PRESSURE RELIEF VALVE AND METHOD FOR SUBSEA COMPONENTS

Background of Disclosure

Field of the Disclosure

[0001] Embodiments of the present disclosure relate to a pressure relief system for subsea vessels. More particularly, embodiments of the present disclosure relate to a relief valve for subsea vessels.

Background Art

[0002] As subsea oil production is taken to greater depths, equipment and processes must be adapted to operate in this harsh environment. A major obstacle in the progress of oil production in deep water is the extremely high pressures experienced at these depths. Accordingly, pressure vessels that maintain an inside pressure of one atmosphere are often used to protect equipment at these depths.

[0003] Pressure vessels used subsea to maintain and simulate an ambient pressure similar to what is experienced at the surface are often called "one atmosphere chambers." A common use in the oil industry for such chambers may be to protect pressure sensitive components subsea. In the event that a pressure chamber leaks slowly while subsea, and then is withdrawn back to surface relatively rapidly, it may contain hyperbaric pressure, or pressure higher than normal atmospheric pressure. With depths reaching close to 10,000 ft, this pressure may become extremely large (about 0.47 psi per foot of depth), even as high as 5000 psi. A large pressure buildup inside the subsea chamber may be capable of releasing large amounts of energy when retrieved and brought to the surface. As such, a relief system may be implemented to reduce the pressure inside the chamber to an acceptable and safe level as it is retrieved to the surface.

[0004] Pressure relief valves are commonly provided in various systems to limit the maximum pressure to less then a predefined threshold level. For example, a pressure relief valve may be provided at the outlet of a pump so that the supply line may not be

pressurized to an excessive level. Should the pressure threshold level be exceeded, the relief valve opens, thereby creating a path to a reservoir, or tank. Another pressure relief valve may be provided at the workport of a control valve assembly to which a hydraulic actuator, such as a piston and cylinder combination, is connected. This arrangement may protect against shock loading or inertial overloading from the load acting on the piston and cylinder. If that load results in an excessively high pressure within the hydraulic lines attached to the cylinder, the workport pressure relief valve is designed to open to relieve pressure to the system tank. The workport relief valve may remain open until the load condition no longer exists and pressure within the hydraulic line decreases below a threshold pressure.

[0005] One type of relief valve includes a movable element biased against a valve seat by a spring to maintain the valve in a closed state. When pressure acting on the valve element exceeds the force of the spring, the valve element moves away from the seat, thereby opening the pressure relief valve. In this type of valve, the valve opens as soon as the spring force is exceeded and closes immediately upon the pressure dropping below the spring force.

[0006] However, in some applications, it may be desirable for the valve not to open immediately when the pressure threshold is exceeded, but rather to delay opening until the excessive pressure exists for a given amount of time. Thus, such a pressure relief valve may be less affected by occasional short duration pressure events which exceed the threshold level. Nevertheless, when the pressure exceeds the threshold setting for longer than a specified amount of time, the valve opens to relieve that pressure before damage to the hydraulic system can occur. Similarly, it is also desirable in certain situations to delay the valve closing to ensure that the pressure remains below the threshold. This may prevent a momentary pressure decrease from closing the valve in a situation where pressure relief may still be required.

[0007] Numerous relief valves have been disclosed in the prior art. U.S. Patent No. 6,957,660, assigned to Holder, discloses a pressure relief valve having a valve element that is biased by a spring into a closed position. A pressure being controlled, or regulated, is applied to the valve element to counter the force of the spring. When the pressure applied to the valve element exceeds the force of the spring the pressure

relief opens. When the pressure applied to the valve element falls below the force of the spring, the valve closes.

[0008] Further, U.S. Patent No. 3,945,395, assigned to Reinicke, et. al, discloses a vent and relief valve for a tank containing pressurized fluid characterized in that coaxial vent and relief valve members have inter-engaged seats to close the vent outlet of the valve. Vent and relief valve further comprises an actuating means associated therewith to disengage said seats to open communication between the interior of the tank and the vent outlet of the valve as during filling of the tank. The relief valve member is actuated by fluid pressure in the tank exceeding a predetermined value to move said relief valve member to disengage said seats and thereby again establish communication between the interior of the tank and the vent outlet of the valve thus to vent excess fluid pressure.

[0009] The American Petroleum Institute mandates certain standards which apply to the equipment used in subsea operations. The American Petroleum Institute, commonly referred to as API, is the main U.S. trade association for the oil and natural gas industry. API is an American National Standards Institute ("ANSI") accredited standards developing organization, operating with approved standards development procedures and undergoing regular audits of its processes. API produces standards, recommended practices, specifications, codes and technical publications, reports and studies that cover each segment of the industry. API standards promote the use of safe, interchangeable equipment and operations through the use of proven, sound engineering practices.

[0010] API specification 16D discusses standards for electrical and electronic chambers, a vessel on which a relief valve may be used. "All electrical and electronic chambers shall be double sealed at all areas exposed to seawater or hydrostatic pressure and should have a provision for a test port. These test ports shall be plugged and sealed when not in use for testing". (API 16D). As such, a relief valve having a double seal between the interior volume of a vessel and an exterior subsea environment, as well as a test port, would be well received in industry. Furthermore, the ability to test both a front and backside of the seals as in a factory acceptance test would be highly desirable.

Summary of Invention

[0011] In one aspect of the present disclosure, a relief valve for a pressure vessel includes a housing having an inner bore extending between an inlet and an outlet, a piston located within the inner bore, and a spring disposed about the piston and configured to bias the piston into a closed position. Furthermore, the relief valve includes a test port in communication with the inner bore, a removable test plug sealingly disposed within the test port, and a first seal and a second seal disposed within the inner bore on either side of the test port. Preferably, the first and second seals configured to engage the piston and hydraulically isolate the inlet from the outlet when the piston is in the closed position.

[0012] In another aspect of the present disclosure, a relief valve for a pressure vessel includes a housing comprising an inlet and an outlet, a piston located within the housing, the piston biased into a closed position by a spring, and a first seal and a second seal configured to hydraulically isolate the inlet from the outlet when the piston is in the closed position. Preferably, the piston configured to move out the closed position when a force exerted on the piston by fluids of the pressure vessel exceeds a force of the spring.

[0013] In another aspect of the present disclosure, a method to test a relief valve includes applying a test pressure to a backside of a first and a second seal through a test port of the relief valve.

[0014] Other aspects and advantages of the disclosure will be apparent from the following description and the appended claims.

Brief Description of Drawings

[0015] Figure 1 is a relief valve in a closed position in accordance with embodiments of the present disclosure.

[0016] Figure 2 is a relief valve in an open, or vent, position in accordance with embodiments of the present disclosure.

[0017] Figure 3 is a relief valve in a test position in accordance with embodiments of the present disclosure.

[0018] Figure 4 is a relief valve in a closed position in accordance with embodiments of the present disclosure.

[0019] Figure 5 is a relief valve in a vent position in accordance with embodiments of the present disclosure.

Detailed Description

[0020] Embodiments disclosed herein relate to a relief valve for a subsea pressure vessel. More particularly, the present embodiments disclose an apparatus and method for a relief valve for a subsea pressure vessel.

[0021] Referring to Figure 1, a section view of a relief valve 100 is shown in accordance with embodiments of the present disclosure. Relief valve 100 includes a housing 102 having an inner bore 104 which allows communication between an inlet 106 and an outlet 108. Relief valve 100 further comprises a piston 110 disposed in inner bore 104, a spring 112 disposed in inner bore 104 and acting upon piston 110, and a first seal 114 and a second seal 116, both of which are circumferentially disposed on and configured to dynamically seal on piston 110.

[0022] Relief valve 100 also includes a test port 118 in communication with inner bore 104, and a test plug 120 removeably and sealably disposed in test port 118. Alternatively test port 118 and test plug 120 may be replaced with a test valve without departing from the present disclosure. Test plug 120 is described as being removeably disposed in test port 118, therefore, it should be understood that engagement in test port 118 could be accomplished by means such as threading, welding, brazing, epoxy, and any other fastening method known to one of ordinary skill in the art. Further, sealably refers to any method know to one of ordinary skill in the art, including, but not limited to, elastomeric seals, rubber seals, metal-to-metal seals, etc. As shown in Figure 1, relief valve 100 is in a "closed" position, wherein spring 112 is uncompressed and piston 110 is in sealed engagement with first seal 114 and second seal 116. Thus, as shown, relief valve 100 prevents communication of a pressure between inlet 106 and outlet 108.

[0023] Referring now to Figure 2, relief valve 100 is shown in a "vent" position in accordance with embodiments of the present disclosure. The vent position is

described as when spring 112 is compressed and piston 110 is axially displaced within inner bore 104 and out of sealed engagement with first seal 114 and second seal 116. Pressure inside a vessel is constantly applied through an inlet onto an area of an end face 122 of piston 110. As the pressure inside the vessel increases and reaches a predetermined level, the force applied to end face 122 of piston 110 becomes greater than a force of spring 112 thereby causing axial displacement of piston 110. As it is displaced, piston 110 breaks contact with first seal 114 and second seal 116, allowing pressure to escape or "vent" through outlet 108. It should be noted that pressure may be unable to escape through relief valve 100 until piston 110 is out of sealable engagement with both first seal 114 and second seal 116.

[0024] As pressure gradually decreases to acceptable levels within the vessel, the preset spring force of spring 112 is able to overcome the applied force from the vessel, and piston 110 is displaced back into sealable engagement with second seal 116 at which point pressure is unable to vent. Piston 110 continues to be displaced and sealably engage first seal 114, at which point spring 112 is substantially uncompressed and relief valve is once again in a closed position. Persons having ordinary skill in the art will recognize that the spring force acting upon the piston may be provided by any means known in the art including, but not limited to, metal coiled springs, Belleville washers, elastomeric springs, etc.

[0025] Referring now to Figure 3, relief valve 100 is shown in a "test" position in accordance with embodiments of the present disclosure. The test position is described as when the test plug (120 of Figure 1 & 2) is removed from test port 118 and pressure is able to be applied to "backside" surfaces of first seal 114 and second seal 116. Backside 130 of first seal 114 is the face of the seal facing away from inlet 106, while backside 132 of second seal 116 is the face of the seal facing away outlet 108. Thus, backside 130 of first seal 114 and backside 132 of second seal 116 face each other.

[0026] Referring still to Figure 3, piston 110 maintains contact with both first seal 114 and second seal 116 during a factory acceptance test (FAT). Test plug (not shown) has been removed from test port 118 to allow access to "backsides" of first seal 114 and second seal 116 for pressure testing and a test pressure is applied through test port 118 and into inner bore 104. The test pressure may be a working pressure of

the valve to simulate working conditions, or any other appropriate pressure know to one of ordinary skill in the art. First seal 114 and second seal 116 may be simultaneously tested to ensure proper sealing for seals between piston 110 and inner bore 104. Upon completion of the FAT procedure, pressurization of inner bore 104 and test port 118 is discontinued and test plug (not shown) is reinstalled in test port 118. Persons having ordinary skill in the art will recognize that the test plug may be replaced with a test valve, etc. without departing from embodiments disclosed.

[0027] Referring now to Figure 4, a section view of a relief valve 200 is shown in accordance with embodiments of the present disclosure. Relief valve 200 comprises a housing 202 having an inner bore 204 which allows communication between an inlet 206 and an outlet 208. Relief valve 200 further comprises a piston 210 disposed within inner bore 204, a spring 212 disposed within inner bore, a first seal 214 and a second seal 216 in sealing engagement with piston 210, and a test port 218 with a test plug 220 removeably and sealably disposed within. Furthermore, piston 210 comprises leak ports 222, which may include circumferential grooves, axial grooves, drilled holes or any other configuration known to one of ordinary skill in the art. Relief valve 200 is shown in a closed position, described as when piston 210 is sealably engaged with first seal 214 and second seal 216 thereby disallowing communication of pressure between inlet 206 and outlet 208.

[0028] Referring now to Figure 5, a section view of relief valve 200 is shown in accordance with embodiments of the present disclosure. Relief valve 200 is shown in a vent position, in which piston 210 has been displaced out of sealable engagement with first seal 214 by pressure inside of a chamber. Pressure inside the chamber enter inlet 206 is applied on an area of an end face 224 of piston 210. When the pressure inside the chamber reaches a certain level, it overcomes a preset force applied to piston 210 by spring 212, and begins to compress spring 212 and move piston 210 out of sealable engagement with first seal 214. Also, a portion of the leak ports 222 is displaced past second seal 216, thereby allowing full communication of pressure between inlet 206 and outlet 208.

[0029] As the pressure applied on the area of end face 224 decreases to a level below the preset force of spring 212, piston 210 is moved back into sealable engagement with first seal 214, and leak ports 222 are moved back into the closed position so as to

disallow further communication of pressure through inner bore 204. Persons having ordinary skill in the art will recognize that the spring force acting upon the piston may be provided by any means known in the art, including, but not limited to, metal coiled springs, Belleville washers, elastomeric springs, etc.

[0030] Further, relief valve 200 may be configured in such a way as to test a backside of both seals. Referring again to Figure 4, test plug 220 may be removed and a test pressure applied through test port 218 and into inner bore 204. A test pressure is applied to backsides of both first seal 214 and second seal 216 with piston 210 in a closed position. Upon completion of testing, pressure is discontinued and test plug 220 is disposed within test port 218. Those having ordinary skill in the art should recognize that the test plug may be replaced with a test valve, etc. without departing from embodiments disclosed.

[0031] Furthermore, alternate embodiments of the present disclosure include a relief valve comprising seals, wherein at least one of the seals may be a metal-to-metal seal. In selected embodiments, the metal-to-metal seal may be the first or primary seal, while the second seal may be an elastomeric seal. Alternatively, the metal-to-metal seal may be the second seal, while the first seal is an elastomeric seal. Alternatively still, both the first and second seals may be metal-to-metal seals. However, it should be understood that embodiments using metal-to-metal seals may require a spring having a larger spring force because of the high contact stresses that may be needed to create a metal-to-metal seal. Further, alternate embodiments of the present disclosure may include a first seal area that is larger than the second seal area. Because of the larger first seal area, the valve may be able to relieve, or vent, at lower pressures.

[0032] Embodiments of the present disclosure advantageously allow for a backside seal test of both seals. Reciprocating motion, as is present between the piston and the two seals adds a extra dimension to the sealing problem. Friction, and its associated wear, join a list of factors that must be contended with including temperature, fluid compatibility, and pressure. The seals used for sealing a reciprocating member must meet static and dynamic sealing requirements at their contact areas with the stationary member, which is the inner bore, and also seal effectively at their contact areas on the reciprocating member, in this case the piston. To ensure reliability of a seal, it may be

desirable and advantageous to be able to test both sides of a seal from opposite directions.

[0033] Further, embodiments of the present disclosure preferably conform to API standard 16D, which requires a "double seal" between an inner chamber of a pressure vessel and an outer subsea environment. Since the relief valve provides communication between the two, a double seal is a desirable feature. According to API Specification 16D, chambers shall be double sealed at all areas exposed to seawater or hydrostatic pressure. Furthermore, a test port may be used, and when present should be plugged and sealed when not in use for testing. The double seal configuration of relief valve is a built-in redundancy that may be appreciated by one of ordinary skill in the art.

[0034] While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.

Claims

I claim:

1. A relief valve for a pressure vessel, comprising:

a housing comprising an inner bore extending between an inlet and an outlet;

a piston located within the inner bore;

a spring to bias the piston into a closed position;

a test port in communication with the inner bore;

a removable test plug sealingly disposed within the test port; and

a first seal and a second seal disposed within the inner bore on either side of the test port, the first and second seals configured to engage the piston and hydraulically isolate the inlet from the outlet when the piston is in the closed position.

2. The relief valve of claim 1, wherein the first seal hydraulically isolates the inlet from the test port when the piston is in the closed position.

3. The relief valve of claim 1, wherein the second seal hydraulically isolates the outlet from the test port when the piston is in the closed position.

4. The relief valve of claim 1, wherein the inlet is in hydraulic communication with the outlet when the piston is in an open position.

5. The relief valve of claim 4, wherein the piston is thrust into the open position when hydraulic pressure at the inlet exceeds a pre-load force of the spring disposed about the piston.

6. The relief valve of claim 1, wherein the inlet is in communication with pressure from inside the pressure vessel.

7. The relief valve of claim 1, wherein the outlet is configured to vent pressure from the pressure vessel.

8. The relief valve of claim 1, wherein integrity of the first and the second seals may be tested through the test port following removal of the test plug.

9. The relief valve of claim 1, wherein the relief valve is in compliance with API 16D.

10. The relief valve of claim 1, wherein at least one of the first and second seals is a metal-to-metal seal.

11. The relief valve of claim 1, wherein a first seal area is larger than a second seal area.

12. A relief valve for a pressure vessel, comprising:.

a housing comprising an inlet and an outlet;

a piston located within the housing, the piston biased into a closed position by a spring;

a first seal and a second seal configured to hydraulically isolate the inlet from the outlet when the piston is in the closed position; and

the piston configured to move out the closed position when a force exerted on the piston by fluids of the pressure vessel exceeds a force of the spring.

13. The relief valve of claim 12, further comprising:

a test port extending through the housing and in communication with backsides of the first and the second seals; and

a removable test plug sealingly disposed within the test port.

14. The relief valve of claim 13, wherein the test port is in communication with the piston between the first and the second seals.

15. The relief valve of claim 13, wherein integrity of the first and the second seals may be tested through the test port following removal of the test plug.

16. The relief valve of claim 12, wherein the relief valve is in compliance with API 16D.

17. The relief valve of claim 12, wherein the inlet is in communication with the fluids of the pressure vessel.

18. A method to test a relief valve, the method comprising:

applying a test pressure to a backside of a first and a second seal through a test port of the relief valve.

19. The method of claim 18, wherein a test plug is removably disposed in the test port.

20. The method of claim 18, wherein the method is in compliance with API 16D.

21. The relief valve of claim 18, wherein the test port is configured to test a backside of the first and second seals.