CONTROL MODULE WITH DUAL BALL VALVE ASSEMBLIES

BACKGROUND

[0001] The present invention relates to subsea control systems, and more particularly, in certain embodiments, to control modules having dual ball valve assemblies for controlling one or more subsea devices.

[0002] Control modules are generally adjacent to one or more subsea devices and have the capability of communicating signals from an operator on a vessel to and/or from the subsea device. Valves in conventional control modules typically have only two positions: a supply position to allow control fluid to pass from supply lines through the valves and into function lines, and a vent position to allow control fluid to pass from the function lines through the valves and into vent lines. Both positions require control fluid to flow to either the supply or vent positions, thus making leak detection impractical. Additionally, valves in conventional control modules have very small orifices, which are prone to blockage. These small orifices place an emphasis on fluid cleanliness for hydraulic fluid typically used in such control modules. Thus, control modules generally must each have a screen filter and use costly control fluid. Any failure of the valves, whether caused by contamination or otherwise, can result in the need to retrieve/service the module to repair the failure.

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SUMMARY

[0003] The present invention relates to subsea control systems, and more particularly, in certain embodiments, to control modules having dual ball valve assemblies for controlling one or more subsea devices.

[0004] One embodiment of the present disclosure provides a subsea control system comprising a control module having a plurality of dual ball valve assemblies. Each dual ball valve assembly of this embodiment is connected to a supply line, a vent line, and a function line connected to a subsea device for controlling said subsea device.

[0005] Another embodiment provides a control module comprising a plurality of dual ball valve assemblies and electronics configured to control the plurality of dual ball valve assemblies. In this embodiment, each of the plurality of dual ball valve assemblies comprises a supply manifold, a vent manifold, and a function port.

[0006] Yet another embodiment provides a subsea control system comprising a control module having a plurality of dual ball valve assemblies that control a plurality of subsea functions.

[0007] The features and advantages of the present invention will be readily apparent to those skilled in the art. While those skilled in the art may make numerous changes, such changes are within the spirit of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Figure 1A illustrates a dual ball valve assembly in a vent position in accordance with certain embodiments of the present disclosure.

[0009] Figure 1B illustrates the dual ball valve assembly of Figure 1A in a supply position in accordance with certain embodiments of the present disclosure.

[0010] Figure 1C illustrates the dual ball valve assembly of Figure 1A in a block position in accordance with certain embodiments of the present disclosure.

[0011] Figure 2 illustrates a schematic of a control module in accordance with certain embodiments of the present disclosure.

[0012] Figure 3 illustrates a cross-sectional top view of a control module, looking down on a base plate, in accordance with certain embodiments of the present disclosure.

[0013] Figure 4 illustrates a cross-sectional side view of a control module in accordance with certain embodiments of the present disclosure.

[0014] Figure 5 illustrates a perspective view of a control module in accordance with certain embodiments of the present disclosure.

[0015] Figure 6 illustrates a side view of a control module and a subsea device in accordance with certain embodiments of the present disclosure.

DETAILED DESCRIPTION OF THE DRAWINGS

[0016] Referring to Figures 1A-1C, each dual ball valve assembly 16 may have first ball valve 38, second ball valve 40, dual motor 42 (illustrated as 42A and 42B), and pressure transducer 44. In some embodiments, dual ball valve assemblies 16 may also include transmission gearing (not shown). Ball valves 38 and 40 may couple or otherwise have the configurations disclosed in U.S. Patent Publication No. 2005/0252556, which is hereby incorporated by reference in its entirety. Ball valves 38 and 40 may use metal seals and withstand 10,000 psi or 15,000 psi, for example. Ball valves 38 and 40, in some embodiments, may have approximately 1/4" diameter openings. Ball valves 38 and 40 may have other configurations, so long as each dual ball valve assembly 16 has at least two ball valves. For example, as indicated in Figures 1A-1C, ball valves 38 and 40 may operate independent of one another. While the

figures illustrate ball valves 38 and 40 as contained within a housing, one or both of ball valves 38 and 40 may be remote from the rest of dual ball valve assembly 16, so long as ball valves 38 and 40 are connected to the same function line 22 and/or included in the same common body. In some embodiments, first ball valve 38 may connect to supply line 18 and function line 22, allowing first ball valve 38 to control flow from supply line 18 through dual ball valve assembly 16 into function line 22. Likewise, second ball valve 40 may connect to vent line 20 and function line 22, allowing second ball valve 40 to control flow from function line 22 through dual ball valve assembly 16 into vent line.

[0017] Dual motor 42 may be DC, Brushless, or any other type of motor suitable for opening, closing, or otherwise actuating ball valves 38 and 40. Dual motor 42 may be a single electric motor to control both ball valves 38 and 40, or dual motor 42 may be multiple motors, as illustrated in Figures 1A-1C. Dual motor 42 may actuate dual ball valve assemblies 16 by turning in the same direction to move to various positions, or dual motor 42 may be a reversible motor allowing the valve assemblies 16 to actuate by turning back and forth. Electronics 32 may control dual motor 42 to actuate one or more of dual ball valve assemblies 16. In some embodiments, the use of electrically controlled valves will allow for the elimination of hydraulic pilot valves, which are susceptible to contamination issues. Pressure transducer 44 may connected to, formed with, or otherwise be associated with dual ball valve assembly 16. Pressure transducer 44 may be 4-20 MA strain gauge transducers, a device configured to indicate whether the dual ball valve assembly 16 is in a block position, or any other transducer useful in subsea operations. In some embodiments, pressure transducer 44 may provide data for use by subsea control systems in detecting leaks when the subsea control system is in a leak detection mode. Pressure transducer 44 may be in a housing with the other components of dual ball valve assembly 16, or pressure transducer 44 may be outside of

a housing containing some or all other components of dual ball valve assembly 16 (as illustrated).

[0018] Dual ball valve assembly 16 may have supply manifold 46, vent manifold 48, and function port 50. These manifold and port facilities may be incorporated into control module base plate 34. Supply manifold 46 may provide a connection point or otherwise allow for flow between supply line 18 and dual ball valve assembly 16. Supply manifold 46 may be a facial seal using an o-ring to a manifold supply line, or any other type of connector. Vent manifold 48 may provide a connection point or otherwise allow for flow between vent line 20 and dual ball valve assembly 16. Vent manifold 48 may be a facial seal using an o-ring to a manifold vent line, or any other type of connector. Function port 50 may provide a connection point or otherwise allow for flow between function line 22 and dual ball valve assembly 16. Function port 50 may be a facial seal using an o-ring to a function line, or any other type of connector. Dual ball valve assembly 16 may have a failsafe mechanism 52 (illustrated as 52A and 52B) to move ball valves 38 and/or 40 into a failsafe position in the event of partial or complete system failure. Failsafe mechanism 52 may be mechanically biased. In some embodiments, failsafe mechanism 52 may include a spring to force ball valves 38 and 40 into a vent position (discussed below and illustrated in Figure 1A) as the failsafe position. In other embodiments, failsafe mechanism 52 may force ball valves 38 and 40 into a block position (discussed below and illustrated in Figure 1C) as the failsafe position. Thus, failsafe mechanism 52 may provide for a mechanically forced failsafe position in the event of a failure of electrical or hydraulic systems.

[0019] Referring to Figure 1A, dual ball valve assembly 16 may have a vent position. The vent position is a position that permits flow from function line 22 through dual ball valve assembly 16 into vent line 20 while preventing flow from supply

line 18 through dual ball valve assembly 16. Dual motor 42 may move or actuate dual ball valve assembly 16 into the vent position by moving ball valve 38 to a closed position and ball valve 40 to an open position.

[0020] Referring to Figure 1B, dual ball valve assembly 16 may have a supply position. The supply position is a position that permits flow from supply line 18 through dual ball valve assembly 16 into function line 22 while preventing flow from vent line 20 through dual ball valve assembly 16. Dual motor 42 may move or actuate dual ball valve assembly 16 into the supply position by moving ball valve 38 to an open position and ball valve 40 to a closed position.

[0021] Referring to Figure 1C, dual ball valve assembly 16 may have a block position. The block position is a position that prevents flow through dual ball valve assembly 16. Dual motor 42 may move or actuate dual ball valve assembly 16 into the block position by moving both ball valves 38 and 40 to a closed position.

[0022] Referring to the schematic illustrated in Figure 2, control module 12 may include dual ball valve assemblies 16, accumulator 24, supply line 18, vent 26, vent line 20, and function lines 22. Control module 12 may use any number of dual ball valve assemblies 16 (illustrated as 16A, 16B, 16C, etc.). For example, in certain embodiments, control module 12 may have between 10 off and 30 off dual ball valve assemblies 16. In some applications, 15 off ball valve assemblies 16 may be appropriate, but other applications may require more or fewer dual ball valve assemblies 16.

[0023] While accumulator 24 as illustrated is a set of three accumulators 24A contained within control module 12 and an accumulator 24B external to control module 12, accumulator 24 may be any type of device for supplying pressurized control fluid to dual ball valve assemblies 16. The control fluid may be, for example, hydraulic,

water based with lubricity additive designed for a specific temperature range. In some embodiments, accumulator 24 may be three 19 Liter bladder accumulators 24A and/or a removable 19 Liter bladder accumulator module 24B configured to connect to control module 12 via base plate 34 within bladder accumulator module 24B and receiver plate 36 associated with control module 12.

[0024] Supply line 18 may be 316 stainless steel (or an approved variation) with a nominal bore of 0.375 inches minimum, or any other type of line to connect any or all dual ball valve assemblies 16 to accumulator 24. In some embodiments, one supply line 18 may deliver control fluid from accumulator 24, to a number of dual ball valve assemblies 16. Alternatively, multiple supply lines (not shown) may deliver control fluid from one or more accumulators 24 to a number of dual ball valve assemblies 16.

[0025] Vent 26 may allow control fluid captured in the subsea device to "vent" to a lower pressure reservoir, in most instances the ocean. Vent 26 may be a hydraulic coupling that includes a check valve so that the internal fluid of the control module is isolated from the caustic sea water and its corrosive effects. Alternatively, vent 26 may be simply an open end of vent line 20, or any other type of vent.

[0026] Vent line 20 may be 316 stainless steel (or an approved variation) with a nominal bore of 0.375 inches minimum, or any other type of line to connect any or all dual ball valve assemblies 16 to vent 26. In some embodiments, one vent line 20 may deliver control fluid from a number of dual ball valve assemblies 16 to vent 26. Alternatively, multiple vent lines (not shown) may deliver control fluid from one or more dual ball valve assemblies 16 to vent 26.

[0027] A number of function lines 22 (illustrated as 22A, 22B, 22C, etc.) may be 316 stainless steel (or an approved variation) with a nominal bore of 0.375

inches minimum, or any other type of line to connect any or all dual ball valve assemblies 16 to one or more subsea devices 14 (illustrated as 14A, 14B, 14C). In some embodiments, function lines 22 may deliver control fluid from dual ball valve assemblies 16 to subsea devices 14.

[0028] Subsea devices 14 may include Christmas trees, manifolds, chokes, downhole smart valves, tooling operations, workover function operations, downhole safety valves, subsea equipment, or any other device suitable for performing a subsea function, including those in very high-pressure environments.

[0029] The configuration of Figure 2 illustrates how a particular dual ball valve assembly 16 might be isolated from other dual ball valve assemblies 16. In the event of a leak or other problem in the system, the operator may use dual ball valve assemblies 16 to isolate the problem. For example, if function line 22B were to have a leak, dual ball valve assembly 16B could be moved into a block position (illustrated in Figure 1C), preventing flow through dual ball valve assembly 16B. In particular, the block position may prevent flow between function line 22B and supply line 18, allowing fluid present in supply line 18 to be capture by dual ball valve assembly 16B. Thus, placing various dual ball valve assemblies 16 in a block position may allow for selective use of function lines 22. For example, if a failure occurs in subsea device 14B, or function line 22B, and subsea device 14B happens to be non-critical, the operator may move dual ball valve assembly 16B into a block position and continue operations using remaining dual ball valve assemblies 16. Thus, while failure of one or more of function lines or subsea devices used with a conventional control module may result in the need to pull the control module, failure of one or more function lines 22 or subsea devices 14 in control module 12 may allow for continued operation of control module 12. In some embodiments, an operator may place most dual ball valve assemblies 16 in a block

position, with only one dual ball valve assembly 16 allowing flow therethrough at a given time. This may prevent interplay between dual ball valve assemblies 16.

[0030] Referring still to Figure 2, control fluid may be stored in accumulator 24 (illustrated as 24A and 24B) and delivered through supply line 18 to dual ball valve assemblies 16. Depending on the positions of dual ball valve assemblies 16, the control fluid may bypass one or more of dual ball valve assemblies 16 as indicated above, or control fluid may flow through one or more of dual ball valve assemblies 16 to function lines 22. Function lines 22, in turn, may pass control fluid to subsea devices 14. Thus, by moving to a block position or a supply position, a particular dual ball valve assembly 16 may readily control an associated subsea device 14. Dual ball valve assemblies 16 may also control the flow of control fluid from function lines 22. Dual ball valve assemblies 16 may block control fluid from entering, or control fluid may flow through dual ball valve assemblies 16 to vent line 20. Vent line 20 may then deliver control fluid to vent 26.

[0031] Referring now to the cross-sectional top view of Figure 3, control module 12 may have a number of dual ball valve assemblies 16 (illustrated as 16A, 16B, 16C, etc.). Dual ball valve assemblies 16 may be modular, allowing for numerous configurations, ease of removal, and/or ease of replacement of individual dual ball valve assemblies 16 in control module 12. Dual ball valve assemblies 16 may be mounted onto base plate 34 of control module 12 using fasteners, for example, 4 off. Control module 12 may be designed for the specific project, which may include a determination of the number of valve assemblies 16 required. Control module 12 may then be machined for that number of mounting interfaces for the valve assemblies 16. The supply line 18 and vent line 20 may be parallel and in communication with a majority of

valve assemblies 16 supply and vent lines. Function line 22 may be separate and dependent from all other function lines.

[0032] Referring now to the cross-sectional side view of Figure 4, in addition to dual ball valve assembly 16, control module 12 may have accumulator 24, vent 26, latchdown assembly 28 to provide for alignment and secure connection between control module 12 and subsea devices 14, one or more filters 30 to remove contaminants from control fluid in a subsea control system, and electronics 32 configured to control dual ball valve assemblies 16, monitor sensors included in subsea devices 14, and monitor/control the overall health of the system including a check for leaks in the hydraulic system. Further, control module 12 may have guide pin 54, electric connectors 56 and 58, protective skirt 60, and any of a number of other components.

[0033] Figure 5 illustrates a perspective view of control module 12, showing dual ball valve assemblies 16 (illustrated as 16A, 16B, 16C, etc.), accumulator 24, vent 26, latchdown assembly 28, filters 30, electronics 32, protective skirt 56, and electric connector 58.

[0034] A subsea control system may be used to operate and monitor subsea devices 14, and, in this capacity, control the flow of oil or gas from a subsea well or multitude of wells in the case where a subsea manifold is employed. A subsea control system may include control module 12 to control any or all of a plurality of subsea functions, including subsea functions associated with subsea devices 14 (shown in Figure 6), downhole functions, manifold functions, tooling functions, workover functions, or any other subsea function. Control module 12 may control and monitor subsea devices 14. A subsea control system may also include a hydraulic power unit, master control station, electric power unit, umbilical termination both on the surface and subsea, jumpers to connect the system components on the sea floor using either divers or

ROVs to effect the connection, the control module, and the sensors. Sensors can be any of a number of devices that measure pressure, temperature, flow rate, sand production, erosion, chemical injection flow rate, and any other measurement typical of a subsea operation.

[0035] The various embodiments disclosed herein may be appropriate for use in the control of production fluids, chemical injection, workover of the well, or any other subsea functions. Some advantages over the conventional control module may include the following: the need for filters may be reduced, a cheaper class of control fluid may be used, sampling of fluid to gauge cleanliness may be decreased, and time may be saved in pumping water to get down to an acceptable level of cleanliness of control fluid.

[0036] Leak detection may be performed when subsea device 14 is under supply line pressure, and dual ball valve assemblies 16 are operated into the block mode. When this set of operations occurs the pressure-sensing device may be positioned to monitor the pressure captured in the line. If the pressure remains at an initial level over a period of time, for example, approximately 1 hour, then the line may be considered in good working order. A drop in initial pressure, however, may be seen as an indication of a leak, with a small leak causing a reduction in pressure over an extended time period, and a large leak causing a reduction in pressure over a short time, for example a matter of minutes or seconds. In a system with 30 function lines, this method of detection may be used repeatedly across multiple, or even all, lines to locate a leaking line. Once a leak is located, an assessment of the significance can be made, and a repair plan generated.

[0037] Potential benefits of the present invention may include reduced reliance on fluid cleanliness, the ability to check for leaks, a reduction in hydraulic

accumulation in the module, and the elimination of hydraulic interaction between devices in the system, as conventionally occurs as a result of sharing a common supply between devices in the control module. Those skilled in the art will also readily appreciate numerous additional potential advantages.

[0038] 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 disclosure 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, many of the features could be moved to different locations on respective parts without departing from the spirit of the invention. Furthermore, no limitations are intended to be limited 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. Moreover, the indefinite articles "a" or "an", as used in the claims, are defined herein to mean one or more than one of the element that it introduces. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee.

CLAIMS

1. A subsea control system, comprising:

a control module having a plurality of dual ball valve assemblies, each dual ball valve assembly connected to a supply line, a vent line, and a function line connected to a subsea device for controlling said subsea device.

2. The subsea control system of claim 1, wherein the plurality of dual ball valve assemblies are connected to a single supply line and a single vent line, wherein each dual ball valve assembly is connected to a different function line, and wherein each function line is connected to a different subsea device.

3. The subsea control system of claim 1, wherein at least one of the plurality of dual ball valve assemblies comprises:

a first ball valve; and

a second ball valve.

4. The subsea control system of claim 3:

wherein the first ball valve is connected to the supply line and controls flow from the supply line through the dual ball valve assembly into the function line; and

wherein the second ball valve is connected to the vent line and controls flow from the function line through the dual ball valve assembly into the vent line.

5. The subsea control system of claim 3, wherein the dual ball valve assembly comprises a dual motor configured to actuate the first ball valve and the second ball valve.

6. The subsea control system of claim 1, comprising:

a pressure transducer associated with at least one of the plurality of dual ball valve assemblies and configured to indicate whether the dual ball valve assembly is in a block position, whereby flow is prevented through the dual ball valve assembly;

wherein the subsea control system has a leak detection mode that utilizes data from the pressure transducer to detect leaks.

7. The subsea control system of claim 1, wherein at least one of the plurality of dual ball valve assemblies is modular.

8. The subsea control system of claim 1, wherein each of the plurality of dual ball valve assemblies has a supply position, a vent position, and a block position;

wherein the supply position permits flow from the supply line, through the dual ball valve assembly, into the function line, and prevents flow to the vent line;

wherein the vent position permits flow from the function line, through the dual ball valve assembly, into the vent line, and prevents flow from the supply line; and

wherein the block position prevents flow through the dual ball valve assembly.

9. The subsea control system of claim 1, wherein at least one dual ball valve assembly has a failsafe position.

10. The subsea control system of claim 9, wherein the failsafe position is a vent position that permits flow from the function line, through the dual ball valve assembly, into the vent line, and prevents flow from the supply line.

11. The subsea control system of claim 10, wherein the failsafe position is mechanically biased.

12. A control module comprising:

a plurality of dual ball valve assemblies; and

electronics configured to control the plurality of dual ball valve assemblies;

wherein each of the plurality of dual ball valve assemblies comprises a supply manifold, a vent manifold, and a function port.

13. The control module of claim 12, wherein the electronics are configured to control at least one dual motor to actuate at least one of the plurality of dual ball valve assemblies.

14. The control module of claim 12, comprising an accumulator connected to each of the supply manifolds via a supply line.

15. The control module of claim 12, comprising a vent connected to each of the vent manifolds via a vent line.

16. The control module of claim 12, comprising a subsea device connected to at least one of the function ports via a function line.

17. The control module of claim 12, comprising a latchdown assembly.

18. The control module of claim 12, comprising a filter.

19. A subsea control system comprising:

a control module having a plurality of dual ball valve assemblies which control a plurality of subsea functions.