanger (11);

a casing hanger seal ring (17) disposed within the annulus (15), engaged with an inner diameter surface of the wellhead (13), and engaged with an outer diameter surface of the casing hanger (11) so that the seal ring (17) prevents flow through the annulus (15); and

a lockdown slip ring (23) secured to a lower end of the seal ring (17) so that, when the seal ring (17) is energized, the lockdown slip ring (23) engages a substantially smooth inner diameter surface portion of the wellhead (13) and a substantially smooth outer diameter surface portion of the casing hanger (11) to limit upwards axial movement of the casing hanger (11).

2. The subsea wellhead assembly of Claim 1, wherein a retaining ring (67) is interposed between the lockdown slip ring (23) and the seal ring (17) to secure the lockdown slip ring (23) to the seal ring (17).

3. The subsea wellhead assembly of Claim 1, wherein the lockdown slip ring (23) comprises:

an annular protrusion having a taper (18) adjacent the smooth surface portion of the inner diameter of the subsea wellhead (13);

the annular protrusion having a ramped surface (20) radially opposite the taper (18), the ramped surface (20) adapted to interface with a shoulder (16) of the substantially smooth outer diameter of the casing hanger (11) so that upward axial movement of the casing hanger (11) will cause the shoulder (16) to engage the ramped surface (20) and displace the annular protrusion radially outward so that the taper (18) engages the smooth surface of the inner diameter of the subsea wellhead (13); and

wherein surfaces of the taper (18) and the ramped surface (20) of the annular protrusion define wickers adapted to engage the substantially smooth surfaces of the casing hanger (11) and subsea wellhead (13).

4. The subsea wellhead assembly of Claim 1, wherein the lockdown slip ring (23) comprises:

a coupling ring (27) secured to a lower end of the seal ring (21), the coupling ring (27) having a ramped surface (37);

a slip ring (29) having a ramped surface (47) abutting the ramped surface (37) of the coupling ring (27), the slip ring (29) held in a first position relative to the coupling ring (27) by a shear element (55); and

the slip ring (29) secured to the coupling ring (27) so that axial movement of the slip ring (29) causing shear of the shear element (55) will cause the slip ring (29) to slide along the ramped surface (37) of the coupling ring (27), increasing the radial width of the lockdown slip ring (23).

5. The subsea wellhead assembly of Claim 4, wherein the coupling ring (27) ramped surface (37) faces the outer diameter surface of the casing hanger (11).

6. The subsea wellhead assembly of Claim 4, wherein the coupling ring (27) ramped surface (37) faces the inner diameter surface of the wellhead (13).

7. The subsea wellhead assembly of Claim 4, wherein:

the ramped surface (37) of the coupling ring (27) faces downward and outward; and

the ramped surface (47) of the slip ring (29) faces upward and inward.

8. The subsea wellhead assembly of Claim 1, wherein

the coupling ring (27) further comprising wickers (73) on a surface parallel to an axis of the coupling ring (27) opposite the ramped surface (37) so that the wickers (73) engage at least one of the inner diameter of the subsea wellhead (13) and the outer diameter of the casing hanger (11); and

the slip ring (29) further comprising wickers (71) on a surface parallel to an axis of the slip ring (29) opposite the surface (47) slidingly engaged with the coupling ring (27) so that

the wickers (71) engage at least one of the outer diameter of the casing hanger (11) and the inner diameter of the subsea wellhead (13).

9. The subsea wellhead assembly of Claim 2, further comprising:

a neck (31) on an upper end of the lockdown slip ring (23), the neck (31) having a groove (33) on an outer diameter of the neck (31);

a lower leg (63) on a lower end of the seal ring (21), the lower leg (63) having a recess (65) on an inner diameter of the lower leg (63); and

wherein the retainer ring (67) comprises a split ring interposed between the neck (31) of the lockdown slip ring (23) and the lower leg (63) of the seal ring (21) so that the retainer ring (67) is partially within the groove (33) and partially within the recess (65), securing the lockdown slip ring (21) to the seal ring (21).

10. A method for sealing a casing hanger (11) to a wellhead (13), comprising:

(a) landing the casing hanger (11) on a shoulder in the wellhead (13);

(b) securing a lockdown slip ring (23) to a lower end of a casing hanger seal (17) and landing the casing hanger seal (17) in an annulus between the casing hanger (11) and the wellhead (13);

(c) energizing the casing hanger seal (17) by exerting a downward axial force on the casing hanger seal (17) to compress the seal (17) and the lockdown slip ring (23) against a shoulder (16) of the casing hanger (11); and

(d) wherein the downward axial force causes the lockdown slip ring (23) to engage a substantially smooth inner diameter surface of the wellhead (13) and a substantially smooth outer diameter surface of the casing hanger (11) to limit upward axial movement of the casing hanger (11).

11. The method of Claim 10, further comprising wickers (71, 73) on the inner and outer diameters of the lockdown slip ring (23), wherein, in the event the casing hanger (11) moves axially upward, step (d) comprises moving the lockdown slip ring (23) of the casing hanger seal (17) radially into tighter engagement with the inner diameter surface of the wellhead (13) by

engaging the wickers (71, 73) on the inner and outer diameter surfaces of the lockdown slip ring (23) with the casing hanger (11) and wellhead (13).

12. The method of Claim 10, wherein, the lockdown slip ring (23) comprises a coupling ring (27) and a slip ring (29) that are moveable axially between contracted and extended positions:

wherein step (a) comprises securing the coupling ring (27) and the slip ring (29) in the extended position with a shear element (55); and

wherein step (d) comprises shearing the shear element (55) and causing the coupling ring (27) and slip ring (29) to move toward the contracted position.

What is claimed is:

1. A subsea wellhead assembly comprising:

a subsea wellhead defining a bore having a shoulder;

a casing hanger landed on the shoulder within the bore of the subsea wellhead and defining an annulus between the subsea wellhead and the casing hanger;

a casing hanger seal ring disposed within the annulus, engaged with an inner diameter surface of the wellhead, and engaged with an outer diameter surface of the casing hanger so that the seal ring prevents flow through the annulus; and

a lockdown slip ring secured to a lower end of the seal ring so that, when the seal ring is energized, the lockdown slip ring engages a substantially smooth generally axially straight inner diameter surface portion of the wellhead and a substantially smooth generally axially straight outer diameter surface portion of the casing hanger to limit upwards axial movement of the casing hanger.

2. The subsea wellhead assembly of Claim 1, wherein a retaining ring is interposed between the lockdown slip ring and the seal ring to secure the lockdown slip ring to the seal ring.

3. The subsea wellhead assembly of Claim 1, wherein the lockdown slip ring comprises:

an annular protrusion having a taper adjacent the smooth surface portion of the inner diameter of the subsea wellhead;

the annular protrusion having a ramped surface radially opposite the taper, the ramped surface adapted to interface with a shoulder of the substantially smooth outer diameter of the casing hanger so that upward axial movement of the casing hanger will cause the shoulder to engage the ramped surface and displace the annular protrusion radially outward so that the taper engages the smooth surface of the inner diameter of the subsea wellhead; and

wherein surfaces of the taper and the ramped surface of the annular protrusion define wickers adapted to engage the substantially smooth surfaces of the casing hanger and subsea wellhead.

4. The subsea wellhead assembly of Claim 1, wherein the lockdown slip ring (23) comprises:

a coupling ring secured to a lower end of the seal ring, the coupling ring having a ramped surface;

a slip ring having a ramped surface abutting the ramped surface of the coupling ring, the slip ring held in a first position relative to the coupling ring by a shear element; and

the slip ring secured to the coupling ring so that axial movement of the slip ring causing shear of the shear element will cause the slip ring to slide along the ramped surface of the coupling ring, increasing the radial width of the lockdown slip ring.

5. The subsea wellhead assembly of Claim 4, wherein the coupling ring ramped surface faces the outer diameter surface of the casing hanger.

6. The subsea wellhead assembly of Claim 4, wherein the coupling ring ramped surface faces the inner diameter surface of the wellhead.

7. The subsea wellhead assembly of Claim 4, wherein:

the ramped surface of the coupling ring faces downward and outward; and the ramped surface of the slip ring faces upward and inward.

8. The subsea wellhead assembly of Claim 1, wherein the lockdown slip ring comprises:

a coupling ring secured to a lower end of the seal ring, the coupling ring having a ramped surface, the coupling ring further comprising wickers on a surface parallel to an axis of the coupling ring opposite the ramped surface so that the wickers engage at least one of the inner diameter of the subsea wellhead and the outer diameter of the casing hanger; and

a slip ring having a ramped surface abutting the ramped surface of the coupling ring, the slip ring further comprising wickers on a surface parallel to an axis of the slip ring opposite the surface slidingly engaged with the coupling ring so that the wickers

engage at least one of the outer diameter of the casing hanger and the inner diameter of the subsea wellhead.

9. The subsea wellhead assembly of Claim 2, further comprising:

a neck on an upper end of the lockdown slip ring, the neck having a groove on an outer diameter of the neck;

a lower leg on a lower end of the seal ring, the lower leg having a recess on an inner diameter of the lower leg; and

wherein the retainer ring comprises a split ring interposed between the neck of the lockdown slip ring and the lower leg of the seal ring so that the retainer ring is partially within the groove and partially within the recess, securing the lockdown slip ring to the seal ring.

10. A seal for sealing an annulus between inner and outer tubular members, wherein the inner tubular member is landed in a bore of the outer tubular member, the seal comprising:

a seal ring adapted to land in annulus and adapted to expand radially when energized to engage an inner diameter surface of the outer tubular member and an outer diameter surface of the inner tubular members;

a lockdown slip ring secured to a lower end of the seal ring so that, when energized, the lockdown slip ring may engage a substantially smooth generally axially straight diameter surface of the outer tubular member and a substantially smooth generally axially straight outer diameter surface of the inner tubular member to limit upwards axial movement of the inner tubular member;

the lockdown slip ring having a neck on an upper end of the lockdown slip ring, the neck having a groove on an outer diameter of the neck;

the seal ring having a lower leg on a lower end of the seal ring, the lower leg having a recess on an inner diameter of the lower leg; and

wherein a retainer ring comprises a split ring interposed between the neck of the lockdown slip ring and the lower leg of the seal ring so that the retainer ring is partially within the groove and partially within the recess, securing the lockdown slip ring to the seal ring.

11. The seal of Claim 10, wherein the lockdown slip ring comprises:

an annular protrusion having a taper adjacent the inner diameter of the outer tubular member; and

the annular protrusion having a ramped surface radially apposite the taper, the ramped surface adapted to interface with a shoulder on the outer diameter of the inner tubular member so that upward axial movement of the inner tubular member will cause the shoulder to engage the ramped surface and displace the annular protrusion radially outward so that the taper engages the inner diameter of the outer tubular member.

12. The seal of Claim 11, wherein the surface of the taper has a first friction factor, and the ramped surface has a second friction factor.

13. The seal of Claim 11, wherein surfaces of the taper and the ramped surface of the annular protrusion define wickers adapted to engage the surfaces of the inner and outer tubular members.

14. The seal of Claim 10, wherein the lockdown slip ring comprises:

a coupling ring secured to a lower end of the seal ring, the coupling ring having a ramped surface;

a slip ring having a ramped surface abutting the ramped surface of the coupling ring, the slip ring held in a first position relative to the coupling ring by a shear element; and

the slip ring secured to the coupling ring so that axial movement of the slip ring causing shear of the shear element will cause the slip ring to slide along the ramped surface of the coupling ring, increasing the radial width of the lockdown slip ring.

15. The seal of Claim 14, wherein the coupling ring ramped surface is adapted to the face the outer diameter surface of the inner tubular member.

16. The seal of Claim 14, wherein the coupling ring ramped surface is adapted to face the inner diameter surface of the outer tubular member.

17. The seal of Claim 14, wherein:

the coupling ring further comprising wickers on a surface parallel to an axis of the coupling ring opposite the ramped surface so that the wickers engage at least one of the inner diameter of the outer tubular member and the outer diameter of the inner tubular member; and

the slip ring further comprising wickers on a surface parallel to an axis of the slip ring opposite the surface slidingly engaged with the coupling ring so that the wickers engage at least one of the outer diameter of the inner tubular member and the inner diameter of the outer tubular member.

18. A method for sealing a casing hanger to a wellhead, comprising:

(a) landing the casing hanger on a shoulder in the wellhead;

(b) securing a lockdown slip ring to a lower end of a casing hanger seal and landing the casing hanger seal in an annulus between the casing hanger and the wellhead;

(c) energizing the casing hanger seal by exerting a downward axial force on the casing hanger seal to compress the seal and the lockdown slip ring against a shoulder of the casing hanger; and

(d) wherein the downward axial force causes the lockdown slip ring to engage a substantially smooth generally axially straight inner diameter surface of the wellhead and a substantially smooth generally axially straight outer diameter surface of the casing hanger to limit upward axial movement of the casing hanger.

19. The method of Claim 18, further comprising wickers on the inner and outer diameters of the lockdown slip ring, wherein, in the event the casing hanger moves axially upward, step (d) comprises moving the lockdown slip ring of the casing hanger seal radially into tighter engagement with the inner diameter surface of the wellhead by engaging the wickers on the inner and outer diameter surfaces of the lockdown slip ring with the casing hanger and wellhead.

20. The method of Claim 18, wherein, the lockdown slip ring comprises a coupling ring and a slip ring that are moveable axially between contracted and extended positions:

wherein step (a) comprises securing the coupling ring and the slip ring in the extended position with a shear element; and

wherein step (d) comprises shearing the shear element and causing the coupling ring and slip ring to move toward the contracted position.