Fluid Power Design Data Sheet

REVISED SHEET 47 - EVOLUTION DESIGN DATA FILE

TIPS ON SIZING ACCUMULATORS

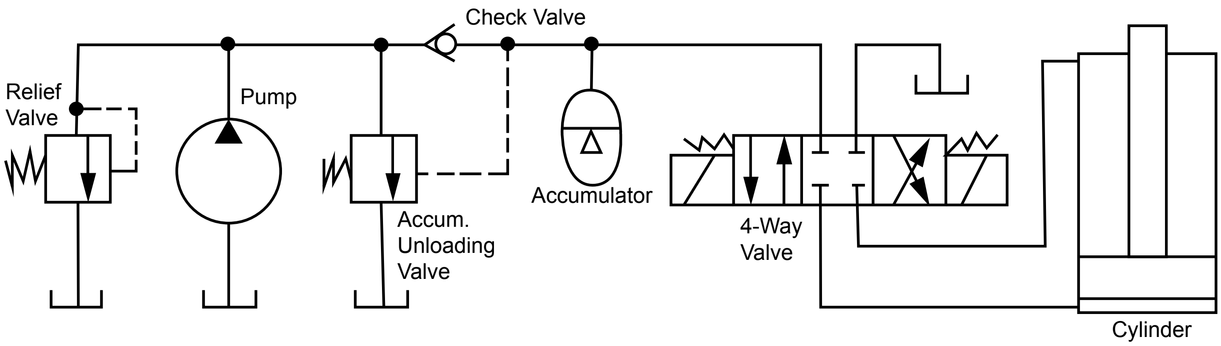
Space does not permit a full discussion of accumulators, and this issue will be limited to a practical method of determining the minimum capacity of an accumulator when used to supplement the flow of oil from a pump as in the circuit shown below.

In the basic circuit, a closed center 4-way valve is used. The purpose of the accumulator is to store high-pressure oil from the pump during periods when the 4-way valve is centered. When stored pressure reaches a predetermined maximum (usually 3000 PSI), the pump is automatically unloaded and allowed to idle for the remainder of the cycle. Either a special pilot-operated unloading valve or a pressure switch and solenoid dump valve is used. When the 4-way valve is shifted to start the cylinder, the stored oil adds to the pump flow to give the cylinder a speed greater than from pump oil alone. The big advantage of accumulators on this type of system is that a smaller (and less expensive) pump, electric motor, and control valve will do the same job as larger and more costly components. See rule-of-thumb on percentage duty cycle.

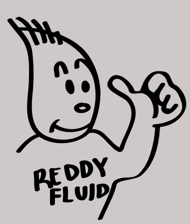
Additional information, plus many accumulator circuits, are shown in publications by Evolution Motion Systems, including "Industrial Fluid Power - Volume 1" and "Fluid Power in Plant and Field."

System PSI. Optimum system pressure for most accumulators is 3000 PSI. They have maximum energy storage, least cost, and smallest size when operated at their maximum pressure rating. Although 5000 PSI models are available in some brands, their greatly increased cost offsets their pressure advantage, so they are less desirable on most systems.

Compressibility. An accumulator adds compressibility in the oil stream between pump and 4-way valve, and if this is undesirable, an accumulator should not be used. However, on systems using a pressure compensated flow control valve or a servo-type 4-way valve, compressibility in the line ahead of the 4-way valve is not usually objectionable.



Basic accumlulator circuit in which a low volume pump stores high pressure oil in the accumulator while the 4-way valve is centered. Pump oil plus accumulator discharge gives cylinder a rapid stroke.



RULE-OF-THUMB FOR LEVEL OF PRE-CHARGE PRESSURE

The accumulator should be charged with dry nitrogen to a pressure equal to 1/2 the maximum hydraulic pressure of the systm - 1500 PSI when used in a 3000 PSI hydraulic system, etc. It need not be re-charged until the nitrogen pressure has dropped to 1/3rd the maximum hydraulic pressure - 1000 PSI in a 3000 PSI hydraulic system.

RULE-OF-THUMB FOR CHOOSING ACCUMULATOR OPERATION

If working time of a hydraulic system is less than 25% of the total running time (75% idling time), the addition of an accumulator will probably save on both the original construction cost and on the operating cost. If, however, the working time is more than 25% of the total running time, the extra cost of an accumulator, its unloading valve, plus charging and gauging equipment ma be more expensice than a more conventional circuit.

DISCHARGE CAPACITY OF A 1-GALLON SIZE ACCUMULATOR

Min. Acceptable System PSI	Max. System PSI With Accumulator Fully Charged				
	3000	2750	2500	2250	2000
2700	12	- - - -	- - - -	- - - -	- - - -
2600	17	- - - -	- - - -	- - - -	- - - -
2500	22	11	- - - -	- - - -	- - - -
2400	27	16	- - - -	- - - -	- - - -
2300	33	21	10	- - - -	- - - -
2200	40	27	15	- - - -	- - - -
2100	46	34	21	8	- - - -
2000	55	41	27	14	- - - -
1900	63	49	35	20	6
1800	73	58	43	27	12
1700	84	67	51	35	19
1600	96	79	61	44	27
1500	109	91	73	55	36
1400	- - - -	105	86	66	47
1300	- - - -	- - - -	101	80	59
1200	- - - -	- - - -	- - - -	96	73
1100	- - - -	- - - -	- - - -	- - - -	89

HOW TO USE THE CHART

As oil is allowed to discharge from a piston or bladder-type accumulator, the pressure of the oil drops. For example, looking at the chart above, in the 3000 PSI column, when 12 cubic inches of oil are discharged from a 1-gallon size accumulator, the pressure falls from 3000 to 2750 PSI, etc. So, one important factor in arriving at an adequate size accumulator is to select a size large enough so this inevitable drop in pressure will not affect normal operation of the hydraulic circuit. Cylinders and hydraulic motors must be large enough to produce the required force or torque at the final pressure remaining at the end of accumulator discharge. In finding the "gallon" capacity needed in a particular application, follow these design steps:

Step 1. Calculate or estimate, as accurately as you can, the volume of oil, in cubic inches, that will be needed from the accumulator on each discharge cycle to supplement the volume of oil flowing from the system pump.

Step 2. Considering the size of cylinders or hydraulic motors being used, calculate to what level the pressure can drop during the discharge cycle without the output force or torque falling below an acceptable level.

Step 3. In the chart, use the column headed by your system pressure when the accumulator is fully charged. In the left column, find the lowest acceptable system pressure at the end of the discharge cycle. The figure in the chart is the number of cubic inches of oil that can be recovered from a 1-gallon size accumulator under these pressure conditions.

Example: If your fully charged pressure is 3000 PSI, and your lowest acceptable pressure is 2000 PSI, the chart shows that 55 cubic inches can be recovered from a 1-gallon accumulator. Suppose you calculated that 230 cubic inches will be needed for your application. The minimum accumulator capacity is:
230 ÷ 55 = 4.18 gallons. The nearest standard accumulator size is 5 gallons - the correct size to use.

Figures in the body of the chart are the number of cubic inches of oil that can be discharged from a "1-gallon" accumulator, starting with a fully charged pressure shown along the top of the chart and discharging until the system pressure falls to values shown in the left column. With larger accumulators, multiply the figures in the chart times the gallon capacity of the accumulator. For example, if working with a 10-gallon accumulator, multipy chart figures times 10, etc.

Figures in the chart are about 5% less than if calculated by Boyle's Law for theoretical discharge. This is to compensate for loss of capacity during discharge caused by a temperature drop in the gas when the accumulator is discharged rapidly.

For operating conditions beyond the range of the chart, the formula in the box below may be used. As explained in the text, accumulator systems are most often designed for a fully charged accumulator pressure of 3000 PSI.

Mathematical Solution for Accumulator Size

The following is a general formula that will solve for the cubic inch oil discharge from any size accumulator under any conditions of pre-charge and system pressure. It may be used for operating conditions not covered by the chart.

A loss-of-capacity allowance of 5% is built into the formula to take care of loss of capacity caused by temperature changes as the gas compresses and expands.

D = [0.95 x P1 x V1 ÷ Ps] - [0.95 x P1 x V1 ÷ P3]

D is the number of cubic inches of oil discharge.
P1 is the nitrogen pre-charge pressure, in PSI.
P2 is sytem pressure, in PSI, after volume D cubic inches has been discharged.
P3 is maximum system pressure, in PSI, with accumulator fully charged.
V1 is the catalog-rated gas volume of the accumulator, in cubic inches.
0.95 gives an allowance of 5% for loss of capacity.

While figures in the chart show 5% less volume than calculated, to take care of loss of capacity that occurs on a quick discharge, the accumulator, when used on long holding applications, will eventually give back an additional 5% of oil as the shell - slightly cooled by the quick discharge - gradually warms back up to normal temperature.