The method of providing a pressurized control fluid for the operation of subsea equipment of providing an accumulator with control fluid pressurized by compressed gas, supplying the control fluid to a control valve for the purpose of operating a function, receiving a return flow of the control fluid from the function to a control valve, directing the return flow of the control fluid to a low pressure chamber whose pressure is substantially unaffected by the subsea environmental pressure, and maintaining the low pressure level in the low pressure chamber.
CONSTANT ENVIRONMENT SUBSEA
CONTROL SYSTEM

TECHNICAL FIELD

[0001] This invention relates to the general subject of providing a pressurized working fluid for the operation of subsea equipment, especially in very deep waters.

CROSS-REFERENCE TO RELATED APPLICATIONS

[0002] Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0003] Not applicable

REFERENCE TO A “MICROFICHE APPENDIX”

[0004] Not applicable

BACKGROUND OF THE INVENTION

[0005] The field of this invention is that of deepwater control systems for the purpose of providing a supply of pressurized working fluid for the control and operation of equipment. The equipment is typically blowout preventers (BOP) which are used to shut off the well bore to secure an oil or gas well from accidental discharges to the environment, gate valves for the control of flow of oil or gas to the surface or to other subsea locations, hydraulically actuated connectors and similar devices. The fluid to be pressurized is typically an oil based product or a water based product with added lubricity and corrosion protection.

[0006] The working fluid for such control systems typically comes from accumulators. Currently accumulators have historically come in three styles which operate on a common principle. The principle is to precharge them with pressurized gas to a pressure at or slightly below the anticipated minimum pressure required to operate equipment. Fluid can be added to the accumulator, increasing the pressure of the pressurized gas and the fluid. The fluid introduced into the accumulator is therefore stored at a pressure at least as high as the precharge pressure and is available for doing hydraulic work.

[0007] The accumulator styles are bladder type having a balloon type bladder to separate the gas from the fluid, the piston type having a piston sliding up and down a seal bore to separate the fluid from the gas, and a float type with a float providing a partial separation of the fluid from the gas and for closing a valve when the float approaches the bottom to prevent the escape of gas.

[0008] Accumulators providing typical 3000 p.s.i. working fluid to surface equipment can be of a 5000 p.s.i. working pressure and contain fluid which raises the precharge pressure from 3000 p.s.i. to 5000 p.s.i.

[0009] As accumulators are used in deeper water, the efficiency of conventional accumulators is decreased. In 1000 feet of seawater the ambient pressure is approximately 465 p.s.i. For an accumulator to provide a 3000 p.s.i. differential at 1000 ft. depth, it must actually be precharged to 3000 p.s.i. plus 465 p.s.i. or 3465 p.s.i.

[0010] At slightly over 4000 ft. water depth, the ambient pressure is almost 2000 p.s.i., so the precharge would be required to be 3000 p.s.i. plus 2000 p.s.i. or 5000 p.s.i. This would mean that the precharge would equal the working pressure of the accumulator. Any fluid introduced for storage would cause the pressure to exceed the working pressure, so the accumulator would be non-functional.

[0011] Another factor which makes the deepwater use of conventional accumulators impractical is the fact that the ambient temperature decreases to approximately 35 degrees F. If an accumulator is precharged to 5000 p.s.i. at a surface temperature of 80 degrees F., approximately 416 p.s.i. precharge will be lost simply because the temperature was reduced to 35 degrees F. Additionally, the rapid discharge of fluids from accumulators and the associated rapid expansion of the pressurizing gas causes a natural cooling of the gas. If an accumulator is quickly reduced in pressure from 5000 p.s.i. to 3000 p.s.i. without chance for heat to come into the accumulator (adiabatic), the pressure would actually drop to 1200 p.s.i.

[0012] A more recent solution to this problem has been what is referred to as constant differential accumulators as is illustrated in U.S. Pat. No. 6,202,753. These accumulators use a double piston looking like a barrel which acts as a mechanical summing relay. On the top side of the top piston is the gas charge similar to the more conventional accumulators. On the lower side of the upper piston is the pressurized working fluid. The lower piston is connected to the upper piston by a connecting rod. Seawater pressure is vented onto the top side of the lower piston, pushing it down and therefore pulling the upper piston down harder onto the working fluid. A vacuum is on the lower side of the lower piston and so offers no support. The net effect is that the working fluid pressure is generally equal to the sum of the nitrogen pressure plus the seawater pressure. In other words its pressure is always higher than the ambient pressure by the amount of the nitrogen pressure. This provides a good solution irrespective of depth, but provides a relatively costly construction.

[0013] Subsea drilling has been done for about 60 years and during that time drilling has occurred in progressively deeper and deeper water. The deeper water is associated with colder temperatures making the deepwater use of accumulators especially difficult. Substantial and ongoing research has been done to try to make conventional accumulators operational in waters in depths of greater than 6,000'. From there it only gets more difficult as drilling is now happening in depths as great as 12,000'. This has resulted in very high nitrogen precharges simply to be higher than the pressure at these ocean depths along with concerns about liquefying the nitrogen charge gas. As industry and standards societies have pursued the difficulties of making conventional accumulators work in conventional situations, a better solution is needed.

[0014] The problem being discussed here is that the environment in which the accumulators are working is changing. The different pressure and temperature combinations of various have been a problem for the industry for many years, and is only exaggerated as the drilling depths continue to be deeper and deeper.

SUMMARY OF THE INVENTION

[0015] The object of this invention is to provide a control system for deepwater ocean service which allows the equipment to be operated as if it were in a constant environment.

[0016] A second object of this invention is to provide a control system for deepwater ocean service which does not lose its operating differential across subsea working pistons due to high deep sea ambient pressures.
A third object of the present invention is to provide a control system for deepwater ocean service which operates with similar characteristics when deep sea and during surface testing.

Another object of the present invention is to provide a control system which operates in conjunction with conventional accumulators rather than requiring constant differential accumulators.

Another object of this invention is to provide a system which does not require high gas precharge pressures so that they will have a differential above ambient pressures at sea depths.

Another object of this invention is to provide a system which does not present a concern with gas pressures high enough and temperatures low enough to provide the possibility of liquefying the compressed gas.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial section of a system of subsea equipment utilizing the control system in the mode of pushing the blowout preventer rams forward to seal across the bore.

FIG. 2 is a partial section of a system of subsea equipment utilizing the control system in the mode of blocking the movement of the blowout preventer ram.

FIG. 3 is a partial section of a system of subsea equipment utilizing the control system in the mode of retracting the blowout preventer rams from the bore.

FIG. 4 is a partial section of a system of subsea equipment utilizing the control system in the mode of emptying the low pressure reservoir of control fluids.

FIG. 5 is a partial section of a system of subsea equipment utilizing the control system in the mode of flooding the low pressure reservoir with sea water to eliminate any accumulated gas.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, a blowout preventer (BOP) stack 10 is landed on a subsea wellhead system 11, which is supported above mudline 12. The BOP stack 10 is comprised of a wellhead connector 14 which is typically hydraulically locked to the subsea wellhead system 11, multiple ram type blowout preventers 15 and 16, an annular blowout preventer 17 and an upper mandrel 18. A riser connector 19, and a riser 20 which extends to the surface are attached for communicating drilling fluids to the surface.

Blowout preventer 16 includes a body 30, rams 32 and 34 for moving into the vertical bore 36, connecting rods 38 and 40, pistons 42 and 44, outer chamber 46 and 48, and inner chambers 50 and 52.

When lines 60 and 62 are pressurized, the pistons 42 and 44, connecting rods, 38 and 40, and rams 32 and 34 move toward the centerline of the bore 36 to seal off the bore 36 when appropriate. When lines 64 and 66 are pressurized, the components are retracted from bore 36.

Control valve 70 is a 3 position valve which is utilized to operate the blowout preventer 16 and is illustrative of dozens of valves which become part of a subsea control system. In the position as shown the control valve 70 receives fluid along line 72 from accumulator 74 and delivers it along line 76 and in turn to lines 60 and 62 to move the rams 32 and 34 towards the bore 36. Accumulator 74 can be any of the conventional accumulators as indicated in the background of the invention.

Conventionally, the return fluid coming out of line 64 and 66 through line 78 are vented to the subsea environment. At a 10,000 ft. depth, this subsea environment is at a 10,000×0.465 p.s.i. ft. −4650 p.s.i. This is extremely hard work to do for a conventional accumulator, with the only workable solution being the more expensive constant differential accumulators as described in the background of this application.

In this embodiment, the flow out of lines 64 and 66 goes through line 78, through control valve 70, through line 80, through check valve 82 and into reservoir 84. Reservoir 84 is simply an empty bottle at normal pressure which will withstand the external pressures of the sea water. If the gas pressure in accumulator 74 is 3000 p.s.i. and the pressure in reservoir 84 is zero, the operating differential pressure across the pistons 42 and 44 is 3000 p.s.i., irrespective of depth. It operates exactly the same at 10,000 ft. as it does at the surface.

Three position control valve 70 is shown with two opposing electric actuators 90 and 92 along with centering springs 94 and 96. As actuated with electricity sent electric actuator 92, program section 98 is active and delivers fluid from the accumulator 74 to the outer chambers 46 and 48. As the pistons 42 and 44 move forward, the fluid in inner chambers 50 and 52 is flushed out to the reservoir 84.

Hydraulic line 104 directs a supply of hydraulic control fluid from the surface through check valve 102 and into accumulator 74 to keep the accumulator 74 charged with pressurized control fluid. Electric line 100 is illustrative of control wires coming from the surface to do tasks such as operating control valve 70.

Referring now to FIG. 2, the electric signal has been removed from the electric actuator 92 and the two springs 94 and 96 have centralized the valve on program section 106. In this case the flow is blocked and the rams 32 and 34 will remain stationary in their present position.

Referring now to FIG. 3, an electric signal is sent to electric actuator 90 and has moved program section 110 to the active position. In this position control fluid will be directed from the accumulator 74, through line 78, through lines 64 and 66 to the inner chambers 50 and 52. This will push the pistons 42 and 44 away from the bore and thereby move the rams 32 and 34 away from the bore.

Referring now to FIG. 4, when control fluid collects in reservoir 84 during operations, electric motor 120 drives pump 122 and pumps the control fluids out of line 124 to the ocean as indicated by arrow 126. The control fluids will be environmentally friendly. Alternatively, the fluid can be returned to a hose back to the surface, such as hose 104.

Referring now to FIG. 5, if there is any gas entrained in the control fluids, they will tend to accumulate as a gas in the low pressure reservoir 84. Over time, a collection of gas in reservoir 84 can impede the performance of the system. Higher gas pressure in reservoir 84 reduces the pressure differential from accumulator 74. If motor 120 and therefore pump 122 is reversed, reservoir 84 will be completely filled with seawater up to flowing out of check valve 132 as indicated by arrow 132. When reservoir 84 is completely filled with water, the entrained gas will be pushed out check valve 130 also. At that time the motor 120 and pump 122 can be returned to the normal pumping direction and remove the
water from the reservoir 84, as is seen in FIG. 4. By this procedure a low pressure gas or vacuum can be maintained in reservoir 84.

[0038] The particular embodiments disclosed above are illustrative only, as the 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. 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 embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the invention. Accordingly, the protection sought herein is as set forth in the claims below.

That which is claimed is:

1. The method of providing a pressurized control fluid for the operation of subsea equipment comprising:
   providing an accumulator with control fluid pressurized by compressed gas,
   supplying said control fluid to a control valve for the purpose of operating a function,
   receiving a return flow of said control fluid from said function,
   directing said return flow of said control fluid to a chamber whose pressure is substantially unaffected by the subsea environmental pressure.

2. The method of claim 1, further comprising pumping the fluids out of said low pressure reservoir.

3. The method of claim 2, further comprising pumping said fluids into the ocean water.

4. The method of claim 2, further comprising pumping said fluids back to the surface.

5. The method of claim 4, further comprising that the hose which returns said fluids back to the surface is the same hose which brought said fluids down from the surface.

6. The method of claim 1, further comprising flooding said low pressure reservoir with water to sweep any accumulated gas out of said low pressure reservoir.

7. The method of claim 6, further comprising said water to sweep said accumulate gas is control fluid from the surface.

8. The method of claim 6, further comprising said water to sweep said accumulate gas is sea water.

9. The method of claim 8, further comprising said sea water to sweep said accumulate gas is pumped by the same pump which will pump fluids out of said reservoir.

10. The method of claim 8, further comprising said sea water to sweep said accumulate gas is pumped by a different pump than the pump which pumps fluids out of said reservoir.

11. The method of providing a pressurized control fluid for the operation of subsea equipment comprising:
    providing an accumulator with control fluid pressurized by compressed gas,
    supplying said control fluid to a control valve for the purpose of operating a function,
    receiving a return flow of said control fluid from said function to a control valve,
    directing said return flow of said control fluid to a chamber whose pressure is substantially unaffected by the subsea environmental pressure.

12. The method of claim 11, further comprising pumping the fluids out of said low pressure reservoir.

13. The method of claim 12, further comprising pumping said fluids into the ocean water.

14. The method of claim 12, further comprising pumping said fluids back to the surface.

15. The method of claim 14, further comprising that the hose which returns said fluids back to the surface is the same hose which brought said fluids down from the surface.

16. The method of claim 11, further comprising flooding said low pressure reservoir with water to sweep any accumulated gas out of said low pressure reservoir.

17. The method of claim 16, further comprising said water to sweep said accumulate gas is control fluid from the surface.

18. The method of claim 16, further comprising said water to sweep said accumulate gas is sea water.

19. The method of claim 18, further comprising said sea water to sweep said accumulate gas is pumped by the same pump which will pump fluids out of said reservoir.

20. The method of claim 18, further comprising said sea water to sweep said accumulate gas is pumped by a different pump than the pump which pumps fluids out of said reservoir.

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