Outcome 1.2.6: Understand the function of accumulators.

Accumulators come in a variety of forms and have important functions in many hydraulic circuits. They are used to store or absorb hydraulic energy.

When storing energy, they receive pressurized hydraulic fluid for later use. Sometimes accumulator flow is added to pump flow to speed up a process. Other times the stored energy is kept in reserve until it is needed and maybe independent of pump flow. This could be for emergency power when pump flow is not available. It could be to hold pressure in a system when pump flow has stopped.

There are several ways in which accumulators are used to absorb energy. The returning flow from a large bore cylinder may be greater than should be conducted by the plumbing. A low-pressure accumulator can receive a portion of the flow and then discharge it at an appropriate rate for the plumbing. Hydraulic fluid has a relatively high rate of thermal expansion. If a volume of fluid is confined and unable to expand or contract due to temperature changes, there could be very high pressure that could damage equipment or low pressure that could cause air bubbles to appear in the hydraulic fluid. Accumulators can be used to absorb the expanding fluid and/or supply the contracting fluid. They also absorb and dissipate energy when used to dampen pressure pulses, reducing noise and vibration.

Safety Tip: Accumulators store energy. There is the potential for the sudden, uncontrolled release of energy whenever working with or around hydraulic accumulators. The energy must be released or isolated before any work is done on an accumulator or on components that may be connected to an accumulator. When hydraulic pressure is relieved, there is still stored energy in the gas. This must also be relieved or isolated.

Accumulators are pre-loaded so that there will be a minimum pressure for any available fluid. The three types of pre-loading are weights, springs, and gas. The symbol for a fluid energy storage or absorption device is the extended oval shown in Fig. 1.AA. The specific type of accumulator is shown by the additional symbols within the oval, as shown Fig.1.BBa, 1.BBb, and 1.BBc. Of the three types of accumulators, only the weighted one has constant pressure. The pressure is produced by the weight divided by the area of the supporting piston. Weighted accumulators are appealing from the perspective of circuit design but are not usually practical for mobile applications. They must be mounted vertically, they are relatively large, and they are heavy. Spring-loaded and gas-charged accumulators weigh less, take up less space, and can be mounted horizontally, although it is preferred to mount accumulators vertically.

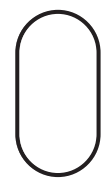

Fig. 1.AA Extended Oval

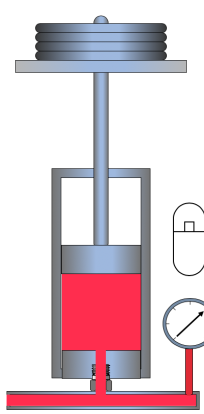

Fig. 1.BBa Weighted Accumulator

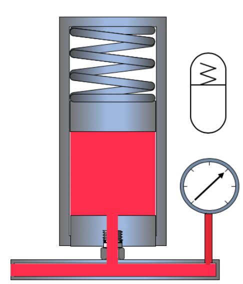

Fig. 1.BBb Spring-Loaded Accumulator

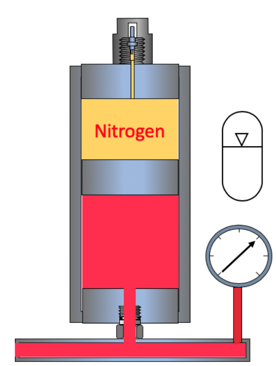

Fig. 1.BBc Gas-Charged Accumulator

Gas accumulators are sometimes referred to as having a gas spring. In the gas accumulator category, there are six main types:

- Piston
- Bladder
- Diaphragm
- Bellows
- Noise Suppressor
- Air-over-oil

Like a compressed spring that wants to push toward its extended position, a compressed gas wants to push toward its decompressed state. The gas used is incombustible, usually nitrogen, unless the pressure is very low. Even though there is usually a separating element between the gas being used and the hydraulic fluid, using a gas that contains oxygen, such as air, can result in an explosion. As the air is compressed, it is heated, and if the heated oxygen interacts with the hydraulic fluid, it may cause ignition.

A hydraulic mechanic may be required to check the gas pressure in an accumulator. Three different pressures are considered when working with gas-charged accumulators. These pressures are not always described in the literature and may simply have the designation of p_0, p_1, and p_2.

p_0 = Pre-charge pressure: The original gas pressure before any hydraulic fluid is stored in the accumulator.
p_1 = Minimum pressure: The lowest hydraulic pressure requirement of the system.
p_2 = Maximum pressure. The highest pressure that the accumulator will see.

Each one of these pressures provides information about the hydraulic system. If the accumulator is fully charged (is holding the maximum amount of hydraulic fluid), the maximum system pressure reading is (p_2). If this reading is too high or too low, the controlling relief valve or pressure compensator may need to be adjusted. During operation, the minimum system pressure (p_1) should be noted. Then the pre-charge (p_0) is tested to be sure it is at the specified pressure below p_1. Over time, some of the gas may escape, reducing the pre-charge. If this happens too frequently, it indicates that the barrier has failed, and the accumulator must be repaired or replaced. When an accumulator loses its pre-charge, it will no longer store energy. The accumulator can be filled to full system pressure, but there would be no energy stored in the gas spring to push the fluid out.

Sizing Gas Accumulators: Gas accumulators are not described by how much hydraulic fluid they can hold. They are described by the volume of gas they hold. A 1-liter accumulator will hold 1-liter of compressed gas. As hydraulic fluid enters the accumulator, it compresses the gas, increasing its pressure and reducing its volume. The amount of stored hydraulic fluid is the difference between the original gas volume and the new compressed volume. A 1-liter gas accumulator half-filled with hydraulic fluid would have ½ liter of compressed gas and ½ liter of stored hydraulic fluid.

Piston Accumulators: These are made of cylinders with pistons. The seals on the pistons are the separation elements that isolate the gas from the liquid. Like all gas accumulators, they are pre-charged (p_0) at a pressure that is below the minimum hydraulic pressure (p_1). This is so that hydraulic pressure will always prevent the piston from bottoming out.

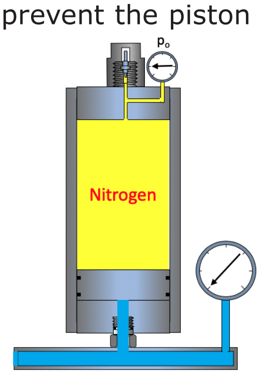

Fig. 1.CCa Pre-Charge Pressure, No Stored Energy

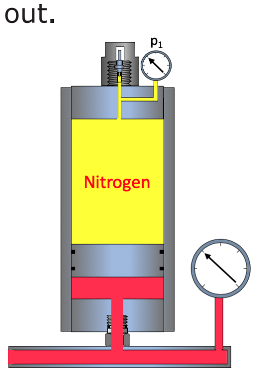

Fig. 1.CCb Minimum System Pressure, Minimal Stored Energy

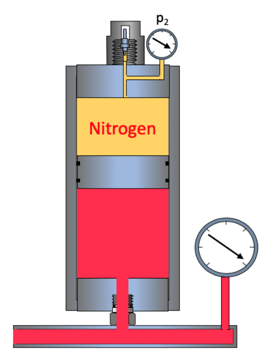

Fig. 1.CCc Maximum Accumulator Pressure, Maximum Stored Energy

Bladder Accumulators: A metal or composite bottle is fitted with an expandable bladder used to store pressurized gas and keep it separated from the hydraulic fluid. A charging valve is connected to the bladder at the top of the bottle. At the bottom of the bottle, there is a spring-loaded poppet valve that is in the open position. When the bladder is pre-charged (p_0), it stretches and completely fills the bottle, closing the poppet. The poppet prevents the bladder from being destroyed by extruding into the piping.

When the accumulator is filled with the maximum volume of hydraulic fluid, the gas is compressed to the maximum pressure (p_2). Just as in the piston accumulator, the pre-charge is lower than the minimum system pressure. In this way, the bladder does not bottom out against the poppet. If the pre-charge is too high, the bladder may extrude under the poppet and be pinched and torn as the poppet closes.

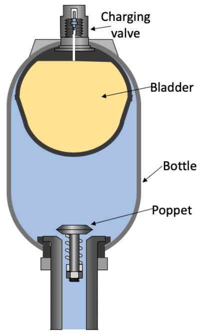

Fig. 1.DDa Bladder Accumulator Before Pre-Charge

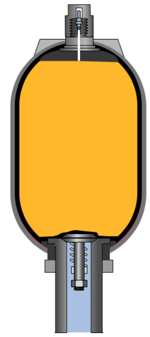

Fig. 1.DDb Bladder Accumulator With Pre-Charge, Poppet Closed

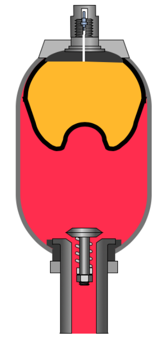

Fig. 1.DDc Bladder Accumulator, Fully-Charged

Diaphragm Accumulators: Diaphragm accumulators use a rubber disc to isolate the gas from the liquid. This disc is positioned between two spherical shells that are either welded or screwed together. The compartment above the diaphragm is filled with nitrogen. The compartment below is directly connected to the hydraulic circuit. There is a poppet that prevents the diaphragm from extruding into the piping. Some of the diaphragm accumulators and not serviceable so that if the disc ruptures or the pre-charge is lost, they must be replaced.

Fig. 1.EE Diaphragm Accumulator

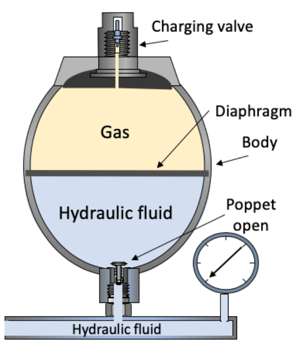

Fig. 1.FFa Diaphragm Accumulator Before Pre-Charge

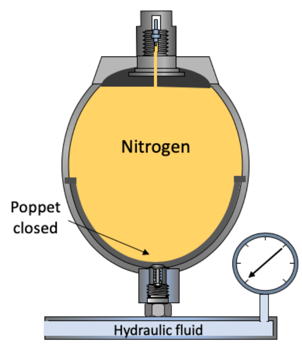

Fig. 1.FFb Diaphragm Accumulator Pre-charged

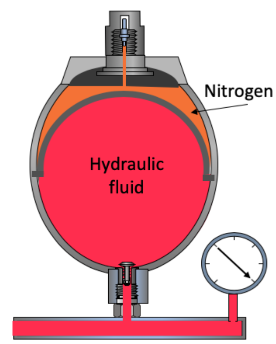

Fig. 1.DDc Diaphragm Accumulator, Fully Charged

Bellows Accumulator: A less common accumulator is the bellows type. It consists of an expandable metal chamber inside a housing. The metal chamber is precharged with nitrogen, and the housing is then exposed to the high-pressure hydraulic fluid. The walls of the expandable container do not touch the walls of the housing, therefore there is no frictional wear as the bellows expand and retract. They do not use elastomeric bladders, diaphragms, or piston seals therefore they are not subject to the limitations of elastomers. Metal bellows operate reliably in high-temperature, extremely abrasive, and harsh environments. The welded bellows are hermetically sealed and can operate reliably without servicing or maintenance.

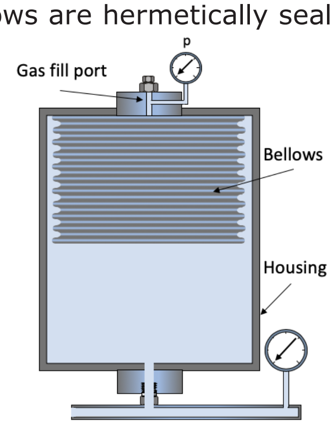

Fig. 1.GGa Bellows Accumulator Before Any Gas or Hydraulic Pressure

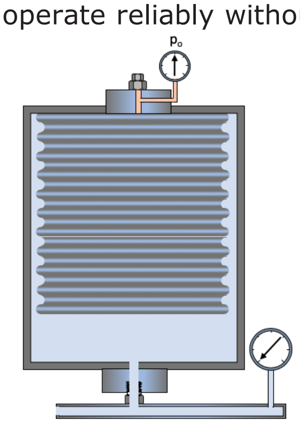

Fig. 1.GGb Bellows Expanded After Pre-charge (p_0)

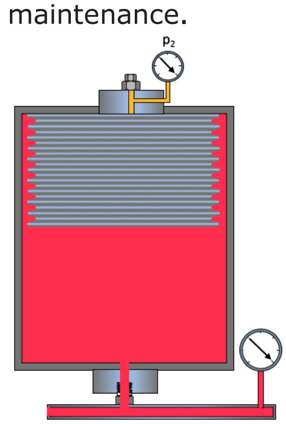

Fig. 1.GGc Bellows Compressed at Full-Charge (p_2)

Noise Suppressor: Most hydraulic pumps produce energy pulses as the individual chambers discharge fluid. These energy pulses produce vibration and noise. A type of accumulator is used to dampen sound and reduce vibration in hydraulic lines. It is an in-line device equipped with a bladder that surrounds a diffusing tube. The bladder is charged with gas, typically at ½ the hydraulic system pressure. As the fluid passes through the suppressor, much of the energy pulse is absorbed, providing reduced vibration and noise.

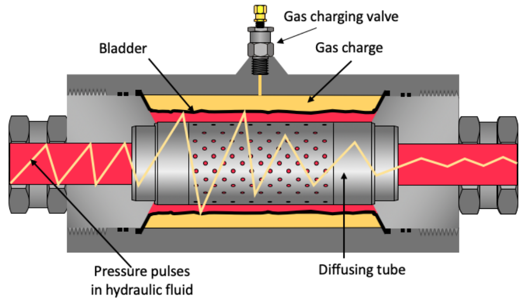

Fig. 3.HH Noise Suppressor

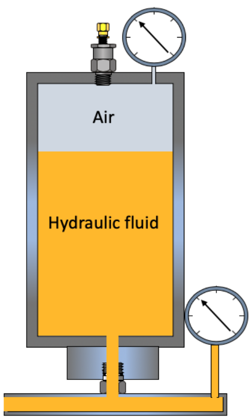

Fig. 4.II Air-Over-Oil Accumulator

Air-Over-Oil: An air-over-oil system is a simple version of an accumulator. However, it has some serious limitations. It must be mounted vertically and be a relatively low-pressure system. High-pressure air can become very hot and could cause ignition of the hydraulic fluid. As seen in the illustration, the hydraulic pressure will be the same as the air pressure. Because there is no barrier between the air and the hydraulic fluid, the unit should not be subject to a lot of motion. Movement and vibration may cause a mixing of the air with the hydraulic fluid, producing a sponginess in the system.

Review 1.2.6.1: Accumulators are used to:
a. Compress nitrogen.
b. Compress hydraulic fluid.
c. Accumulate particulates.
d. Store or absorb energy.
e. Reduce flow.

Review 1.2.6.2: The advantage of the weighted accumulator is that:
a. It can be mounted horizontally.
b. It is lighter in weight.
c. It takes up less space.
d. It can be charged with shop air.
e. It has a constant pressure.

Review 1.2.6.3: The amount of hydraulic fluid that can be stored in a gas charged, 1-gallon accumulator:
a. Will always be ½-gallon.
b. Will be equal to the gas volume.
c. Will be less than 1 gallon.
d. Will be 1.5 times the gas volume.
e. Will be determined by the spring force

Review 1.2.6.4: The poppet in a bladder or diaphragm accumulator:
a. Is to prevent the separation element from extruding into the piping.
b. Is to prevent hydraulic fluid from leaking into the accumulator.
c. Is to prevent hydraulic fluid from leaking out of the accumulator.
d. Is to prevent the oxygen for igniting the fluid.
e. Is to prevent the air from escaping.

Review 1.2.6.5: An air over oil accumulator:
a. Uses a diaphragm to isolate the air from the oil.
b. Is only used for high pressure systems.
c. Must not be mounted vertically.
d. Prevents air from entering the hydraulic fluid.
e. Should not be subject to a lot of motion or vibration.