

## EXTERNAL PRESSURE GASKET

### BACKGROUND

[0001] In order to find and produce new oil and gas reserves, exploration continues to lead to greater depths within the ocean. As a result, Christmas tree and wellhead equipment must operate at greater depths and therefore must be capable of withstanding greater external hydrostatic head pressures. For oil wells, the increased external hydrostatic head pressure is not particularly problematic, as the internal pressure of the well typically balances the external hydrostatic head pressure.

[0002] In gas wells, on the other hand, the external hydrostatic head pressure is much more likely to create problems. This is particularly true when a valve closes in the subsea Christmas tree and pressure is bled from the flow line. When this occurs, equipment downstream of a closed valve can have atmospheric or near-atmospheric pressure on the inside, and full subsea head pressure on the outside. With maximum water depths currently around 10,000 feet, the pressure differential between the inside and the outside can be substantial at around 4470 psi. Most components of the subsea wellhead equipment and Christmas trees are sized based on designs originally intended for surface use. The surface designed components are sized for higher internal pressures and can thus withstand the external subsea pressure. However, gaskets are typically designed for internal pressure only, and therefore may not be suitable for substantial external pressure. One example of this type of gasket is a bonnet gasket found on a valve.

[0003] To overcome external pressure on the bonnet gasket, some manufacturers have added o-rings or made the gasket with a second, external seal to keep the external pressure off the primary bonnet gasket seal surface. This approach has the disadvantage in that, during factory acceptance testing with internal pressure, a slight leak may occur at the gasket's primary seal, which may be masked by the external seal. Another disadvantage is that there is no way to test the external seal with external pressure during the factory acceptance test. Thus, when the equipment is installed, if external pressure were to leak past the external seal, the primary seal may also leak because it is not stiff enough to withstand the external pressure.

[0004] Another approach to overcoming the pressure differential involves a specialized gasket with a cross-section that is substantially thicker for subsea applications than for surface



applications. The use of this type of gasket may result in a bonnet and body with a special gasket seat profile and therefore not desirable.

#### **SUMMARY**

[0005] The present invention relates generally to gaskets. More specifically, the present invention relates to gaskets designed to withstand pressure differentials in subsea environments, such as those where the greater pressure may be acting either on the inside or on the outside of the gasket.

[0006] In one embodiment of the present invention a gasket has an upper surface, a substantially cylindrical inner surface abutting the upper surface, a lower surface abutting the inner surface, and generally opposite the upper surface, and an outer surface abutting the upper surface and the lower surface, and generally opposite the inner surface. The outer surface has a sealing surface between the upper surface and the lower surface, a first depression between the sealing surface and the upper surface, and a second depression between the sealing surface and the lower surface.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

[0007] Figure 1 is a cross sectional view of a conventional gasket with the outer portion of the gasket being on the right side of the gasket and the inner portion being on the left.

[0008] Figure 2 is a model of the conventional gasket of Figure 1.

[0009] Figure 3 is a model of the conventional gasket of Figure 1, after installation.

[0010] Figure 4 is a model of the conventional gasket of Figure 1, after installation, with internal pressure present.

[0011] Figure 5 is a model of the conventional gasket of Figure 1, after installation, with external pressure present.

[0012] Figure 6 is a cross sectional view of a gasket in accordance with one embodiment of the present invention.

[0013] Figure 7 is a cross sectional view of a gasket in accordance with another embodiment of the present invention.

[0014] Figure 8 is a cross sectional view of a gasket in accordance with another embodiment of the present invention.

[0015] Figure 9 is a cross sectional view of a gasket in accordance with another embodiment of the present invention

[0016] Figure 10 is a model of a gasket in accordance with one embodiment of the present invention.

[0017] Figure 11 is a model of the gasket of Figure 10, after installation.

[0018] Figure 12 is a model of the gasket of Figure 10, after installation, with internal pressure present.

[0019] Figure 13 is a model of the gasket of Figure 10, after installation, with external pressure present.

[0020] Figure 14 is a cross sectional view of a gasket having an insert in accordance with yet another embodiment of the present invention.

#### **DETAILED DESCRIPTION**

[0021] Referring generally to Figures 1-5, conventional gasket 100 may generally be considered a short cylinder with a thin cross section. Conventional gasket 100 has the purpose of forming a seal between two mating components. Conventional gasket 100 sits in a "seating area" of one component and the other component, which also has a "seating area," is placed over conventional gasket 100. The "seating area" of the components has a very smooth surface finish and is slightly smaller in diameter than the mating surface of the conventional gasket 100. The seating area of the components can have a slight taper or a taper and a straight bore. Likewise, on the outside of conventional gasket 100 on or near upper and lower surfaces 106 and 108, the surface finish is also very smooth and conventional gasket 100 is slightly larger than the "seating area" of the two components into which conventional gasket 100 will be installed.

[0022] The two components are "made up," or drawn together by some means, such as tightening of bolting, until the components are at a desired position and conventional gasket 100 is at the installed condition or state. As the components are "made up," conventional gasket 100 contacts the taper that, as the components are further "made up" causes conventional gasket 100 to deflect inward and to be squeezed. As conventional gasket 100 is squeezed, it resists deflection and exerts an outward force. This outward force forms the seal between conventional gasket 100 and the components. A way to analyze conventional gasket 100 is to split it up into three parts: the two ends and the mid-section. The end sections of gasket 100 are located directly under the sealing surface of the "seating area," which is being deflected inward. The end sections of conventional gasket 100 are in compression, and therefore exert a resistant force. The mid-section of gasket 100 is between the two end sections of conventional gasket 100 and also will deflect inward when the end sections are deflected inward. This section of conventional gasket 100 will also develop a reaction load, due to being deflected inward, although this mid-section will not deflect inward as much as the end sections do. These three loading mechanisms are what conventional gasket 100 uses to develop its sealing force.

[0023] Figure 1 is a cross sectional view of conventional gasket 100, with sealing surfaces 102 and 104 directly abutting upper surface 106 and lower surface 108 of conventional gasket 100. Sealing surfaces 102 and 104 may or may not be raised from the main surfaces of conventional gasket 100. In the Figures, sealing surfaces 102 and 104 are shown raised for clarity. Non-sealing, outer gasket surfaces 103 and 105 may be located between central stabilization ring 110 and sealing surfaces 102 and 104.

[0024] Figure 2 is a model of conventional gasket 100 of Figure 1. Conventional gasket 100 is modeled with sealing surfaces 102 and 104 being attached to central stabilization ring 110 via springs 112 and 114. Stabilization ring 110 may extend from this gasket as shown in Figures 1-14 or it may be flush. Springs 112 and 114 are indicated by zigzag lines between the sealing surfaces 102 and 104 of conventional gasket 100 and central stabilization ring 110. Springs 112 and 114 are used to model how conventional gasket 100 may flex when installed and when pressure is applied to the inner diameter or outer diameter of conventional gasket 100.

[0025] Figure 3 is a model of the conventional gasket of Figure 1, after installation into gasket seat profile 200. The sealing length of conventional gasket 100 is shown deflected inward with central stabilization ring 110 helping to energize sealing surfaces 102 and 104 as depicted by springs 112 and 114 bending. Gasket sealing force, as indicated by arrow 116, is present on sealing surfaces 102 and 104.

[0026] Figure 4 is a model of conventional gasket 100 of Figure 1, after installation into gasket seat profile 200, with internal pressure 118 present. Gasket sealing force 116 has increased, relative to force 116 of Figure 3. This is due to internal pressure 118. Internal pressure 118 acts on the full inner length of conventional gasket 100. The load from internal pressure 118 causes stabilization ring 110 and the mid portion of conventional gasket 100 to deflect outward to the right, pivoting over sealing surfaces 102 and 104. This is depicted by springs 112 and 114 further bending.

[0027] Figure 5 is a model of conventional gasket 100 of Figure 1, after installation into gasket seat profile 200, with external pressure 120 present. Gasket sealing force 116 has decreased relative to force 116 of Figures 3 and 4. Stabilization ring 110 and mid-portion of gasket 100 has deflected to the left. This is due to external pressure 120. External pressure 120 acts on the outer length of conventional gasket 100 only up to the point where sealing surfaces 102 and 104 start. Thus, when external pressure 122 is at or near that of ambient sea pressure at a great depth with no internal pressure, then a leak path 122 may occur, such that external fluid may get past sealing surfaces 102 and 104. It is desirable to prevent leakage from external pressure that occurs with conventional gasket 100 for a number of reasons. This may be accomplished by using a different gasket 10.

[0028] Referring generally to Figures 6-13, gasket 10 not only uses the same mid-portion and end loadings as conventional gasket 100, but has two additional loadings to help energize the seal. The additional two loadings come from seal wings 34 and 36. Seal wings 34 and 36 give loadings in a similar manner as the second loadings of conventional gasket 100. A gasket with seal wings 34 and 36 may seal on gasket seat profile 200 that is tapered inward from flange faces 210, as shown, or tapered outward, or straight bored.

[0029] One potential advantage of gasket 10 with seal wings 34 and 36 is that the loading on the gasket sealing area may be increased over that of conventional gasket 100 having a similar profile. In surface applications, this may provide some advantage. In subsea applications, the profile of gasket 10 may provide a significant advantage as conventional gasket 100 is typically thinned down towards the top and bottom ends, where the sealing surfaces of conventional gasket 100 are located. The thinned down portion of conventional gasket 100 helps conventional gasket 100 to flex without being over-stressed during installation or service. While this thinning is helpful in surface applications, it is detrimental in subsea applications. In the most extreme loading, with a high ambient sea pressure on the outside of gasket 100 and atmospheric pressure on the inside of gasket 100, the sea pressure will load gasket 100 such that sea pressure attempts to unload gasket 100. Gasket 100 needs to be stiff to resist the sea pressure. However, in typical designs, the thin gasket area at the ends of gasket 100 may not be stiff enough to withstand the external pressure. The design of gasket 10 incorporates seal wings 34 and 36, allowing the thin portion of gasket 10 to remain thin and flexible enough to not be over-stressed but stiff enough to seal even when external sea pressure is present.

[0030] Referring now to Figure 6, one embodiment of gasket 10 may be generally annular with upper surface 12, inner surface 14, lower surface 16, and outer surface 18. Inner surface 14 may be substantially cylindrical, with opposing ends abutting upper surface 12 and lower surface 16. Upper surface 12 and lower surface 16 may be generally opposite one another, and may generally radiate outward from inner surface 14. Outer surface 18 may abut upper surface 12 and lower surface 16 and be generally opposite inner surface 14. Outer surface 18 may have a profile that allows gasket 10 to withstand pressure differentials found in a subsea environment. For example, the pressure associated with 10,000 feet or more of ocean depth on the outside and near atmospheric pressure on the inside.

[0031] Outer surface 18 may have stabilization ring 20 generally disposed between upper surface 12 and lower surface 16. As shown in Figure 6, stabilization ring 20 may be at an approximate midpoint between upper surface 12 and lower surface 16. Outer surface 18 may also include first sealing surface 22 between stabilization ring 20 and upper surface 12 and second sealing surface 26 between stabilization ring 20 and lower surface 16. First and second sealing surfaces 22 and 26 allow a seal to form between gasket 10 and corresponding sealing surfaces on

the pressure-containing component. Stabilization ring 20 may be a central stabilization ring that helps to stiffen gasket 10 with its large outer diameter. Gasket 10 may also be designed such that stabilization ring 20 is offset slightly, or even such that stabilization ring 20 is not present.

[0032] A first depression 24 may be included between first sealing surfaces 22 and upper surface 12, and a second depression 28 may be included between second sealing surface 26 and lower surface 16. Depressions 24 and 28 form recessed surfaces from their respective sealing surfaces 22 and 26. Note that the recess is sufficiently large that it will not contact the mating body when the seal is installed.

[0033] Sealing length 30 or distance between first depression 24 and second depression 28 may be less than distance 32 between upper surface 12 and lower surface 16. Thus, a length extends beyond sealing length 30 of gasket 10.

[0034] Figure 7 is a cross sectional view of gasket 10 in accordance with another embodiment of the present invention. More specifically, Figure 7 shows a different configuration for seal wings 34 and 36.

[0035] In Figures 8 and 9, depression 38 between stabilization ring 20 and first sealing surface 22, and depression 40 between stabilization ring 20 and second sealing surface 26 have been added. This is to help show the location of the gasket's sealing surfaces 22 and 26.

[0036] Figures 10-13, compared with Figures 2-5, show that seal wings 34 and 36 help energize gasket 10. These model figures show the respective gaskets broken into sections that show the gaskets in a free state, in an installed condition, installed with internal pressure, and installed with external pressure.

[0037] Figure 10 is a model of gasket 10 in accordance with one embodiment of the present invention. Figure 10 illustrates gasket 10, in the uninstalled state. The model shows modeled with sealing surfaces 22 and 26 being attached to stabilization ring 20 via springs 42 and 44. Additionally, springs 46 and 48 attach sealing surfaces 22 and 26 to seal wings 34 and 36.

[0038] Figure 11 is a model of gasket 10 of Figure 10, after installation. The unsupported mid-length 32 of gasket 10 is shown bowed inward with stabilization ring 20, seal wings 34 and 36, and gasket portion behind sealing surfaces 22 and 26 helping to energize sealing surfaces 22 and 26 as depicted with springs 42, 44, 46, and 48 bending. Gasket sealing force 50 is present on sealing surfaces 22 and 26.

[0039] Figure 12 is a model of gasket 10 of Figure 10, after installation, with internal pressure 52 present. Gasket sealing force 50 has increased, relative to force 50 of Figure 11 and mid-portion of gasket 10 is shown deflected further to the right. This is due to internal pressure 50. Internal pressure 50 acts on only the portion of the inner length of gasket 10 that is supported by seal surfaces 22 and 26. Seal wings 34 and 36 do not add any pressure load as they have pressure on their inner diameter and outer diameter and therefore are pressure balanced.

[0040] Figure 13 is a model of gasket 10 of Figure 10, after installation, with external pressure 54 present. Gasket sealing force 50 has decreased relative to force 50 of figures 11 and 12. The mid-portion of gasket 10 is shown slightly deflected to the left as compared to Figure 11. This is due to external pressure 54. External pressure 54 acts on the outer length of gasket 10 only up to the point where sealing surfaces 22 and 26 start. However, there is no leak path because the net force from seal wings 34 and 36, stabilization ring 20 and gasket portion behind seal surfaces 22 and 26 create force 50 great enough to prevent leakage.

[0041] As can be seen in Figures 12 and 13, seal wings' 34 and 36 extra length acts as a spring and helps urge or energize sealing surfaces 22, 26 towards a mating sealing surface on the body when gasket 10 is installed. This extra force aids in the sealing ability of gasket 10 and helps gasket 10 withstand considerable pressure differential in both directions. For example, gasket 10 may withstand an external pressure load developed by seawater at a depth of 10,000 feet while only atmospheric pressure is present inside the valve body. Using single outer surface 18 as the only sealing surface for the body and bonnet for sealing both internal and external pressure allows for verification of both pressures by conducting only the internal pressure test during the factory acceptance testing.

[0042] It is desirable that gasket 10 readily fit within a standard gasket seat profile. By being able to do so, existing equipment, originally designed for operation on the surface or in

shallow water, may be used in deep water. Alternatively, gasket 10 may fit within a new gasket seat profile. For example, a new gasket seat profile may be a straight bore seal.

[0043] Gasket 10 may include first seal wing 34 between first sealing surface 22 and upper surface 12, and second seal wing 36 between second sealing surface 26 and lower surface 16. Seal wings 34 and 36 help load the seal surfaces of gasket 10 and thereby allow gasket 10 to seal high external pressure 54 (shown in Figure 13). Thus, seal wings 34 and 36 allow gasket 10 to have a higher sealing force, yet still be compatible with the current sealing profile in the bonnet and the body. Additionally seal wings 34 and 36 allow gasket 10 to use only outer surface 18 to seal both internal and external pressure. As illustrated, first seal wing 34 is between first depression 24 and upper surface 12, and second seal wing 36 is between second depression 28 and lower surface 16. Seal wings 34 and 36 add to seal force 50 (shown in Figures 11 – 13).

[0044] Gasket 10 may be a bonnet gasket, which is used in a subsea assembly at the junction between a bonnet body and a valve body. Similarly, gasket 10 could be used for a valve body to a flange to which a tubular was attached or a non-valve product such as wellhead to flange, wellhead to wellhead, flange to flange, or connector to connector. Gasket 10 may be made from any of a number of different materials suitable for use in a subsea application. For example, gasket 10 may be elastomeric or metal. More specifically, gasket 10 may be stainless steel, alloy steel, titanium, nickel based alloy, or any other material resistant to both rusting and melting in a subsea environment. The material of gasket 10 may be coated or left uncoated. Inner surface 14 of gasket 10 may have an inner diameter of up to about 10" or the inner diameter may fall within a range of about 2" to 9." In addition to the popular size ranges listed, gasket 10 may be sized to fit any number of applications.

[0045] Gasket 10 may include one or more inserts 56 in the sealing area, as shown in Figure 14. Inserts 56 may be, for example, plastic, elastomeric, or a soft metal. Inserts 56 may allow gasket 10 to seal on gasket seat profile 200 having a rougher surface than what is required for gasket 10 to seal normally. This then has the advantage in that it may be easier to machine gasket seat profile 200.

[0046] Gasket 10 may be used in other applications where it is desired to seal external pressure from other sources than the pressure developed by sea water at great depths.

[0047] The words "upper" and "lower" are used with reference to the Figures. However, one of ordinary skill in the art will readily see that the terms may refer to direction of flow, and not to the actual orientation of the seal.

[0048] Therefore, the present invention is well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular embodiments disclosed above are illustrative only, as the present invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. For example, stabilization ring 20 is not required, such that first sealing surface 22 and second sealing surface 26 form a single sealing surface. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular illustrative embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the present invention. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee.

## CLAIMS

What is claimed is:

1. A gasket comprising:
  - an upper surface;
  - a substantially cylindrical inner surface abutting the upper surface;
  - a lower surface abutting the inner surface, and generally opposite the upper surface; and
  - an outer surface abutting the upper surface and the lower surface, and generally opposite the inner surface, the outer surface comprising
    - a sealing surface between the upper surface and the lower surface,
    - a first depression between the sealing surface and the upper surface, and
    - a second depression between the sealing surface and the lower surface.
2. The gasket of claim 1, wherein a distance between the first depression and the second depression is less than a distance between the upper surface and the lower surface.
3. The gasket of claim 1, wherein the outer surface is configured to fit into a standard gasket seat profile.
4. The gasket of claim 1, wherein the outer surface is configured to fit into a new gasket seat profile.
5. The gasket of claim 1, wherein the outer surface further comprises:
  - a first seal wing between the sealing surface and the upper surface; and
  - a second seal wing between the sealing surface and the lower surface.

6. The gasket of claim 5, wherein the first seal wing is between the first depression and the upper surface; and wherein the second seal wing is between the second depression and the lower surface.
7. The gasket of claim 1, wherein the outer surface further comprises a stabilization ring between the upper surface and the lower surface and wherein the sealing surface comprises a first sealing surface between the stabilization ring and the upper surface and a second sealing surface between the stabilization ring and the lower surface.
8. The gasket of claim 7, wherein the stabilization ring is centralized.
9. The gasket of claim 1, comprised of metal.
10. The gasket of claim 9, wherein the metal is selected from the group consisting of stainless steel, alloy steel, titanium, and nickel based alloy.
11. The gasket of claim 1, wherein the inner surface has an inner diameter within the range of about 2" to about 9."
12. The gasket of claim 1, wherein the inner surface has an inner diameter of up to about 10."
13. The gasket of claim 1, configured to seal tapered surfaces.
14. The gasket of claim 1, configured to seal straight bored surfaces.
15. The gasket of claim 1, further comprising one or more inserts.
16. The gasket of claim 15, wherein the inserts are comprised of a material selected from the group consisting of plastic, elastomeric, and soft metal.
17. A subsea assembly comprising:
  - a valve body;
  - a bonnet body; and

a bonnet gasket sealing a connection between the valve body and the bonnet body,  
the bonnet gasket comprising  
an upper surface;  
an inner surface abutting the upper surface;  
a lower surface abutting the inner surface, and generally opposite the  
upper surface; and  
an outer surface abutting the upper surface and the lower surface, and  
generally opposite the inner surface, the outer surface comprising  
a sealing surface between the upper surface and the lower surface,  
a first depression between the sealing surface and the upper  
surface, and  
a second depression between the sealing surface and the lower  
surface.