inward facing surface and a curvilinear portion of the second radially outward facing surface.

[0019a] In a further aspect, there is provided a method of producing tubular members with a center shoulder that separates metal-to-metal seals from high stress areas of the center shoulder: producing first and second tubular members, each with a pin end and a box end, where: each pin end includes: a center shoulder configuration having a first annular groove and a first annular tooth, the first annular groove defined by a radially inward facing undercut surface, an adjacent first annular shoulder face and an adjacent first radially outward facing surface, the first annular tooth defined by the radially inward facing undercut surface, a first annular tooth face and a second radially outward facing surface, and at least a first threaded section on a side of the center shoulder configuration; each box end includes: a center shoulder configuration having a second annular groove and a second annular tooth, the second annular groove defined by a radially outward facing undercut surface, an adjacent second annular shoulder face and an adjacent first radially inward facing surface, the second annular tooth defined by the radially outward facing undercut surface, a second annular tooth face and a second radially inward facing surface, and at least a first threaded section on a side of the center shoulder configuration; the center shoulder configuration and first threaded section of the pin end of the first tubular member configured for mating connection with the center shoulder configuration and first threaded section of the box end of the second tubular member and sized such that upon make-up of the pin end of the first tubular member with the box end of the second tubular member: the second annular tooth will be positioned within the first annular groove with the-second annular tooth face engaging the first annular shoulder face to define a first shoulder and the first annular tooth will be positioned within the second annular groove with the first annular tooth face engaging the second annular shoulder face to define a second shoulder;

a location of primary sealing contact between the first radially outward facing surface of the pin end of the first tubular member and the second radially inward facing surface of the box end of the second tubular member will be axially spaced apart from the first shoulder; and a location of primary sealing contact between the first radially inward facing surface of the box end of the second tubular member and the second radially outward facing surface of the pin end of the first tubular member will be axially spaced apart from the second shoulder.

[0019b] In another aspect, there is provided a method of connecting tubular members, comprising: (a) utilizing first and second tubular members, each with a pin end and a box end, where: each pin end includes: a center shoulder configuration having a first annular groove and a first annular tooth, the first annular groove defined by a radially inward facing undercut surface, an adjacent first annular shoulder face and an adjacent first radially outward facing surface, the first annular tooth defined by the radially inward facing undercut surface, a first annular tooth face and a second radially outward facing surface, and at least a first threaded section on a side of the center shoulder configuration, and each box end includes: a center shoulder configuration, having a second annular groove and a second annular tooth, the second annular groove defined by a radially outward facing undercut surface, an adjacent second annular shoulder face and an adjacent first radially inward facing surface, the second annular tooth defined by the radially outward facing undercut surface, a second annular tooth face and a second radially inward facing surface, and at least a first threaded section on a side of the center shoulder configuration; (b) engaging the pin end of the first tubular member with the box end of the second tubular member; (c) producing relative rotation between the first tubular member and the second tubular member such that interaction of at least a first threaded section of each of the the first and second tubular members moves the first and second tubular

tubular member such that: the second annular tooth is positioned within the first annular groove with the second annular tooth face engaging the first annular shoulder face to define a first shoulder and the first annular tooth is positioned within the second annular groove with the first annular tooth face engaging the second annular shoulder face to define a second shoulder; a location of primary sealing contact between the first radially outward facing surface of the pin end of the first tubular member and the second radially inward facing surface of the box end of the second tubular member is axially spaced apart from the first shoulder; and a location of primary sealing contact between the first radially inward facing surface of the box end of the second tubular member and the second radially outward facing surface of the pin end of the first tubular member is axially spaced apart from the second shoulder.

[0020] The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] Fig. 1 is a partial cross-section of one prior art center shoulder seal arrangement;

[0022] Fig. 2 is a partial cross-section of another prior art center shoulder seal arrangement;

[0023] Fig. 3 is a partial cross-section of one embodiment of a center shoulder seal;

[0024] Fig. 4 is a partial cross-section of another embodiment of a center shoulder seal; and

[0025] Fig. 5 is a partial cross-section of another embodiment of a center-shoulder seal in which the location of primary sealing contact to opposite sides of the connection includes engaged threads to one side of the center-shoulder, but lacks any engaged threads to the other side of the center-shoulder.

DETAILED DESCRIPTION

[0026] Referring to Fig. 3, a partial cross-section of a center shoulder connection 200 between two tubular members 202 and 204 is shown. Tubular member 202 forms the pin portion of the connection and tubular member 204 forms the box end of the connection. An axial centerline of the connection is shown at 206, and it is recognized that a full cross-section of the center shoulder connection would include a mirror image of the components on the opposite side of the axial centerline (i.e., below the centerline 206 in Fig. 3).

[0027] A seal configuration on tubular member 202 includes an annular groove 208 and an annular tooth 210. The annular groove 208 is defined by a radially inward facing (i.e., facing toward the centerline 206) undercut surface 212, an adjacent annular shoulder face 214 and an adjacent radially outward facing surface 216. The annular tooth is defined by the radially inward facing undercut surface 212, an annular tooth face 218 and a radially outward facing surface 220. In the illustrated embodiment, the surface 216 includes a corner radius that transitions to the shoulder face 214, and the surface 220 includes a corner radius that transitions to the tooth face 218.

[0028] A seal configuration on the tubular member 204 includes an annular groove

CLAIMS

1. A metal-to-metal sealing system connecting first and second tubular members comprising:

a first seal configuration on the first tubular member including a first annular groove and a first annular tooth, the first annular groove defined by a radially inward facing undercut surface, an adjacent first annular shoulder face and an adjacent first radially outward facing surface, the first annular tooth defined by the radially inward facing undercut surface, a first annular tooth face and a second radially outward facing surface;

a second seal configuration on the second tubular member including a second annular groove and a second annular tooth, the second annular groove defined by a radially outward facing undercut surface, an adjacent second annular shoulder face and an adjacent first radially inward facing surface, the second annular tooth defined by the radially outward facing undercut surface, a second annular tooth face and a second radially inward facing surface;

wherein the second annular tooth is positioned within the first annular groove with the second annular tooth face engaging the first annular shoulder face to define a first shoulder;

wherein the first annular tooth is positioned within the second annular groove with the first annular tooth face engaging the second annular shoulder face to define a second shoulder;

wherein a location of primary sealing contact between the first radially outward facing surface of the first tubular member and the second radially inward facing surface of the second tubular member is spaced axially away from the first shoulder;

wherein a location of primary sealing contact between the first radially inward facing surface of the second tubular member and the second radially outward facing surface of the first tubular member is axially spaced from the second shoulder.

2. The system of claim 1 wherein:

clearance is provided between the first radially outward facing surface and the second radially inward facing surface adjacent to the first shoulder; and

clearance is provided between the first radially inward facing surface and the second radially outward facing surface adjacent to the second shoulder.

3. The system of claim 1 wherein the location of primary sealing contact between the first radially outward facing surface and the second radially inward facing surface is axially spaced from the first shoulder by a greater distance than the location of primary sealing contact between the first radially inward facing surface and the second radially outward facing surface.

4. The system of claim 1 wherein the location of primary sealing contact between the first radially outward facing surface and the second radially inward facing surface is axially spaced from the first shoulder by between about 25 thousandths of an inch and about two inches, and the location of primary sealing contact between the first radially inward facing surface and the second radially outward facing surface is axially spaced from the second shoulder by between about 25 thousandths of an inch and about one inch.

5. The system of claim 1 wherein a radial spacing between the first radially outward facing surface and the second radially outward facing surface in a plane of the first shoulder is between about 40 and about 500 thousandths of an inch, and a radial spacing between the first radially inward facing surface and the second radially inward facing surface in a plane of the second shoulder is between about 40 and about 500 thousandths of an inch.

6. The system of claim 1 wherein the radially inward facing undercut surface engages the radially outward facing undercut surface.

7. The system of claim 1 wherein:

the location of primary sealing contact between the first radially outward facing surface and the second radially inward facing surface is formed by interference between one of:

(i) a frustoconical portion of the first radially outward facing surface and a frustoconical portion of the second radially inward facing surface;

(ii) a frustoconical portion of the first radially outward facing surface and a curvilinear portion of the second radially inward facing surface;

(iii) a curvilinear portion of the first radially outward facing surface and a frustoconical portion of the second radially inward facing surface; or

(iv) a curvilinear portion of the first radially outward facing surface and a curvilinear portion of the second radially inward facing surface;

the location of primary sealing contact between the first radially inward facing surface and the second radially outward facing surface is formed by interference between one of:

(i) a frustoconical portion of the first radially inward facing surface and a frustoconical portion of the second radially outward facing surface;

(ii) a frustoconical portion of the first radially inward facing surface and a curvilinear portion of the second radially outward facing surface;

(iii) a curvilinear portion of the first radially inward facing surface and a frustoconical portion of the second radially outward facing surface; or

(iv) a curvilinear portion of the first radially inward facing surface and a curvilinear portion of the second radially outward facing surface.

8. The system of claim 1 wherein the first radially outward facing surface of the first tubular member and the second radially inward facing surface of the second tubular member are configured such that a location of primary sealing contact between the surfaces lies outside of an axial region between the first shoulder and the second shoulder and wherein the first radially inward facing surface of the second tubular member and the second radially outward facing surface of the first tubular member are configured such that a location of primary sealing contact between the surfaces lies outside of the axial region.

9. The system of claim 8 wherein the axial region extends from between about 20 and about 250 thousandths of an inch.

10. A metal-to-metal sealing system connecting first and second tubular members comprising:

a first seal configuration on the first tubular member including a first annular groove and a first annular tooth, the first annular groove defined by a radially inward facing undercut surface, an adjacent first annular shoulder face and an adjacent first radially outward facing surface, the first annular tooth defined by the radially inward facing undercut surface, a first annular tooth face and a second radially outward facing surface;

a second seal configuration on the second tubular member including a second annular groove and a second annular tooth, the second annular groove defined by a radially outward facing undercut surface, an adjacent second annular shoulder face and an adjacent first radially inward facing surface, the second

annular tooth defined by the radially outward facing undercut surface, a second annular tooth face and a second radially inward facing surface;

wherein the second annular tooth is positioned within the first annular groove with the second annular tooth face engaging the first annular shoulder face to define a first shoulder;

wherein the first annular tooth is positioned within the second annular groove with the first annular tooth face engaging the second annular shoulder face to define a second shoulder;

wherein the first radially outward facing surface of the first tubular member and the second radially inward facing surface of the second tubular member are configured such that a location of primary sealing contact between the surfaces lies outside of an axial region between the first shoulder and the second shoulder;

wherein the first radially inward facing surface of the second tubular member and the second radially outward facing surface of the first tubular member are configured such that a location of primary sealing contact between the surfaces lies outside of the axial region.

11. The system of claim 10 wherein the axial region extends from between about 20 and about 250 thousandths of an inch.

12. The system of claim 11 wherein:

wherein the location of primary sealing contact between the first radially outward facing surface and the second radially inward facing surface is external of the axial region but within at least about 1750 thousandths of an inch of the axial region;

wherein the location of primary sealing contact between the first radially inward facing surface and the second radially outward facing surface is external of the axial region but within at least about 750 thousandths of an inch of the axial region.

13. The system of claim 12 wherein:

the location of primary sealing contact between the first radially outward facing surface and the second radially inward facing surface is formed by interference between one of:

(i) a frustoconical portion of the first radially outward facing surface and a frustoconical portion of the second radially inward facing surface;

(ii) a frustoconical portion of the first radially outward facing surface and a curvilinear portion of the second radially inward facing surface;

(iii) a curvilinear portion of the first radially outward facing surface and a frustoconical portion of the second radially inward facing surface; or

(iv) a curvilinear portion of the first radially outward facing surface and a curvilinear portion of the second radially inward facing surface;

the location of primary sealing contact between the first radially inward facing surface and the second radially outward facing surface is formed by interference between one of:

(i) a frustoconical portion of the first radially inward facing surface and a frustoconical portion of the second radially outward facing surface;

(ii) a frustoconical portion of the first radially inward facing surface and a curvilinear portion of the second radially outward facing surface;

(iii) a curvilinear portion of the first radially inward facing surface and a frustoconical portion of the second radially outward facing surface; or

(iv) a curvilinear portion of the first radially inward facing surface and a curvilinear portion of the second radially outward facing surface.

14. A method of producing tubular members with a center shoulder that separates metal-to-metal seals from high stress areas of the center shoulder:

producing first and second tubular members, each with a pin end and a box end, where:

each pin end includes: a center shoulder configuration having a first annular groove and a first annular tooth, the first annular groove defined by a radially inward facing undercut surface, an adjacent first annular shoulder face and an adjacent first radially outward facing surface, the first annular tooth defined by the radially inward facing undercut surface, a first annular tooth face and a second radially outward facing surface, and at least a first threaded section on a side of the center shoulder configuration;

each box end includes: a center shoulder configuration having a second annular groove and a second annular tooth, the second annular groove defined by a radially outward facing undercut surface, an adjacent second annular shoulder face and an adjacent first radially inward facing surface, the second annular tooth defined by the radially outward facing undercut surface, a second annular tooth face and a second radially inward facing surface, and at least a first threaded section on a side of the center shoulder configuration;

the center shoulder configuration and first threaded section of the pin end of the first tubular member configured for mating connection with the center shoulder configuration and first threaded section of the box end of the second tubular member and sized such that upon make-up of the pin end of the first tubular member with the box end of the second tubular member:

the second annular tooth will be positioned within the first annular groove with the-second annular tooth face engaging the first annular shoulder face to define a first shoulder and the first annular tooth will be positioned within the second annular groove with the first annular tooth face engaging the second annular shoulder face to define a second shoulder;

a location of primary sealing contact between the first radially outward facing surface of the pin end of the first tubular member and the second radially inward facing surface of the box end of the second tubular member will be axially spaced apart from the first shoulder; and

a location of primary sealing contact between the first radially inward facing surface of the box end of the second tubular member and the second radially outward facing surface of the pin end of the first tubular member will be axially spaced apart from the second shoulder.

15. The method of claim 14 wherein:

clearance is provided between the first radially outward facing surface and the second radially inward facing surface adjacent to the first shoulder; and

clearance is provided between the first radially inward facing surface and the second radially outward facing surface adjacent to the second shoulder.

16. The method of Claim 14 wherein the location of primary sealing contact between the first radially outward facing surface and the second radially inward facing surface is axially spaced from the first shoulder by a greater distance than the location of primary sealing contact between the first radially inward facing surface and the second radially outward facing surface.

17. The method of Claim 14 wherein the location of primary sealing contact between the first radially outward facing surface and the second radially inward facing surface is axially spaced from the first shoulder by between about 25 thousandths of an inch and about two inches, and the location of primary sealing contact between the first radially inward facing surface and the second radially outward facing surface is axially spaced from the second shoulder by between about 25 thousandths of an inch and about one inch.

18. The method of Claim 14 wherein a radial spacing between the first radially outward facing surface and the second radially outward facing surface in a plane of the first shoulder is between about 40 and about 500 thousandths of an inch, and a radial spacing between the first radially inward facing surface and the second radially inward facing surface in a plane of the second shoulder is between about 40 and about 500 thousandths of an inch.

19. The method of Claim 14 wherein the radially inward facing undercut surface engages the radially outward facing undercut surface.

20. The method of Claim 14 wherein:

the location of primary sealing contact between the first radially outward facing surface and the second radially inward facing surface is formed by interference between one of:

(i) a frustoconical portion of the first radially outward facing surface and a frustoconical portion of the second radially inward facing surface;

(ii) a frustoconical portion of the first radially outward facing surface and a curvilinear portion of the second radially inward facing surface;

(iii) a curvilinear portion of the first radially outward facing surface and a frustoconical portion of the second radially inward facing surface; or

(iv) a curvilinear portion of the first radially outward facing surface and a curvilinear portion of the second radially inward facing surface;

the location of primary sealing contact between the first radially inward facing surface and the second radially outward facing surface is formed by interference between one of:

(i) a frustoconical portion of the first radially inward facing surface and a frustoconical portion of the second radially outward facing surface;

(ii) a frustoconical portion of the first radially inward facing surface and a curvilinear portion of the second radially outward facing surface;

(iii) a curvilinear portion of the first radially inward facing surface and a frustoconical portion of the second radially outward facing surface; or

(iv) a curvilinear portion of the first radially inward facing surface and a curvilinear portion of the second radially outward facing surface.

21. The method of claim 14 wherein the first radially outward facing surface of the first tubular member and the second radially inward facing surface of the second tubular member are configured such that a location of primary sealing contact between the surfaces lies outside of an axial region between the first shoulder and the second shoulder and wherein the first radially inward facing surface of the second tubular member and the second radially outward facing surface of the first tubular member are configured such that a location of primary sealing contact between the surfaces lies outside of the axial region.

22. The method of Claim 21 wherein the axial region extends from between about 20 and about 250 thousandths of an inch.

23. A method of connecting tubular members, comprising:

(a) utilizing first and second tubular members, each with a pin end and a box end, where:

each pin end includes: a center shoulder configuration having a first annular groove and a first annular tooth, the first annular groove defined by a radially inward facing undercut surface, an adjacent first annular shoulder face and an adjacent first radially outward facing surface, the first annular tooth defined by the radially inward facing undercut surface, a first annular tooth face and a second radially outward facing surface, and at least a first threaded section on a side of the center shoulder configuration, and

each box end includes: a center shoulder configuration, having a second annular groove and a second annular tooth, the second annular groove defined by a radially outward facing undercut surface, an adjacent second annular shoulder face and an adjacent first radially inward facing surface, the second annular tooth defined by the radially outward facing undercut surface, a second annular tooth face and a second radially inward facing surface, and at least a first threaded section on a side of the center shoulder configuration;

(b) engaging the pin end of the first tubular member with the box end of the second tubular member;

(c) producing relative rotation between the first tubular member and the second tubular member such that interaction of at least a first threaded section of each of the the first and second tubular members moves the first and second tubular members together;

(d) completing make-up of the pin end of the first tubular member and the box end of the second tubular member such that:

the second annular tooth is positioned within the first annular groove with the second annular tooth face engaging the first annular shoulder face to define a first shoulder and the first annular tooth is positioned within the second annular groove with the first annular tooth face engaging the second annular shoulder face to define a second shoulder;

a location of primary sealing contact between the first radially outward facing surface of the pin end of the first tubular member and the second radially inward facing surface of the box end of the second tubular member is axially spaced apart from the first shoulder; and

a location of primary sealing contact between the first radially inward facing surface of the box end of the second tubular member and the second radially outward facing surface of the pin end of the first tubular member is axially spaced apart from the second shoulder.

Claims

1. A metal-to-metal sealing system connecting first and second tubular members comprising:

a first seal configuration on the first tubular member including a first annular groove and a first annular tooth, the first annular groove defined by a radially inward facing undercut surface, an adjacent first annular shoulder face and an adjacent first radially outward facing surface, the first annular tooth defined by the radially inward facing undercut surface, a first annular tooth face and a second radially outward facing surface;

a second seal configuration on the second tubular member including a second annular groove and a second annular tooth, the second annular groove defined by a radially outward facing undercut surface, an adjacent second annular shoulder face and an adjacent first radially inward facing surface, the second annular tooth defined by the radially outward facing undercut surface, a second annular tooth face and a second radially inward facing surface;

wherein the second annular tooth is positioned within the first annular groove with the second annular tooth face engaging the first annular shoulder face to define a first shoulder;

wherein the first annular tooth is positioned within the second annular groove with the first annular tooth face engaging the second annular shoulder face to define a second shoulder;

wherein a location of primary sealing contact between the first radially outward facing surface of the first tubular member and the second radially inward facing surface of the second tubular member is spaced axially away from the first shoulder;

wherein a location of primary sealing contact between the first radially inward facing surface of the second tubular member and the second radially outward facing surface of the first tubular member is axially spaced from the second shoulder.

2. The system of claim 1 wherein:

clearance is provided between the first radially outward facing surface and the second radially inward facing surface in the vicinity of the first shoulder; and

clearance is provided between the first radially inward facing surface and the second radially outward facing surface in the vicinity of the second shoulder.

3. The system of claim 1 wherein the location of primary sealing contact between the first radially outward facing surface and the second radially inward facing surface is axially spaced from the first shoulder by between about 25 thousandths of an inch and about two inches, and the location of primary sealing contact between the first radially inward facing surface and the second radially outward facing surface is axially spaced from the second shoulder by between about 25 thousandths of an inch and about one inch.

4. The system of claim 1 wherein a radial spacing between the first radially outward facing surface and the second radially outward facing surface in a plane of the first shoulder is between about 40 and about 500 thousandths of an inch, and a radial spacing between the first radially inward facing surface and the second radially inward facing surface in a plane of the second shoulder is between about 40 and about 500 thousandths of an inch.

5. The system of claim 1 wherein the radially inward facing undercut surface engages the radially outward facing undercut surface.

6. The system of claim 1 wherein:

the location of primary sealing contact between the first radially outward facing surface and the second radially inward facing surface is formed by interference between one of:

(i) a frustoconical portion of the first radially outward facing surface and a frustoconical portion of the second radially inward facing surface;

(ii) a frustoconical portion of the first radially outward facing surface and a curvilinear portion of the second radially inward facing surface;

(iii) a curvilinear portion of the first radially outward facing surface and a frustoconical portion of the second radially inward facing surface; or

(iv) a curvilinear portion of the first radially outward facing surface and a curvilinear portion of the second radially inward facing surface;

the location of primary sealing contact between the first radially inward facing surface and the second radially outward facing surface is formed by interference between one of:

(i) a frustoconical portion of the first radially inward facing surface and a frustoconical portion of the second radially outward facing surface;

(ii) a frustoconical portion of the first radially inward facing surface and a curvilinear portion of the second radially outward facing surface;

(iii) a curvilinear portion of the first radially inward facing surface and a frustoconical portion of the second radially outward facing surface; or

(iv) a curvilinear portion of the first radially inward facing surface and a curvilinear portion of the second radially outward facing surface.

7. A metal-to-metal sealing system connecting first and second tubular members comprising:

a first seal configuration on the first tubular member including a first annular groove and a first annular tooth, the first annular groove defined by a radially inward facing undercut surface, an adjacent first annular shoulder face and an adjacent first radially outward facing surface, the first annular tooth defined by the radially inward facing undercut surface, a first annular tooth face and a second radially outward facing surface;

a second seal configuration on the second tubular member including a second annular groove and a second annular tooth, the second annular groove defined by a radially outward facing undercut surface, an adjacent second annular shoulder face and an adjacent first radially inward facing surface, the second annular tooth defined by the radially outward facing undercut surface, a second annular tooth face and a second radially inward facing surface;

wherein the second annular tooth is positioned within the first annular groove with the second annular tooth face engaging the first annular shoulder face to define a first shoulder;

wherein the first annular tooth is positioned within the second annular groove with the first annular tooth face engaging the second annular shoulder face to define a second shoulder;

wherein the first radially outward facing surface of the first tubular member and the second radially inward facing surface of the second tubular member are configured such that a location of primary sealing contact between the surfaces lies outside of an axial region between the first shoulder and the second shoulder;

wherein the first radially inward facing surface of the second tubular member and the second radially outward facing surface of the first tubular member are configured such that a location of primary sealing contact between the surfaces lies outside of the axial region.

8. The system of claim 7 wherein the axial region extends from between about 40 and about 250 thousandths of an inch.

9. The system of claim 8 wherein:

wherein the location of primary sealing contact between the first radially outward facing surface and the second radially inward facing surface is external of the axial region but within at least about 1750 thousandths of an inch of the axial region;

wherein the location of primary sealing contact between the first radially inward facing surface and the second radially outward facing surface is external of the axial region but within at least about 750 thousandths of an inch of the axial region.

10. The system of claim 9 wherein:

the location of primary sealing contact between the first radially outward facing surface and the second radially inward facing surface is formed by interference between one of:

(i) a frustoconical portion of the first radially outward facing surface and a frustoconical portion of the second radially inward facing surface;

(ii) a frustoconical portion of the first radially outward facing surface and a curvilinear portion of the second radially inward facing surface;

(iii) a curvilinear portion of the first radially outward facing surface and a frustoconical portion of the second radially inward facing surface; or

(iv) a curvilinear portion of the first radially outward facing surface and a curvilinear portion of the second radially inward facing surface;

the location of primary sealing contact between the first radially inward facing surface and the second radially outward facing surface is formed by interference between one of:

(i) a frustoconical portion of the first radially inward facing surface and a frustoconical portion of the second radially outward facing surface;

(ii) a frustoconical portion of the first radially inward facing surface and a curvilinear portion of the second radially outward facing surface;

(iii) a curvilinear portion of the first radially inward facing surface and a frustoconical portion of the second radially outward facing surface; or

(iv) a curvilinear portion of the first radially inward facing surface and a curvilinear portion of the second radially outward facing surface.

11. A method of producing tubular members with a center shoulder that separates metal-to-metal seals from high stress areas of the center shoulder:

producing first and second tubular members, each with a pin end and a box end, where:

each pin end includes: a center shoulder configuration having a first annular groove and a first annular tooth, the first annular groove defined by a radially inward facing undercut surface, an adjacent first annular shoulder face and an adjacent first radially outward facing surface, the first annular tooth defined by the radially inward facing undercut surface, a first annular tooth face and a second radially outward facing surface, and at least a first threaded section on a larger diameter side of the center shoulder configuration;

each box end includes: a center shoulder configuration having a second annular groove and a second annular tooth, the second annular groove defined by a radially outward facing undercut surface, an adjacent second annular shoulder face and an adjacent first radially inward facing surface, the second annular tooth defined by the radially outward facing undercut surface, a second annular tooth face and a second radially inward facing surface, and at least a first threaded section on a larger diameter side of the center shoulder configuration;

the center shoulder configuration and first threaded section of the pin end of the first tubular member configured for mating connection with the center shoulder configuration and first threaded section of the box end of the second tubular member and sized such that upon make-up of the pin end of the first tubular member with the box end of the second tubular member:

the second annular tooth will be positioned within the first annular groove with the second annular tooth face engaging the first annular shoulder face to define a first shoulder and the first annular tooth will be

positioned within the second annular groove with the first annular tooth face engaging the second annular shoulder face to define a second shoulder;

a location of primary sealing contact between the first radially outward facing surface of the pin end of the first tubular member and the second radially inward facing surface of the box end of the second tubular member will be axially spaced apart from the first shoulder; and

a location of primary sealing contact between the first radially inward facing surface of the box end of the second tubular member and the second radially outward facing surface of the pin end of the first tubular member will be axially spaced apart from the second shoulder.

12. A method of connecting tubular members, comprising:

(a) utilizing first and second tubular members, each with a pin end and a box end, where:

each pin end includes: a center shoulder configuration having a first annular groove and a first annular tooth, the first annular groove defined by a radially inward facing undercut surface, an adjacent first annular shoulder face and an adjacent first radially outward facing surface, the first annular tooth defined by the radially inward facing undercut surface, a first annular tooth face and a second radially outward facing surface, and at least a first threaded section on a larger diameter side of the center shoulder configuration;

each box end includes: a center shoulder configuration having a second annular groove and a second annular tooth, the second annular groove defined by a radially outward facing undercut surface, an adjacent second annular shoulder face and an adjacent first radially inward facing surface, the second annular tooth defined by the radially outward facing undercut surface, a second annular tooth face and a second radially inward facing surface, and at least a first threaded section on a larger diameter side of the center shoulder configuration;

(b) engaging the pin end of the first tubular member with the box end of the second tubular member;

(c) producing relative rotation between the first tubular member and the second tubular member such that interaction of the first threaded sections of the first and second tubular members moves the first and second tubular members together;

(d) completing make up of the pin end of the first tubular member and the box end of the second tubular member such that:

the second annular tooth is positioned within the first annular groove with the second annular tooth face engaging the first annular shoulder face to define a first shoulder and the first annular tooth is positioned within the second annular groove with the first annular tooth face engaging the second annular shoulder face to define a second shoulder;

a location of primary sealing contact between the first radially outward facing surface of the pin end of the first tubular member and the second radially inward facing surface of the box end of the second tubular member is axially spaced apart from the first shoulder; and

a location of primary sealing contact between the first radially inward facing surface of the box end of the second tubular member and the second radially outward facing surface of the pin end of the first tubular member is axially spaced apart from the second shoulder.