CLAIMS

What is claimed is:

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 first 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 axially spaced away from the first shoulder;

wherein a second 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; and

wherein at least one of the first tubular member and the second tubular member comprises a dope relief recess that is axially spaced away from the first and second locations of primary sealing contact.

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 first 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 second 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 first 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 second 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 first 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 second location of primary sealing contact between the surfaces lies outside of the axial region; and

wherein at least one of the first tubular member and the second tubular member comprises a dope relief recess that is axially spaced away from the first and second locations of primary sealing contact.

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 first 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 second 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 first 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 second 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 first 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 second 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; and

wherein at least one of the first tubular member and the second tubular member comprises a dope relief recess that is axially spaced away from the first and second locations of primary sealing contact.

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 first 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 second 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; and

wherein at least one of the first tubular member and the second tubular member comprises a dope relief recess that is axially spaced away from the first and second locations of primary sealing contact.

13. 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 first 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 second location of primary sealing contact between the surfaces lies outside of the axial region; and

wherein clearance is provided between at least one of:

the first radially outward facing surface and the second radially inward facing surface in the vicinity of the first shoulder; and

the first radially inward facing surface and the second radially outward facing surface in the vicinity of the second shoulder.

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 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 first 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 second 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; and

wherein clearance is provided between at least one of: the first radially outward facing surface and the second radially inward facing surface in the vicinity of the first shoulder; and

the first radially inward facing surface and the second radially outward facing surface in the vicinity of the second shoulder.