ACCUMULATORS

Function

Accumulators store hydraulic fluid under pressure and can serve a number of functions within a hydraulic system including:

- leakage compensation
- emergency power source
- pulsation and shock absorption
- noise elimination
- load counter-balance

Gas pre-charge pressure

The most common type of accumulator employed in modern hydraulic systems is the nitrogen gas loaded type, of which there are three variations: bladder, diaphragm and piston. The required gas pre-charge pressure (p_1) for nitrogen gas loaded accumulators expressed as a percentage of the minimum hydraulic system pressure (p_2) varies with the application as follows:

Application	Gas pressure (p_1)	Formula
Storage	90% of p_2	$p_2 \times 0.9$
Shock elimination	60% of p_2	$p_2 \times 0.6$
Pulsation dampening	70% of p_2	$p_2 \times 0.7$

Sizing

Accumulators are sized according to their effective or actual gas volume (V_1) when all oil is discharged. The volume of oil available from a given size accumulator depends on the volume of gas available to push it out, known as the working volume (V_w). Working volume varies as the pressure and temperature of the gas varies. Gas temperature and therefore volume, are influenced by the speed at which the gas compresses and decompresses as the accumulator is charged and discharged. For this reason the rate of charge and discharge needs to be considered when sizing an accumulator.

Storage application

The effective gas volume (V_1) in cubic inches (or litres) required for an accumulator in a storage application can be calculated using the following formulae. Before proceeding, the following variables must be determined based on hydraulic system requirements:

V_w	=	the required oil volume to or from the accumulator in in³ (or litres)
p_1	=	gas pre-charge pressure in psi (or bar)
p_2	=	minimum required operating pressure in psi (or bar)
p_3	=	maximum system pressure in psi (or bar)
κ	=	correction factor for adiabatic (fast charge and discharge) conditions. For nitrogen gas in adiabatic conditions $\kappa = 1.4$ is normally used.

For applications where conditions are isothermal (slow charge and slow discharge):

$$V_1 = \frac{V_w \times (p_2 \div p_1)}{1 - (p_2 \div p_3)}$$

For isothermal (slow) charge and adiabatic (fast) discharge conditions:

$$V_1 = \frac{V_w \times (p_3 \div p_1)}{(p_3 \div p_2)^{1/\kappa} - 1}$$

For adiabatic (fast) charge and discharge conditions:

$$V_1 = \frac{V_w \times (p_2 \div p_1)^{1/\kappa}}{1 - (p_2 \div p_3)^{1/\kappa}}$$

To quickly approximate the working volume (V_w) of a given size accumulator under isothermal conditions:

$$V_w = \frac{0.95 \times p_1 \times V_1}{p_2} - \frac{0.95 \times p_1 \times V_1}{p_3}$$

Pulsation dampening application

To calculate the minimum effective volume (V_1) required for an accumulator in a pulsation dampening application:

$$V_1 = \frac{0.45 \times Q}{n}$$

Where

V_1 = effective volume in in^3 (or litres)
Q = pump flow in in^3/min (or litres/min)
n = pump speed in rpm

The connection port of the accumulator should be at least equal in diameter to the discharge port of the pump.

Installation

The optimum installation position for all accumulators is vertical with the hydraulic port down. Accumulators can be mounted horizontally, however in the case of bladder type units this can result in accelerated bladder wear as the bladder rubs against the shell while floating on the hydraulic fluid. This can result in premature failure of the accumulator.