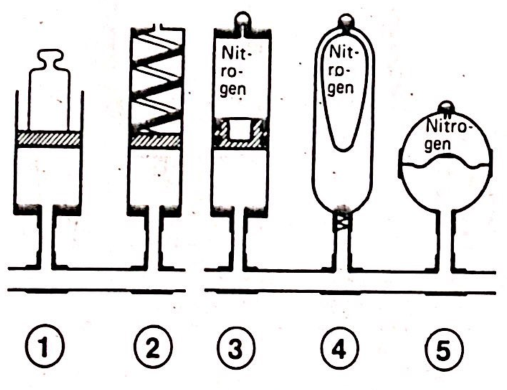
Hydraulic Accumulators

A hydraulic accumulator serves to take into store a volume of fluid under pressure and to release it again, as required. The pressure accumulator can carry out many tasks in a hydraulic circuit.

- As **fluid reserve**, where a large quantity of fluid may be required at short notice in a hydraulic system. The hydraulic pump is not designed for the maximum flow required for a short time only. It has a lower flow volume and fills the accumulator, if, during the working cycle, the volume of fluid required for the system is lower than the pump flow. If the maximum volume is then required, the difference between this and the pump flow volume is taken from the accumulator. The accumulator therefore helps to avoid the use of a large pump with high drive power, suitable for the short-term high power requirement.
- As an **emergency unit**, to stop an operation which has already started, should there be any damage to the pump or its drive.
- As **leakage compensation**, to make up leakage losses and thus maintain pressure over a long period.
- To **balance out the volume** at temperature changes, e.g. for a closed system.
- To **break down pressure peaks** during switching processes.
- To **cushion vibrations**; decrease of pressure amplitudes on pumps.
- For the **recovery of brake energy**.

Various models of accumulator are available:

Fig. 1



1 Weight accumulator
2 Spring accumulator
3 Piston type accumulator
4 Bladder accumulator
5 Membrane accumulator

Weight and spring type accumulators are of practically no importance for industrial applications.

The gas pressure accumulator is used most frequently. The actual accumulation of pressure energy is undertaken by the compressible gas (nitrogen). One differentiates between piston, bladder and membrane accumulators.

Piston Accumulators

They are suitable mainly for large volumes and large discharge quantities. The gas and fluid are separated by a free-moving piston ("flying piston"). The piston runs in a cylinder tube and provides a seal between the gas and the fluid by means of rings. The maximum pressure ratio, i.e. the ratio gas pressure to maximum operating pressure, is 1 : 10.

Membrane Accumulators

They are used for small volumes, for example, to absorb shocks, cushion vibrations and for pilot circuits. The membrane, which is generally semi-spherical, divides the two medien and arches to the fluid side.
The maximum pressure ratio is again 1 : 10.

Bladder Accumulators

Hydraulic Accumulators

Fig. 2

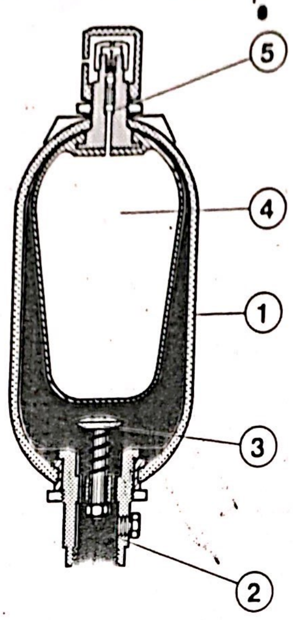
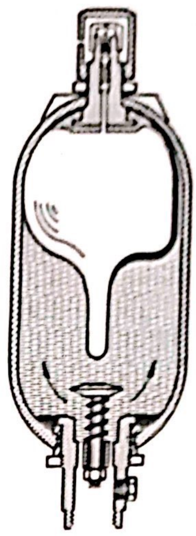


Fig. 3

Fig. 4



Symbol

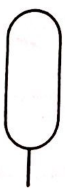
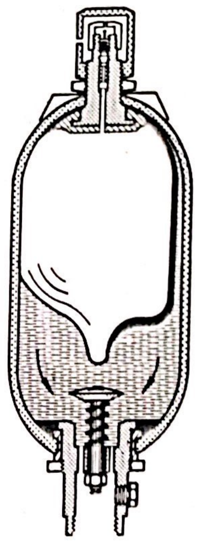


Fig. 5



It is distinguished by its absolute sealing feature, very short response time and very low inertia operation.

In a bladder accumulator, the nitrogen and fluid are separated by a closed flexible bladder. The gas is inside the bladder.
The maximum pressure ratio is 1 : 4.

The bladder accumulator (fig. 2) comprises a steel container 1 with fluid connection 2, plate valve 3, accumulator bladder 4 and gas valve 5.

The accumulator bladder 4, initially stressed with gas via gas valve 5, completely fills the steel container and closes the plate valve (fig. 3). The plate valve prevents the bladder from coming out of the container and also protects it from damage.

If the pressure in the hydraulic system becomes equal to the initial gas stress, fluid then flows into the accumulator by means of the plate valve and compresses the nitrogen in the bladder (fig. 4). The gas volume is decreased by the fluid intake volume. As the fluid drains, the accumulator bladder increases in size again (fig. 5). The gas pressure and also the pressure in the system follow the gas laws:

$$p \cdot V^n = \text{constant.}$$

p = gas pressure

V = gas volume

If the conditions change very slowly, causing exchange of heat, one talks of the **isothermal change of conditions.**

The gas temperature remains constant.

The power n = 1.

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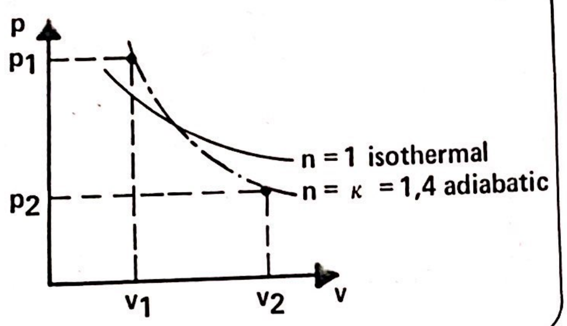
With an **adiabatic change in condition,** there is no change in heat. This means that an exchange of heat between the gas volume in the accumulator bladder and its immediate surroundings is not possible, when considering a pressure accumulator system. This conditions occurs, if the compression or expansion processes occur very quickly.

The power $n = \kappa - 1.4$

gas equation $p_1 \cdot V^n = p_2 \cdot V^n$

Representation of the process in P-V diagram (fig. 6)

Fig. 6



In practice, the change in conditions will lie between adiabatic and isothermal, depending on the drain speed. This is called a **politropic change in conditions.** The power n lies between 1 and 1.4. $(1 < n < 1.4)$.

The following quantities for the accumulator are calculated by means of the gas equation: nominal volume, working volume available and prefill pressure related to the minimum and maximum operating pressure. These data can also be taken direct from the diagram, using the power performance curves (fig. 7).

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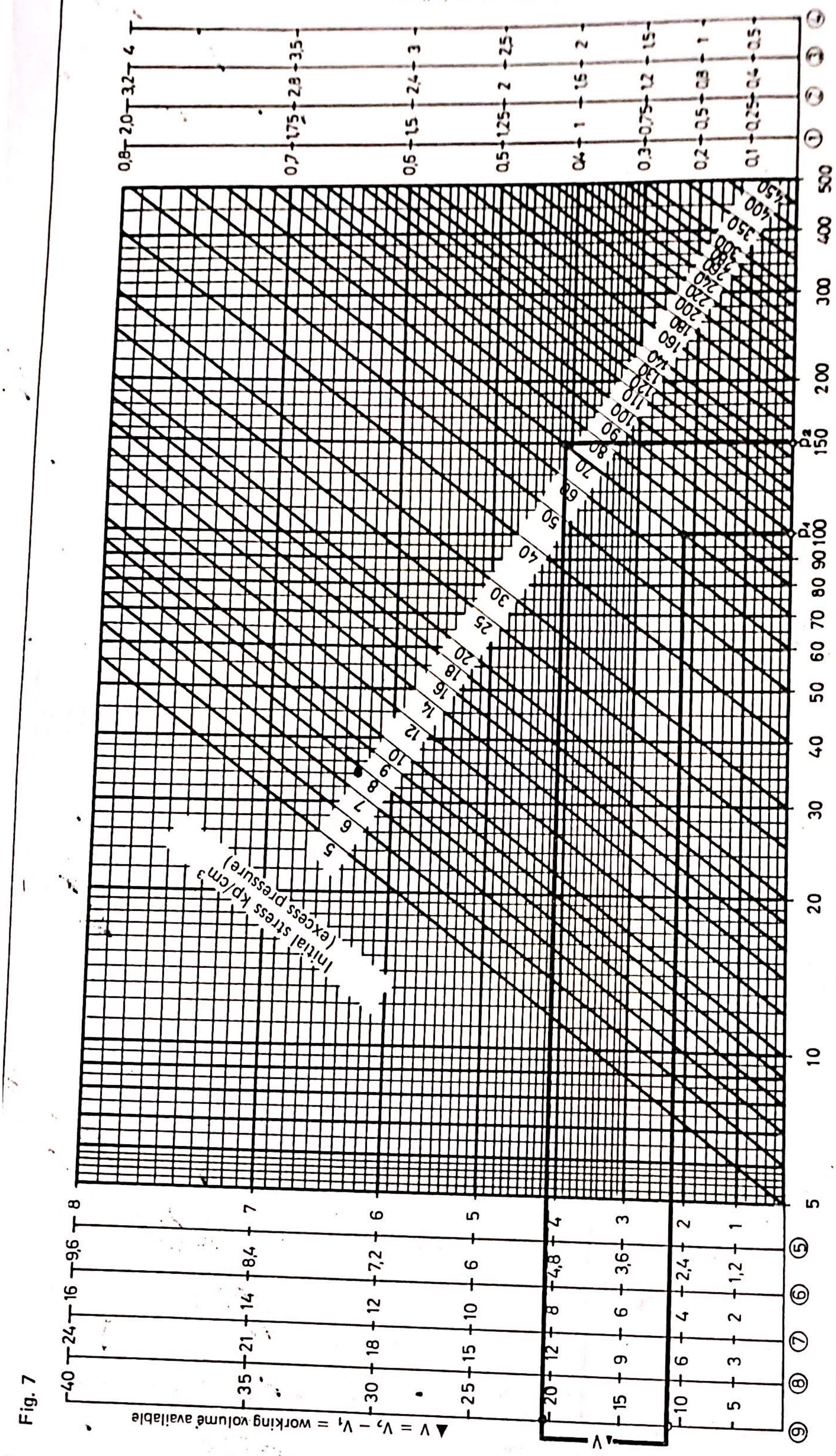
Fig. 7



Nominal size of the accumulator in litres

① = 1 / ④ = 5 / ⑦ = 20
② = 2,5 / ⑤ = 10 / ⑧ = 32
③ = 4 / ⑥ = 12 / ⑨ = 50

p_1 = min. operating pressure, p_2 = max. operating pressure in the hydraulic unit kp/cm³ (excess pressure)

The diagram is based on the gas laws: $V_0 = V_1 \left(\frac{P_1}{P_0}\right)^{\frac{1}{K}}$ or $P_1 = P_0 \left(\frac{V_0}{V_1}\right)^{K}$

(K – nitrogen = 1.4; p_1 and p_2 in kp/cm³, absolute pressure) bar

For de-stressing under 2 minutes, when temperature between gas and pressure fluid is not balanced out.

Adiabatic performance curve

Diagram: Messrs. Hydac Gesellschaft für Hydraulic-Zubehör mbH

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The prefill pressure initial gas stress of the accumulator should lie between 0.7 – 0.9 of the minimum working pressure.

$$p_0 \leqslant 0.9 \times p_1$$

p_0 = initial gas stress
p_1 = minimum operating pressure
p_2 = maximum operating pressure

This should prevent the accumulator bladder from operating constantly in the oil valve range, which could cause damage.

The smaller the pressure difference between p_2 and p_1, the larger is the accumulator, related to a pre-stated working volume.

If accumulators are used in hydraulic systems, certain instructions must be heeded.

All pressure accumulators are subject to the safety instructions of the professional associations (UVV 13.5 pressure containers).

A few important points from these instructions:

– Each pressure container must have a suitable pressure gauge, indicating the operating pressure. The highest operating pressure permissible must be clearly marked.
(This refers to an additional pressure gauge.)
– A suitable safety valve must be available for each pressure container. The setting must be secured against alteration by unauthorised people (control seal).
– The safety valve must not be lockable.
– Easily accessible isolating devices must be available in the pressure supply lines, as near as possible to the pressure container. It must be possible to isolate each container (accumulator).

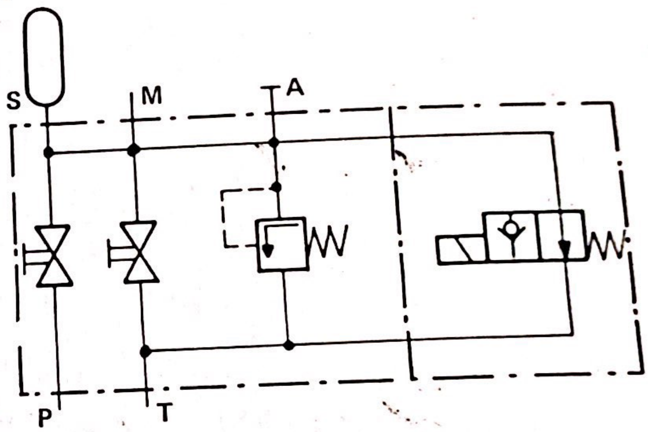
– Test requirement for pressure containers:

Group A: maximum operating pressure over 0.5 bar pressure litre product $p \cdot l \leqslant 200$
Accumulator need not undergo test.
p = maximum operating pressure of the accumulator (not the complete unit)
l = volume of the pressure chamber (accumulator size)

Group C: maximum operating pressure over 0.5 bar pressure litre product $p \cdot l > 200$ to 1000
Accumulators must be tested before first commissioning.

Group D: maximum operating pressure over 0.5 bar pressure litre product $p \cdot l > 1000$
Accumulators must be tested before first commissioning and at regular intervals thereafter.

The safety and shut-off block in the following diagram corresponds to the first points mentioned.



S = accumulator connection
M = pressure gauge connection
P = pump connection
T = tank connection
A = test connection

Electrical unloading is also possible, as shown in the circuit on the right.