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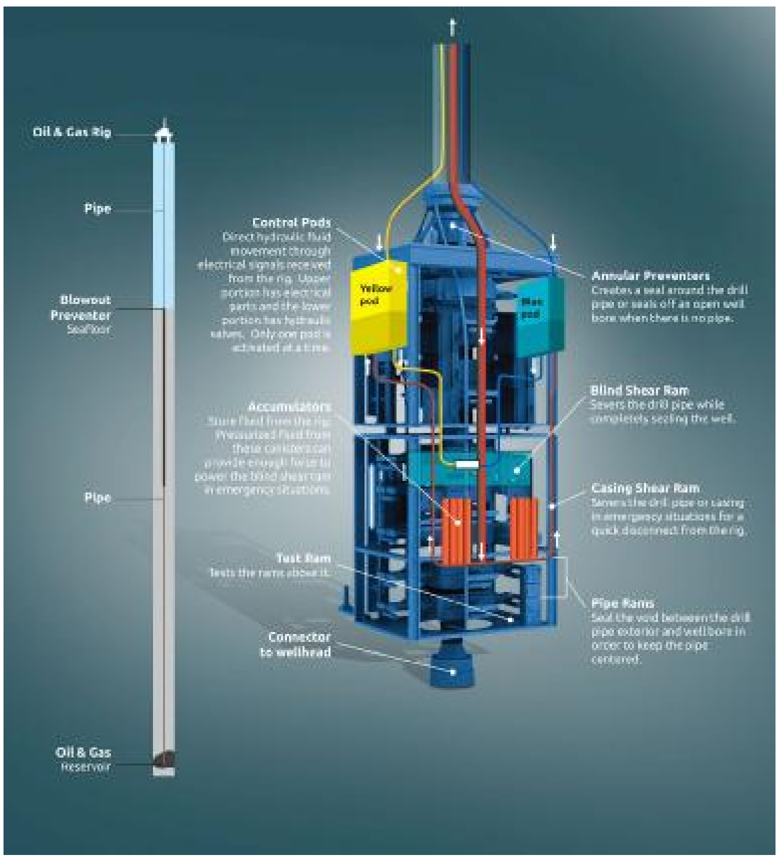
Protecting subsea hydraulic systems

Written by Aaron Glafenhein and Tim Leister Thursday, 01 August 2013 00:00

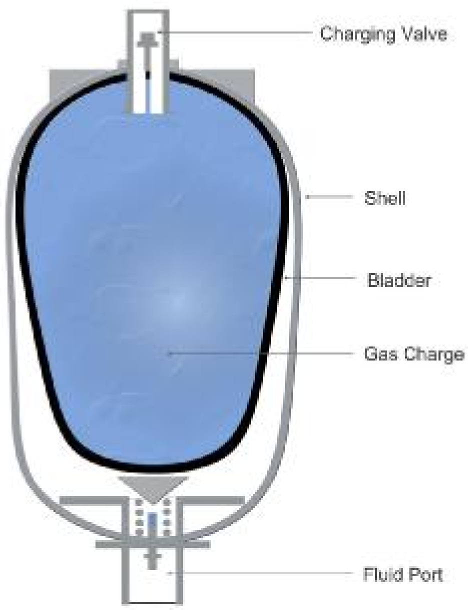
Determining accumulator best suited for an application depends on the environment in which it will operate, reliability, and maintenance cost.



Accumulators are energy storage devices that have a variety of applications. Most notably, they can be used to store potential energy, accommodate fluid expansion or provide damping for pressure transients. Accumulators are typically positioned on the high-pressure side of a system, whereas similar devices on the low-pressure side are referred to as reservoirs. For this discussion, the term accumulator refers to both device types.

There are many different types of accumulators, each with its advantages and disadvantages, to consider when designing hydraulic systems for subsea applications, including thermal and volume compensation, energy storage, and water-hammer damping. Among the key criteria in the selection process are cost, service life, maintenance, performance, and reliability. Reliability is particularly important, since the wrong choice can cost millions of dollars in additional maintenance and operating costs.

Thermal-compensation accumulators are required to accommodate fluid expansion and contraction due to temperature changes in the environment or operating conditions. These accumulators also can be used to store extra fluid in case of leaks in the system.



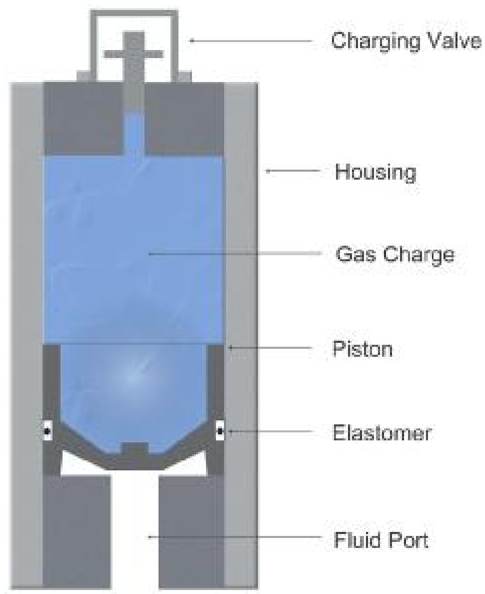
Energy-storage accumulators can be used as a backup in the event a pump fails, or to temporarily provide a higher flow rate than the pump can supply, much like a capacitor in an electrical system. These accumulators store potential energy using compressed gas or a spring to supply hydraulic pressure to a system on demand. One such instance is actuation of the shear rams on blowout preventers (BOP) to seal off wells, even during a loss of power, Figure 1. A bank of accumulators stores a large volume of hydraulic fluid at high pressure that can quickly be discharged to power the shear rams without the need for pumps or power. Since a blowout preventer operates on the ocean floor, a great deal of expense is incurred when maintenance is required. Servicing a BOP requires the use of ROVs or removal of the system to the surface. While the BOP is offline, the well is also offline, which costs a great deal in lost production and maintenance expense.

In addition, providing a steady pressure to hydraulic components such as actuators and valves can considerably improve performance and accuracy.

An accumulator can be installed near pumps and other devices, which produce pressure transients, as a damper to reduce spikes and pulsations for longer system life. The addition of an accumulator in the system may result in increased system weight.

Suitable for use in any of these applications are bladder, piston, or bellows accumulators. In addition to these types, there are several others not discussed. All function essentially the same, except for how they separate compressed gas and hydraulic fluid.

Bladder accumulators

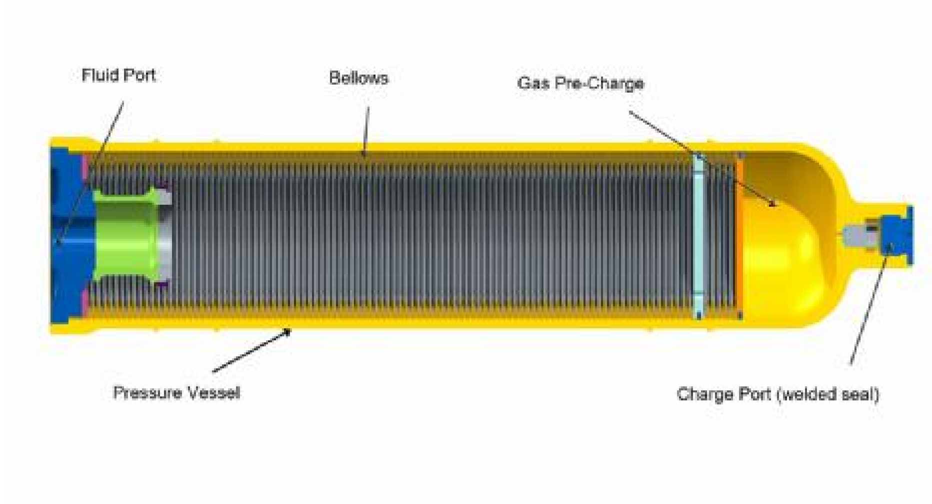


Bladder accumulators typically consist of a pre-charged pressure vessel, elastomeric bladder, fluid port, and gas-charge service port. As system pressure increases, the fluid compresses the gas and the bladder, which acts as a barrier between the fluid and gas. Pressure is balanced on both sides of the bladder, Figure 2.

This type of accumulator offers a number of advantages. Besides being the lightest and least expensive option, bladder accumulators can be designed to fit into a smaller envelope than piston or bellows accumulators. They also provide high reliability with regular maintenance.

Unfortunately they lose their precharge over time, due to the permeability of the elastomer. As a result, they need to be repressurized periodically to ensure safe operation. In addition, bladder materials are not compatible with corrosive environments such as hydrogen sulfides, sour gas, and others. Bladders must be replaced from time to time, which requires taking equipment offline.

Piston accumulators



Piston accumulators similarly consist of a pre-charged pressure vessel, fluid port, and gas-charge service port or valve, Figure 3. But instead of a bladder, they use a metal piston with an elastomeric or non-elastomeric seal. As system fluid pressure increases, the gas is compressed by the sliding piston and dynamic seal. Provided the friction is low, the pressure on both sides of the piston is essentially balanced.

These accumulators are relatively inexpensive, can outlast bladder accumulators, and can fit in a smaller envelope than bellows accumulators. With fewer components they also offer high reliability with proper maintenance. However, as with elastomeric bladders, typical piston seal materials are not compatible with some fluid environments and have a more limited temperature range, when compared to metal bellows. In addition, the piston seals must be replaced periodically, which can be quite costly when operating on the ocean floor, as it requires bringing the accumulator to the surface. And like bladder accumulators, piston accumulators tend to lose their pre-charge, requiring periodic repressurization.

Bellows accumulators

	BELLOWS	PISTON	BLADDER
LIFE	●●●	●●	●
MAINTENANCE	●●●	●	●
INITIAL COST	●	●●	●●●
RELIABILITY	●●●	●●	●●
ENVELOPE	●●	●●	●●●
FLUID COMPATIBILITY	●●●	●●	●
WEIGHT	●●	●●	●●●
TEMPERATURE	●●●	●●	●

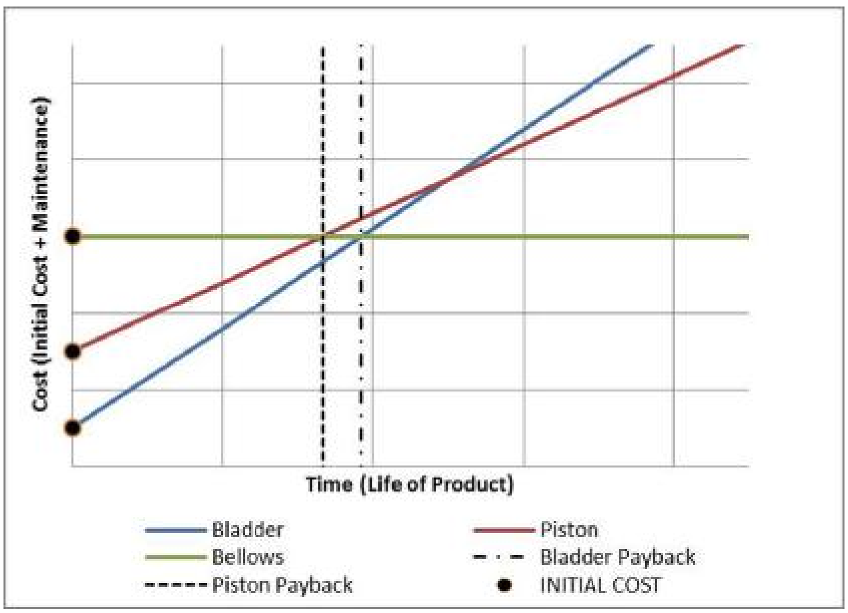
BEST	●●●	BETTER	●●	GOOD	●

Bellows accumulators consist of essentially the same components as bladder and piston accumulators, but use edge-welded bellows to separate the gas charge from the system fluid, Figure 4. As the fluid pressure increases, the extending bellows compresses the gas.

Provided the bellows have a low spring rate, pressure is essentially balanced on both sides. Since no permeation or dynamic seals are involved, bellows accumulators can be designed to provide extremely long life.

Among the major advantages offered by bellows accumulators is the fact that they are maintenance-free and do not require recharging. The bellows form a hermetic seal between the gas charge and the fluid, allowing them to remain in service for the life of a system without loss of the gas pre-charge. In addition, a service-gas port can be used to produce a variable pre-charge to accommodate different service depths. Moreover, bellows can be made of corrosion-resistant materials to withstand extreme environments that bladder and piston accumulators cannot.

However, bellows accumulators are more labor-intensive to produce than bladder and piston devices, and in general cannot be repaired if the internal components are damaged.



They also may require a slightly larger envelope than the other types.

Choosing equipment

As the demand for oil and gas increases, the industry is moving into deeper waters and more extreme environments. As a result, the equipment used in these applications is being pushed to its design limits. Determining the type of accumulator best suited for an application depends on a number of factors, notably the importance of reliability, cost of maintenance and the environment in which it will operate.

Figures 5 and 6 provide a summary comparison of the different types of accumulators in terms of these and other factors.

Bladder or piston accumulators can be used for applications where they can be easily accessed for maintenance, loss of the gas charge is not critical, and the environment is not extreme. However, where maintenance shutdowns are prohibitively costly, the risk of failure is great, and the operating environment is extreme, bellows accumulators are the best solution.