



# HYDROPNEUMATIC BLADDER ACCUMULATORS



**CAUTION**  
NEVER FILL WITH OXYGEN. DANGER OF  
EXPLOSION. PRESSURE SHOULD NOT BE LESS  
OR MORE THAN WORKING PRESSURE. -3) MAKE SURE THE  
PRESSURE BEFORE DISASSEMBLING. SEE INSTRU-  
CTIONS. -4) DO NOT TAMPER WITH THE BOTTLE.



**ATTENZIONE**  
-1) PRECARICARE CON AZOTO  
-2) LA PRESSIONE NON DEVE  
INFERIORE A 1/3 DELLA PRESSIONE  
A 9/10 LA PRESSIONE NOMINALE  
CUMULATORE ASSICURARE  
LE CONDIZIONI DI USO E MANUTEN-  
TIONE.

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## 1.1 Definition and operation

The hydropneumatic accumulator is a device designed specifically for the storage of liquids under pressure. As liquids are, for all practical purposes, incompressible, the objective is achieved by utilising the compressibility of gases (fig. 1):

- A) A flexible separator bladder is fitted into a pressure vessel (accumulator shell).
- B) Through a special valve an inert gas (nitrogen) is introduced into the bladder with pressure  $P_0$ . The bladder expands, filling the entire volume  $V_0$  of the accumulator shell.
- C) When circuit pressure  $P_1$  is higher than the gas precharge pressure  $P_0$ , the liquid valve opens, and the bladder is compressed reducing the gas volume to  $V_1$ .
- D) When the liquid pressure rise to  $P_2$ , the volume of gas reduces to  $V_2$  with an attendant rise in pressure, thus balancing the liquid pressure.

This means that the accumulator has been pressurised  $\Delta V = V_1 - V_2$  and a potential energy has been created to be utilised as desired (refer to section 2).

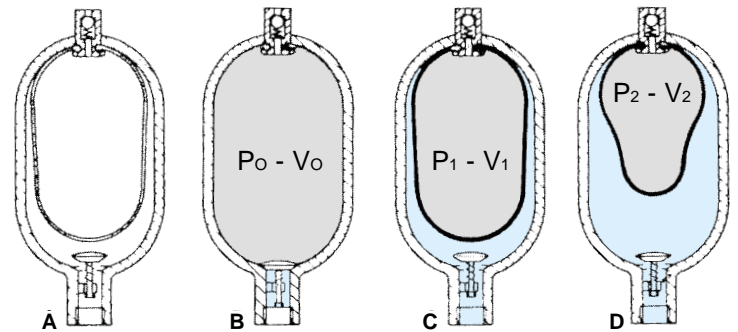


fig. 1

## 1.2 Construction features

The EPE Bladder Accumulator comprises a steel shell in which is fitted a bladder complete with a gas valve and fluid port with the poppet valve (fig. 2):

- **The shell** is a pressure vessel forged or fabricated from high grade steel designed and manufactured to meet the relevant international standards. For special applications various surface coatings are available as well as a stainless steel construction.
- **The bladder**, which separates the gas from the liquid, is made in nitrile rubber in the standard version. Bladders in butyl, neoprene, ethylene-propylene etc. are available for special uses. The main feature of the EPE bladder, which makes it unique, is the special manufacturing process thanks to which it is produced in one single piece without joints, even in the larger sizes, so as to avoid all the problems which poor gluing may involve. Another advantage of the EPE bladder is the gas valve which, not being vulcanised to the bladder, can be fit to it and removed simply and safely. For this reason the same bladder can be supplied with gas valve in different versions, or the valve can be reused, thus reducing the cost of spare parts.
- **The gas valve** is connected to the bladder by a rubber coated washer to ensure a gas tight joint and a non return valve is incorporated for bladder inflation. The bladder, complete with the gas valve, is fixed to the accumulator shell by a lock nut, and the assembly is protected by a cover.
- **The fluid port valve** prevents the bladder from extruding into the fluid port and, at the same time, allows the liquid to flow. In the high pressure range is used a poppet valve, while in the low pressure range is used a drilled disc. In the latter case the precharge pressure should not exceed 15 bar.

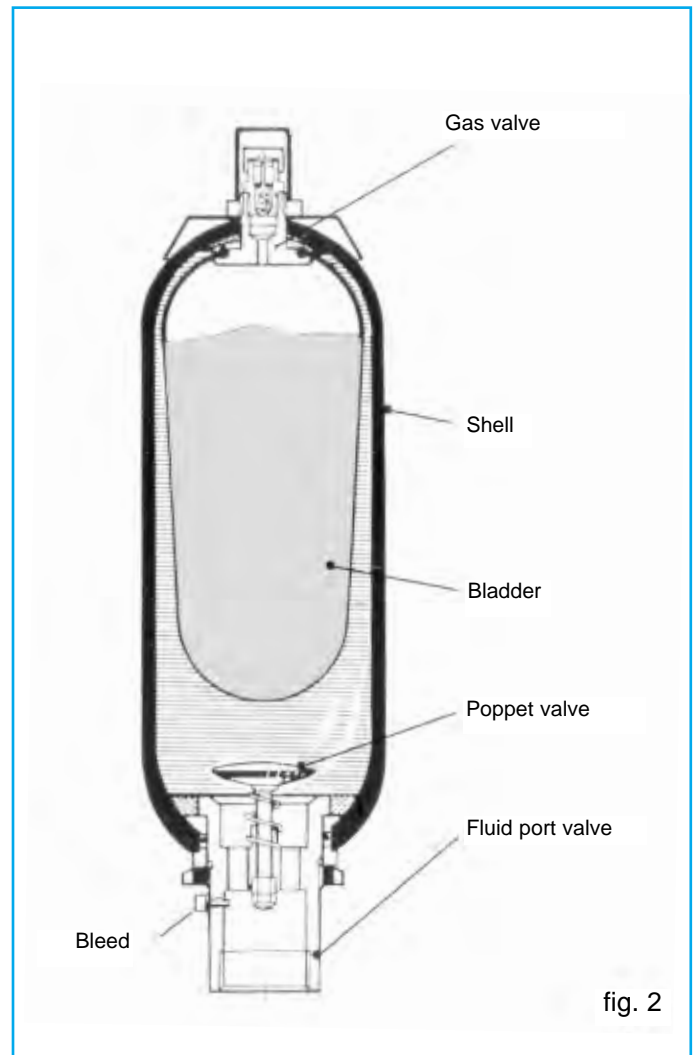


fig. 2



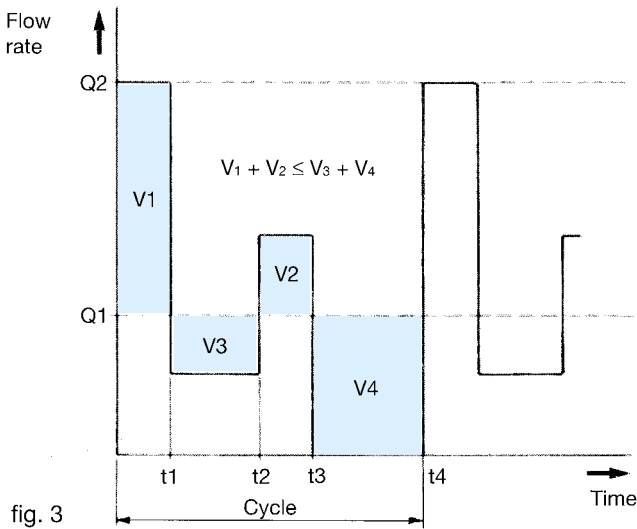
## 2.1 Fluid power storage

In the case of hydraulic circuits where a large flow rate is required for a short period, alternating with a low or no flow condition, the use of an accumulator allows smaller pumps and motors to be used, thus reducing both installation and operating costs.

The operation cycle shown in fig. 3 would require a pump having a capacity  $Q_2$ . If an oleo-pneumatic accumulator is used, it is possible to store oil during the time periods  $(t_2 - t_1)$  and  $(t_4 - t_3)$  when requirement is very low or zero, and to reutilize it during  $t_1$  and  $t_3 - t_2$ , when the required flow rate is higher than pump capacity  $Q_1$ .

This pump must be selected in order to have the volumes  $V_1 + V_2 \leq V_3 + V_4$ .

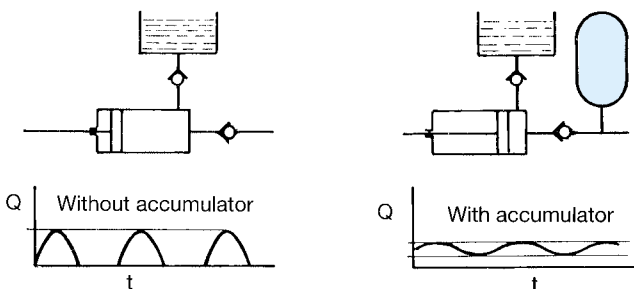
There are many potential applications including thermoplastic extruders, transfer lines in steel mills, rolling mills, machine tools, hydraulic presses etc.



## 2.2 Pulsation damper

By virtue of their design both piston and diaphragm pumps create pulsation or pressure peaks during operation, this being undesirable and detrimental for both the smooth operation and operational life of components.

The fitting of a bladder accumulator near the pressure line of the pump, will damp the pulsations to an acceptable level (fig. 4). Typical applications are: dosing pumps, pumps with a small number of pistons, etc.



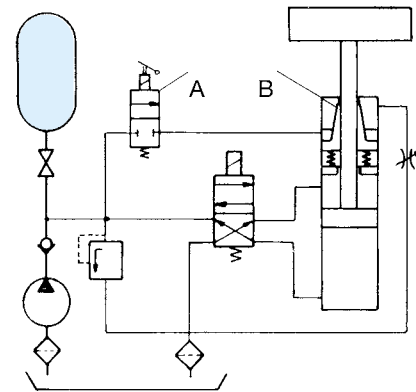
## 2.3 Emergency energy reserve

In the case of a sudden power loss, e.g. pipe or joint failure, pump breakdown etc. the accumulator can provide sufficient energy to complete an operational cycle or to allow actuators, valves etc. to re-set to a "safe" position, and so prevent damage to equipment or product.

Besides, the availability of such an emergency power source, is essential in case where a hydraulic power supply is required for closing a safety door, electrical switch, safety valve, emergency brakes etc.

Another typical application is the emergency supply of fuel oil to power plant burners.

Fig. 5 illustrates that a failure at "B" causing a loss of energy can be offset operating manually the electro valve "A" thus utilising the potential energy of the accumulator.



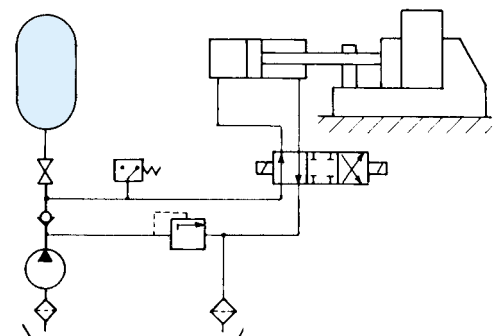
## 2.4 Volume compensator

In a closed hydraulic circuit a rise in temperature can cause an increase in pressure due to thermal expansion.

An accumulator installed in the line will protect the valves, gaskets, pressure gauges etc. Common applications are found in refineries and pipelines.

## 2.5 Pressure compensator

When a constant static pressure is required for a long period, an accumulator is indispensable as it will compensate for pressure loss due to seepage through joints, seals etc. as well as balancing pressure peaks which may occur during the operating cycle. Typical applications are found in closing systems, fig. 6, loading platforms, curing presses, machine tools, lubricating systems, etc.







## 2.6 Counter balancing

The balancing of a force or weight can be achieved by using hydraulic pistons driven by an accumulator, thus avoiding the use of counterweights with attendant dimensional and weight saving. Typical applications are in machine tools (fig. 7), hoists etc.

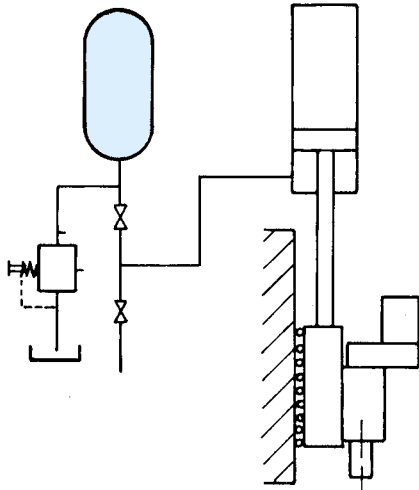


fig. 7

## 2.7 Hydraulic line shock damper

Rapid valve closure can produce shock waves (water hammer) resulting in overpressurisation of pipes, joints, valves etc. The use of a suitable accumulator can neutralize or significantly reduce the shock. Typical applications are water (fig. 8), fuel and oil distribution circuits, washing equipment etc.

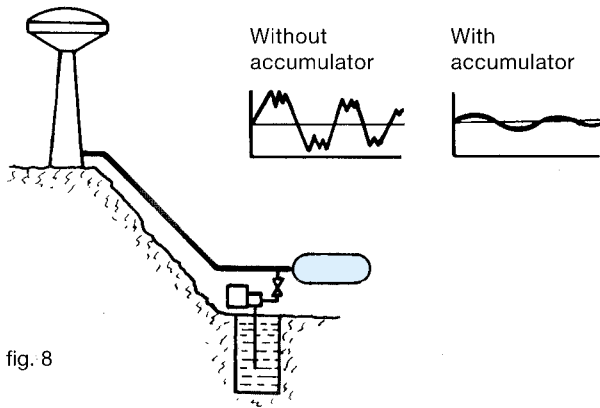


fig. 8

## 2.8 Shock absorber

Mechanical shocks in hydraulically driven equipment can be absorbed by accumulators. Possible applications are in drive and suspension systems for fork-lifts, mobile cranes, agricultural and civil engineering machinery etc. (fig. 9)

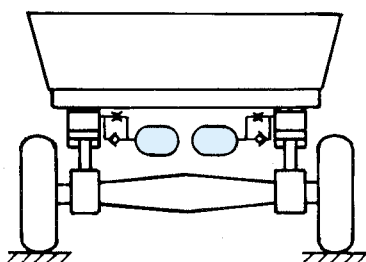


fig. 9

## 2.9 Hydraulic spring

The accumulator can be used with advantage as an alternative to mechanical springs, e.g. deep drawing (fig. 10). The thrust can be easily controlled with great accuracy over a wide range of pressures by oil pressure control without the need of springs or supports.

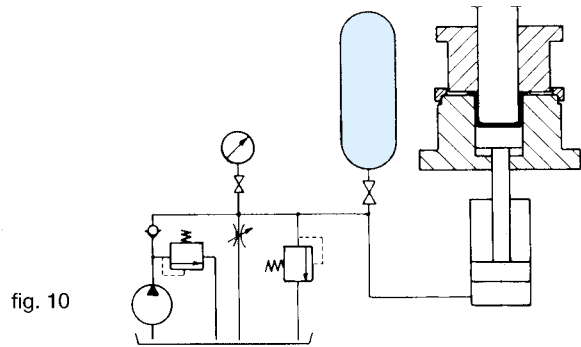


fig. 10

## 2.10 Fluid separator (transfer barrier)

Fundamentally the accumulator separates two fluids (in the case of hydraulic applications nitrogen and oil). However, the accumulator can be used when pressure has to be transferred between two incompatible fluids, hence the name TRANSFER. Fig. 11 is a simplified diagram for a fatigue test of a vessel "S" using water. The initial pressure pulse is generated by piston pump "P" using oil. An equal volume and pressure is transferred to the water into the vessel by the accumulator. Many similar applications are found in the petro-chemical industries.

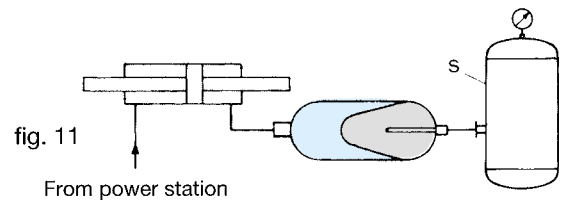


fig. 11

From power station

Fig. 11A shows a typical application of TRANSFER between a liquid and a gas by using an **accumulator with additional gas bottles**. This application is especially convenient in those cases where the amount of liquid required is quite large compared to the small difference between the operating pressures.

To reduce the total capacity, therefore the number of accumulators required, the volume of available gas is increased by connecting the accumulators to additional gas bottles (refer to Section 3.11).

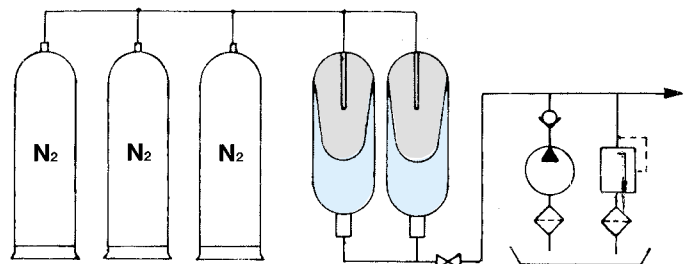


fig. 11A



### 3.1 Method of selection

Many parameters are involved in the selection of an accumulator, the most important are:

#### a) Minimum working pressure $P_1$ and maximum pressure $P_2$

The value of  $P_2$  must be lower or equal to the maximum authorised working pressure of the accumulator to be chosen for safety reasons.

The value of  $P_1$  is found in the ratio  $\frac{P_2}{P_0} \leq 4$

which will give optimum efficiency and operating life. (For calculation of pre-loading pressure  $P_0$ , refer to Section 3.2)

#### b) Volume $\Delta V$ of liquid to be stored or utilised

This information is required in addition to the maximum and minimum pressure values for the correct sizing of the accumulator.

#### c) Method and Application

It is important to establish if the gas during operation is subjected to isothermal or adiabatic conditions. If compression (or expansion) is slow, (more than 3 minutes) so that the gas maintains approximately constant temperature, the condition is **ISOTHERMAL** (examples: pressure stabilisation, volume compensation, counter balancing lubrication circuits). In all other cases (energy accumulator pulsation damper, shock wave damper, etc.) owing to high speed transfer heat inter-change is negligible, and therefore the condition is **ADIABATIC**. Approximately the adiabatic condition will exist when the compression or expansion period is less than 3 minutes.

#### d) Operating temperature

Operating temperature will determine the choice of materials for the bladder and steel and will also have an influence on the pre-loading pressure, and consequently on the accumulator volume.

#### e) Type of Liquid

This will determine the choice of materials.

#### f) Maximum required flow rate

For the same  $\Delta V$  required, the size or the accumulator connection can be influenced by the immediate flow rate necessary.

#### g) Location

It is important to know the eventual destination of the accumulator in order that the design can meet local design and test parameters.

Based on the foregoing, it is possible to choose a suitable accumulator for the specific application required.

### 3.2 Gas precharge pressure

The accurate choice of precharge pressure is fundamental in obtaining the optimum efficiency and maximum life from the accumulator and its components. The maximum storage (or release) of liquid is obtained theoretically when the gas precharge pressure  $P_0$  is as close as possible to the minimum working pressure. For practical purposes to give a safety margin, and **to avoid valve shut-off during operation**, the value (unless otherwise stated) is:

$$P_0 = 0.9 P_1$$

The limit values of  $P_0$  are:  $P_0 \text{ min} \geq 0.25 \times P_2$   
 $P_0 \text{ max} \leq 0.9 P_1$

Special values are used for:

#### Pulsation damper and shock absorber

$$P_0 = 0.6 \div 0.75 P_m \quad \text{or} \quad P_0 = 0.8 P_1$$

where:

$P_m$  = average operation pressure.

#### Hydraulic line shock damper

$$P_0 = 0.6 \div 0.9 P_m$$

where:

$P_m$  = average working pressure with free flow.

#### Accumulator + additional gas bottles

$$P_0 = 0.95 \div 0.97 P_1$$

Value  $P_0$  is valid for **MAXIMUM OPERATING TEMPERATURE REQUIRED BY THE USER**.

Checking or pre-loading of accumulator takes place generally at a different temperature from the operating one  $\theta_2$ , so that the value  $P_0$  at the checking temperature  $\theta_c$ , becomes:

$$P_{0c} = P_0 \frac{\theta_c + 273}{\theta_2 + 273}$$

for  $\theta_c = 20^\circ\text{C}$  we have:

$$P_{0(20^\circ\text{C})} = P_0 \frac{293}{\theta_2 + 273}$$

**NOTE** Precharge pressure of accumulators directly supplied from the factory is referred to a temperature of  $20^\circ\text{C}$ .



### 3.3 Calculation principles

Compression and expansion of gas inside the accumulator takes place according to the Boyle-Mariotte law regarding the status change in the perfect gases:

$$P_0 \cdot V_0^n = P_1 \cdot V_1^n = P_2 \cdot V_2^n$$

The PV diagram Fig. 12 shows the “pressure-volume” relationship inside the accumulator.

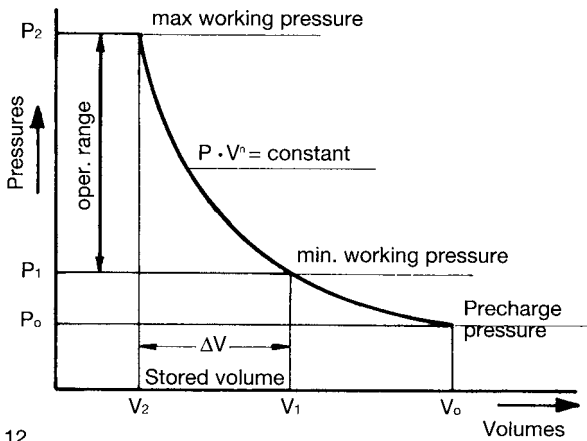


fig. 12

where:

$V_0$  = Nitrogen pre-charge volume at pressure  $P_0$  (litres).  
 It is the maximum volume of gas which can be stored in the accumulator and it is equal to, or slightly lower than, nominal capacity.

$V_1$  = Nitrogen volume at pressure  $P_1$  (litres).

$V_2$  = Nitrogen volume at pressure  $P_2$  (litres).

$\Delta V$  = Volume of discharged or stored liquid (litres).

$P_0$  = Precharge pressure (bar).

$P_1$  = Minimum operating pressure (bar).

$P_2$  = Maximum operating pressure (bar).

$n$  = Polytropic exponent.

The curve of volume variation as a function of pressure is dependant on the exponent  $n$ , which for nitrogen is contained between the limit values:

**$n = 1$**  In case compression or expansion of nitrogen takes place so slowly that a complete interchange of heat is allowed between gas and environment, that is at constant temperature, **the condition is isothermal.**

**$n = 1,4$**  When operation is so quick that no interchange of heat can take place, **the condition is adiabatic.**

In fact, these are theoretical and not practical conditions. It is however possible to state, with reasonable accuracy, that when an accumulator is used as a volume compensator, leakage compensator, the condition is isothermal. In the remaining applications, such as energy accumulator, pulsation damper, emergency power source, dynamic pressure compensator, water hammer absorber, shock absorber, hydraulic spring, etc., it is possible to state, with reasonable accuracy, that the condition is adiabatic.

When is required a more accurate calculation, is possible to use intermediate values of  $n$  as function of  $t$ , that is of expansion or compression time, according to diagram (fig. 13):

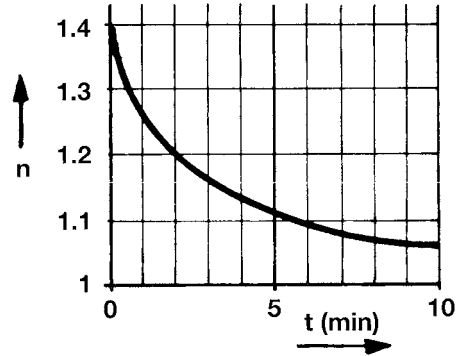


fig. 13

**Note:** In all calculations, pressures are expressed as **absolute bar** and **Temperature as Kelvin degrees.**

### 3.4 Volume calculation (isothermal condition)

When  $n = 1$ , the Boyle-Mariotte law becomes

$$P_0 \cdot V_0 = P_1 \cdot V_1 = P_2 \cdot V_2$$

so that:

$$V_1 = V_0 \cdot \frac{P_0}{P_1} \quad \text{and} \quad V_2 = V_0 \cdot \frac{P_0}{P_2}$$

The difference between volume  $V_1$  (at minimum operating pressure) and  $V_2$  (at maximum operating pressure) gives the amount of stored liquid (See Section 1.1):

$$\Delta V = V_1 - V_2 = V_0 \frac{P_0}{P_1} - V_0 \frac{P_0}{P_2}$$

so that:

$$\Delta V = V_0 \left( \frac{P_0}{P_1} - \frac{P_0}{P_2} \right)$$

Accumulator volume  $V_0$  will be:

$$V_0 = \frac{\Delta V}{\left( \frac{P_0}{P_1} \right) - \left( \frac{P_0}{P_2} \right)}$$

which could be also written:

$$V_0 = \frac{\Delta V}{P_0 \left( \frac{1}{P_1} - \frac{1}{P_2} \right)}$$

which shows that accumulator volume increases when  $\Delta V$  is increasing, when  $P_0$  is decreasing and when the difference between the two operation pressures  $P_1$  and  $P_2$  is decreasing. The values of  $\Delta V$  and  $V_0$  could be deduced more quickly from the diagrams on pages 12 and 13.



### 3.4.1 Volume compensator (isothermal)

A typical example of calculation in the isothermal condition is when the accumulator is used as a volume compensator.

Assume a tube with ØI.D.=77,7 mm, 120 m long and inside which some oil is flowing at a pressure of 10 bar and a temperature of  $\theta_1 = 10^\circ\text{C}$  and  $\theta_2 = 45^\circ\text{C}$ .

Permissible change of pressure  $\pm 8\%$ .

The volume variation will be:

$$\Delta V = V_T (\theta_2 - \theta_1) (\beta - 3\alpha) \\ = 596 (45 - 10) (0.00095 - 3 \cdot 0.000012) = 18,2 \text{ lt.}$$

where:

$V_T$  = piping volume (litres).

$\theta_2$  = max. temperature ( $^\circ\text{C}$ ).

$\theta_1$  = min. temperature ( $^\circ\text{C}$ ).

$\beta$  = cubic expansion coefficient of fluid ( $\frac{1}{^\circ\text{C}}$ ).

$\alpha$  = linear expansion coefficient of piping ( $\frac{1}{^\circ\text{C}}$ ).

$P_1$  = min. permissible operating pressure (bar).

$P_2$  = max. permissible operating pressure (bar).

where:

$$P_o = 0.9 \cdot 10 = 9.0 \text{ bar}$$

$$P_1 = -8\% \text{ of } 10 = 9.2 \text{ bar}$$

$$P_2 = +8\% \text{ of } 10 = 10.8 \text{ bar}$$

and necessary volume will be:

$$V_o = \frac{\Delta V}{\frac{P_o}{P_1} - \frac{P_o}{P_2}} = \frac{18.2}{\frac{10}{10.2} - \frac{10}{11.8}} = 137 \text{ lt.}$$

Problem solution requires the use of an accumulator station with 3 accumulators type **AS55P360**...

### 3.4.2 Leakage compensator (isothermal)

- a) Assume a molding press working at 200 bar which has to be kept closed during the curing time and at constant pressure. Min. permissible pressure 198 bar. After the mold has been closed, the pump is stopped. The oil leakages are in the order of 2 cm<sup>3</sup>/minute. Curing time is 60 minutes.

$$\Delta V = Q_l \cdot t = 0.002 \times 60 = 0.12 \text{ lt.}$$

$$P_o = 0.9 \cdot 198 = 178 \text{ bar}$$

$$P_1 = 198 \text{ bar}$$

$$P_2 = 200 \text{ bar}$$

$$V_o = \frac{\Delta V}{\frac{P_o}{P_1} - \frac{P_o}{P_2}} = \frac{0.12}{\frac{179}{199} - \frac{179}{201}} = 13.41 \text{ lt.}$$

The capacity of the standard accumulator closest to the calculated value is **15 litres**. So the chosen accumulator is **AS15P360**...

- b) If it is required to know when the pump must operate again to reload an accumulator of 15 litres to maintain the condition stated on a), we will have:

$$t = \frac{\Delta V}{Q_l}$$

$$\Delta V = V_o \left[ \frac{P_o}{P_1} - \frac{P_o}{P_2} \right]$$

$V_o = 14.5$  litres of nitrogen for accumulator AS15P360 (see page 18)

$$\Delta V = 14.5 \left[ \frac{179}{199} - \frac{179}{201} \right] = 0.13 \text{ lt.}$$

where:

$$t = \frac{0.13}{0.002} = 65 \text{ min.}$$

### 3.5 Volume calculation (adiabatic condition)

Starting from the basic formula:

$$P_o \cdot V_o^n = P_1 \cdot V_1^n = P_2 \cdot V_2^n$$

and following what is shown for isothermical calculation, we have:

$$\Delta V = V_o \left[ \left( \frac{P_o}{P_1} \right)^{\frac{1}{n}} - \left( \frac{P_o}{P_2} \right)^{\frac{1}{n}} \right] \quad \text{where } \frac{1}{n} = 0.7143$$

$$V_o = \frac{\Delta V}{\left( \frac{P_o}{P_1} \right)^{\frac{1}{n}} - \left( \frac{P_o}{P_2} \right)^{\frac{1}{n}}}$$

Formulas are valid when operation is taking place in adiabatic conditions both in the expansion as well as the compression phases.

Bear in mind however that accumulator yield, and therefore the accumulator calculation, is influenced by both operating temperature and pressure (see section 3.6 and 3.7).

This values of  $\Delta V$  and  $V_o$  can be obtained from the diagrams on pages 14 and 15.





### 3.6 Temperature influence

It should be anticipated that the operating temperature will change considerably during the cycle and this variation should be taken into account when the volume is calculated.

If an accumulator is sized to a maximum temperature, then the precharge pressure will be referenced to that temperature. When the temperature drops there will be a comparable reduction of the precharge pressure according to the **Gay Lussac law** on the relationship between pressures and volumes, as a result, you will get a **lower accumulator capacity**.

Therefore it will be necessary to have a higher  $V_o$  to accumulate or to yield the same amount of liquid  $\Delta V$  (see section 3.4).

The relationship between pressures and volumes is:

$$V_{oT} = V_o \frac{T_2}{T_1}$$

where:

$$T_2 = \theta_2 (^{\circ}\text{C}) + 273 = \text{max. working temperature } (^{\circ}\text{K}).$$

$$T_1 = \theta_1 (^{\circ}\text{C}) + 273 = \text{min. working temperature } (^{\circ}\text{K}).$$

$V_o$  = volume calculated neglecting thermal variation (litres)

$V_{oT}$  = increased volume for thermal variation (litres)

#### Example:

Assume the accumulator volume has to be calculated with the following data:

Stored volume  $\Delta V = 1.7 \text{ Lt. in } 2 \text{ s}$

Min. pressure  $P_1 = 50 \text{ bar}$

Max. pressure  $P_2 = 115 \text{ bar}$

Operating temperature =  $+25^{\circ}\text{C} \div +70^{\circ}\text{C}$

The precharge pressure referred to maximal temperature is:

$$P_o = 0.9 P_1 = 45 \text{ bar}$$

Volume, calculated in adiabatic conditions, will be:

$$V_o = \frac{\Delta V}{\left(\frac{P_o}{P_1}\right)^{\frac{1}{n}} - \left(\frac{P_o}{P_2}\right)^{\frac{1}{n}}} = \frac{1.7}{\left(\frac{46}{51}\right)^{0.7143} - \left(\frac{46}{116}\right)^{0.7143}} = 4.12 \text{ lt.}$$

Keeping in mind the temperature, we have:

$$V_{oT} = V_o \frac{T_2}{T_1} = 4.12 \frac{343}{298} = 4.74 \text{ lt.}$$

The precharge pressure at  $20^{\circ}\text{C}$  will be:

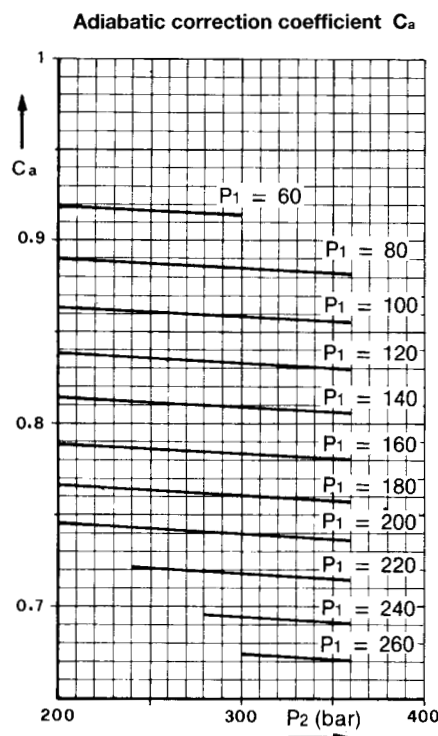
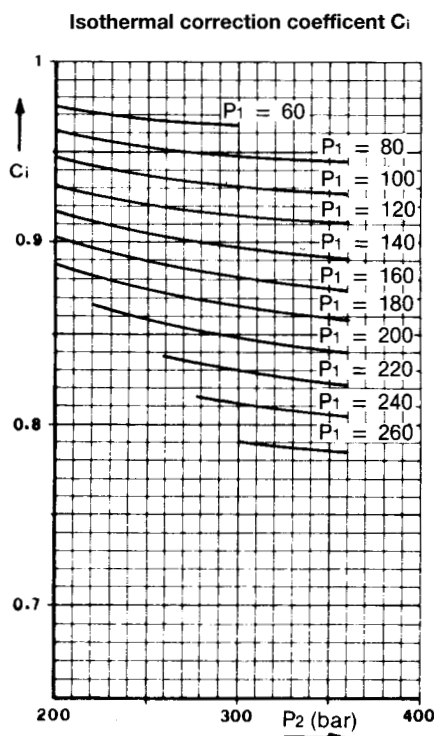
$$P_{o(20^{\circ}\text{C})} = 46 \times \frac{293}{343} = 39.3 \text{ abs. bar} = 38.3 \text{ relative bar}$$

The accumulator type is **AS5P360....**

### 3.7 Correction coefficient for high pressure

The formulas refer to ideal gases, but industrial nitrogen used in accumulators does not behave according to ideal gas laws when pressures increase.

It is convenient to keep in mind this characteristic for pressure  $P_2 > 200 \text{ bar}$ , both for adiabatic as well as for isothermal conditions.



Value of  $V_o$  becomes:

$$V_{or} = \frac{V_o}{C_i} \text{ (isothermal)}$$

$$V_{or} = \frac{V_o}{C_a} \text{ (adiabatic)}$$

Yielded volume  $\Delta V$  becomes:

$$\Delta V_r = \Delta V \cdot C_i \text{ (isothermal)}$$

$$\Delta V_r = \Delta V \cdot C_a \text{ (adiabatic)}$$

where:

$V_{or}$  = real volume of accumulator to be used for operating pressures  $P_1$  and  $P_2$ .

$\Delta V_r$  = real yield obtained from accumulator for the same pressures.

$C_i, C_a$  = Coefficients to be deduced from diagrams of Figures 14 and 15.



### 3.8 Emergency energy reserve

Typical occasion when storage is slow (isothermal) and discharge is quick (adiabatic).

Volume will be given by:

$$V_o = \frac{\Delta V}{\left(\frac{P_o}{P_2}\right)^{\frac{1}{n}} \cdot \left[\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} - 1\right]}$$

and stored volume by:

$$\Delta V = V_o \left(\frac{P_o}{P_2}\right)^{\frac{1}{n}} \cdot \left[\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} - 1\right]$$

where:

$n = 1.4$  adiabatic coefficient (quick discharge phase)

$n = 1 \div 1.4$  polytropic coefficient (slow storage phase)

Value is a function of time and it will be deduced from the diagram in Fig. 13.

In the majority of cases it is possible to suppose  $n_c = 1$  so that calculation is simplified and result is not affected:

$$V_o = \frac{\Delta V \frac{P_2}{P_o}}{\left(\frac{P_2}{P_1}\right)^{0.7143} - 1}; \Delta V = V_o P_o \frac{\left(\frac{P_2}{P_o}\right)^{0.7143} - 1}{P_2}$$

#### Example:

An accumulator must discharge 4.6 litres of oil in 3 seconds with a change of pressure from  $P_2 = 280$  bar to  $P_1 = 220$  bar. The loading time is 4 minutes. Define the capacity keeping in mind that ambient temperature will change from 20°C to 50°C.

$$V_o = \frac{\Delta V}{\left(\frac{P_o}{P_2}\right)^{\frac{1}{1.1}} - \left[\left(\frac{P_2}{P_1}\right)^{\frac{1}{1.4}} - 1\right]}$$

$$= \frac{4.6}{\left(\frac{199}{281}\right)^{0.9091} \cdot \left[\left(\frac{281}{221}\right)^{0.7143} - 1\right]} = 33.63 \text{ lt.}$$

$P_1 = 221$  abs. bar  $n_c = 1.1$  (from Figure 13)

$P_2 = 281$  abs. bar  $T_1 = (273 + 20) = 293$  °K

$P_o = 0.9 \times 220 = 198 = 199$  bar abs.  $T_2 = (273 + 50) = 323$  °K

Considering the correction coefficient for high pressure and the temperature change, we have:

$$V_{oT} = \frac{V_o}{C_m} \times \frac{T_2}{T_1} = \frac{33.63}{0.777} \times \frac{323}{293} = 47.7 \text{ lt.}$$

where:

$C_a = 0.72$

$C_i = 0.834$

$$C_m = \frac{C_a + C_i}{2} = 0.777$$

The precharge pressure at 20°C will be:

$$P_{o(20^\circ\text{C})} = 199 \times \frac{293}{323} = 180.5 \text{ bar} = 179.5 \text{ rel. bar}$$

The accumulator type is **AS55P360...**

### 3.9 Pulsation compensator Q

A typical calculation in adiabatic conditions due to high speed storage and discharge.

The liquid amount  $\Delta V$  to be considered in the calculation is a function of type and capacity of pump:

$$\Delta V = K \cdot q$$

Volume becomes:

$$V_o = \frac{K \cdot q}{\left(\frac{P_o}{P_1}\right)^{0.7143} - \left(\frac{P_o}{P_2}\right)^{0.7143}}$$

where:

$q$  = pump displacement (litres)

=  $A \times C$  (piston surface x stroke)

$$= \frac{Q}{n} = \frac{\text{flow rate (l/min)}}{\text{strokes/min.}}$$

$P$  = average working pressure (bar)

$P_1 = P - X$  (bar)

$P_2 = P + X$  (bar)

$$X = \frac{\alpha \cdot P}{100} \text{ (bar) deviation from average pressure}$$

$\alpha$  = remaining pulsation  $\pm$  (%)

$K$  = coefficient taking into account the number of piston and if pump is single or double acting.

Pump type	K
1 piston, single acting	0.69
1 piston, double acting	0.29
2 pistons, single acting	0.29
2 pistons, double acting	0.17
3 pistons, single acting	0.12
3 pistons, double acting	0.07
4 pistons, single acting	0.13
4 pistons, double acting	0.07
5 pistons, single acting	0.07
5 pistons, double acting	0.023
6 pistons, double acting	0.07
7 pistons, double acting	0.023

#### Example:

Assume a 3-piston pump, single acting, with a flow rate  $Q = 8$  m<sup>3</sup>/h and operating pressure of 20 bar. Calculate the volume necessary to limit the remaining pulsation to  $\alpha = \pm 2.5\%$ . Pump R.P.M. 148. Working temperature 40°C.

$$P = 20 \text{ bar} \quad q = \frac{8000}{60 \times 148 \times 3} = 0.3 \text{ lt.}$$

$P_2 = (20 - 0.5) = 19.5$  bar

$P_2 = (20 + 0.5) = 20.5$  bar

$K = 0.12$

$P_o = (0.7 \cdot 20) = 14$  bar

$$X = \frac{2.5 \times 20}{100} = 0.5 \text{ bar}$$

$$V_o = \frac{0.12 \times 0.3}{\left(\frac{15}{20.5}\right)^{0.7143} - \left(\frac{15}{21.5}\right)^{0.7143}} = 1.345 \text{ lt.}$$

$$P_{o(20^\circ\text{C})} = 15 \times \frac{293}{313} = 14 \text{ abs. bar} = 13 \text{ bar rel.}$$

The most suitable accumulators is the low pressure type: **AS1,5P80...**



### 3.10 Hydraulic line shock damper

A rapid increase in pressure caused by a high acceleration or deceleration in flow is commonly known as water hammer. The overpressure,  $\Delta P_{max}$ , that takes place in piping when a valve is closed is influenced by the length of the piping, the flow rate, the density of the liquid and the valve shut down time. This is given by:

$$\Delta P_{max} \text{ (bar)} = \frac{2 \gamma L v}{t \times 10^5}$$

The volume of the accumulator required to reduce shock pressure within predetermined limits  $\Delta P$ , is obtained with:

$$V_o = \frac{Q \left( \frac{2 \gamma L v}{\Delta P_o \times 10^5} - t \right)}{\left( \frac{P_o}{P_1} \right)^{0.7143} - \left( \frac{P_o}{P_2} \right)^{0.7143}}$$

where:

$V_o$  = accumulator gas capacity (litres)

$Q$  = flow rate in the piping ( $m^3/h$ )

$L$  = total length of piping (m)

$\gamma$  = specific gravity of liquid ( $kg/m^3$ )

$V = \frac{Q}{S} \times \frac{10^3}{3.6}$  = flow velocity (m/s)

$S = \frac{\pi d^2}{4}$  = internal pipe section ( $mm^2$ )

$d$  = internal pipe diameter ( $mm$ )

$\Delta P$  = allowable overpressure (bar)

$P_1$  = operating pressure by free flow (absolute bar)

$P_2 = P + \Delta P$  = max allowable pressure (absolute bar)

$t$  = deceleration time (s) (valve shut down, etc.)

#### Example:

Assume a water pipe ( $\gamma = 1000 \text{ Kg/m}^3$ ) with internal diameter  $d = 80 \text{ mm}$ , length  $L = 450 \text{ m}$ , flow rate  $Q = 17 \text{ m}^3/h$ , operating pressure  $P_1 = 5 \text{ bar}$ , allowable overpressure  $\Delta P = 2 \text{ bar}$ , valve closure time  $t = 0.8 \text{ s}$ .

$$\Delta P_{max} = \frac{2 \times 1000 \times 450 \times 0.94}{0.8 \cdot 10^5} = 10.57 \text{ bar}$$

The accumulator volume necessary to reduce the  $\Delta P_{max}$  to 2 bar is:

$$V_o = \frac{17 \left( \frac{2 \times 1000 \times 450 \times 0.94}{2 \times 10^5} - 0.8 \right)}{\left( \frac{5.5}{6} \right)^{0.7143} - \left( \frac{5.5}{8} \right)^{0.7143}} = 46.4 \text{ lt.}$$

where:  $S = \frac{\pi \times 80^2}{4} = 5026.5 \text{ mm}^2$

$$V = \frac{17 \times 10^3}{5026.5 \times 3.6} = 0.94 \text{ m/s}$$

$$P_o = 5 \times 0.9 = 4.5 = 5.5 \text{ abs. bar}$$

$$P_1 = 6 \text{ abs. bar}$$

$$P_2 = 5 + 2 = 7 \text{ bar} = 8 \text{ abs. bar}$$

An accumulator of 55 litres low pressure range will be chosen, type **AS55P30....**

### 3.11 Accumulator + additional gas bottles (transfer)

**In all cases where a considerable amount of liquid must be obtained with a small difference between  $P_1$  and  $P_2$ , the resultant volume  $V_o$  is large compared to  $\Delta V$ .**

In these cases it could be convenient to get the required nitrogen volume by additional bottles.

Volume calculation is performed, in function of the application, both in isothermal as well as in adiabatic conditions using the formulas given before always taking temperature into account.

To get the maximum of efficiency it is convenient to fix for precharge quite a high value. In cases of **energy reserve, volume compensator, hydraulic line shock damper**, etc. it is possible to use:

$$P_o = 0.97 P_1$$

Once the required gas volume is calculated, the volume must be allocated between the minimum indispensable portion  $V_A$ , which will be contained in the accumulator, and the remaining portion  $V_B$ , which represents the volume of additional bottles.

$$V_{oT} = V_{oA} + V_{oB}$$

where:

$$V_{oA} \geq \frac{\Delta V + (V_{oT} - V_o)}{0.75}$$

That means that the sum of volume of required liquid plus volume change due to temperature must be **lower than 3/4 of accumulator capacity**.

The bottle volume is given by the difference

$$V_{oB} = V_{oT} - V_{oA}$$

#### Example:

Suppose a  $\Delta V = 30 \text{ lts.}$  must be obtained in 2 seconds going from a pressure  $P_2 = 180 \text{ bar}$  to  $P_1 = 160 \text{ bar}$ .  
Temperatures:  $\theta_1 = 20^\circ\text{C}$ ;  $\theta_2 = 45^\circ\text{C}$

$$P_{o(50^\circ\text{C})} = 0.97 \times 160 = 155 \text{ bar}$$

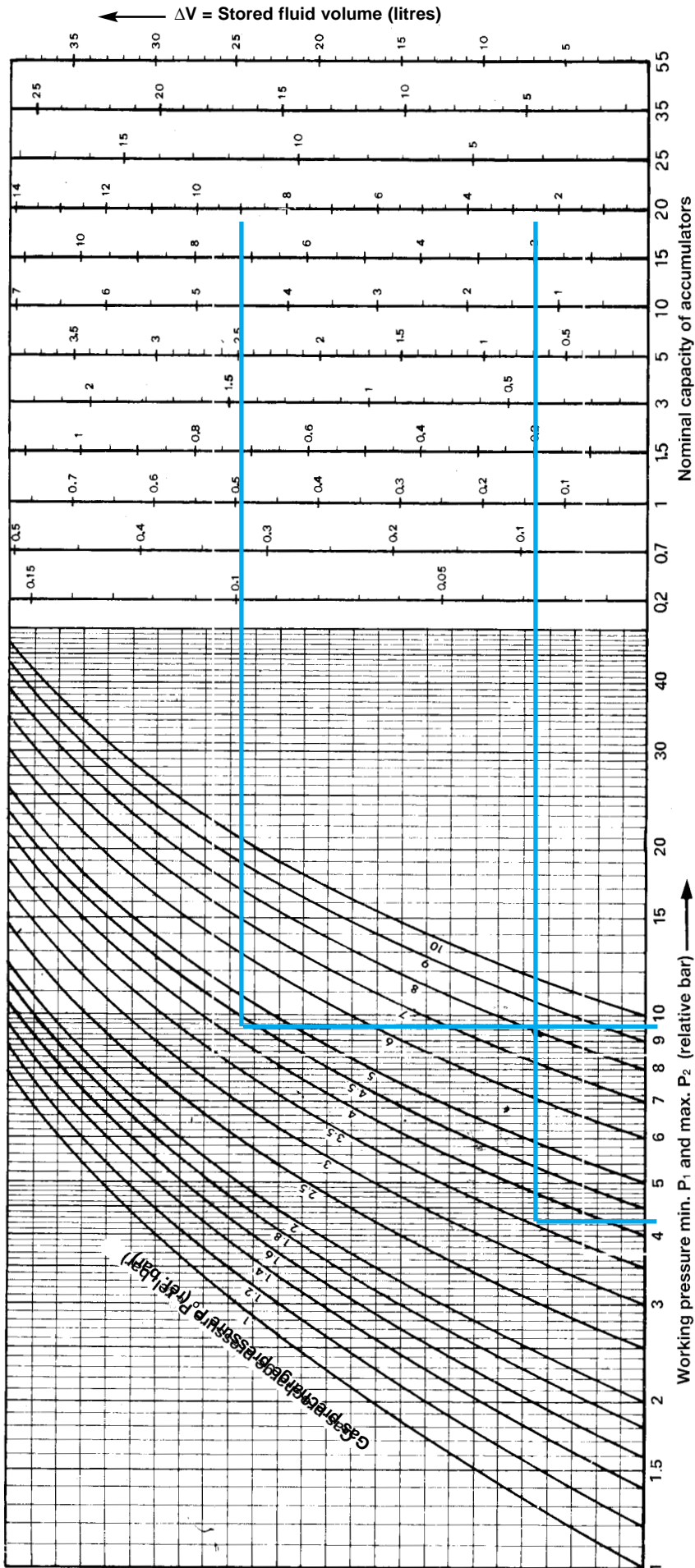
$$V_o = \frac{\Delta V}{\left( \frac{P_o}{P_1} \right)^{0.7143} - \left( \frac{P_2}{P_1} \right)^{0.7143}} = \frac{30}{\left( \frac{156}{161} \right)^{0.7143} - \left( \frac{156}{181} \right)^{0.7143}} = 382.4 \text{ lt.}$$

$$V_{oT} = 382.4 \times \frac{318}{293} = 415 \text{ lt.}$$

$$V_{oA} = \frac{30 + (415 - 382.4)}{0.75} = 83.5 \text{ lt.}$$

**Two accumulators AS55P360.... are used with total  $V_o = 100 \text{ lts.}$  plus 6 bottles of 50 lts. type BB52P360....**

### 3.12.1 Selection of volumes (isothermal conditions) - low pressure graph



#### Example I: Evaluation of accumulator volume

Data:  
Max. working pressure **P<sub>2</sub> = 8.5 bar**  
Min. working pressure **P<sub>1</sub> = 3.8 bar**  
Precharge pressure **P<sub>0</sub> = 3.5 bar**  
Required liquid volume **ΔV = 1.3 litres**

Starting from the 2 intersection points of curve of P<sub>0</sub> = 3.5 with the ordinates of P<sub>1</sub> = 3.8 and P<sub>2</sub> = 8.5 trace 2 straight lines parallel to the abscissa axis reaching the scales of ΔV.

Stored volume, for each capacity, is the one included between the two traced straight lines. In our case the accumulator giving the storage closest to the required one, that is 1.3 lts., has the capacity of **3 litres**.

#### Example II: Evaluation of stored liquid ΔV

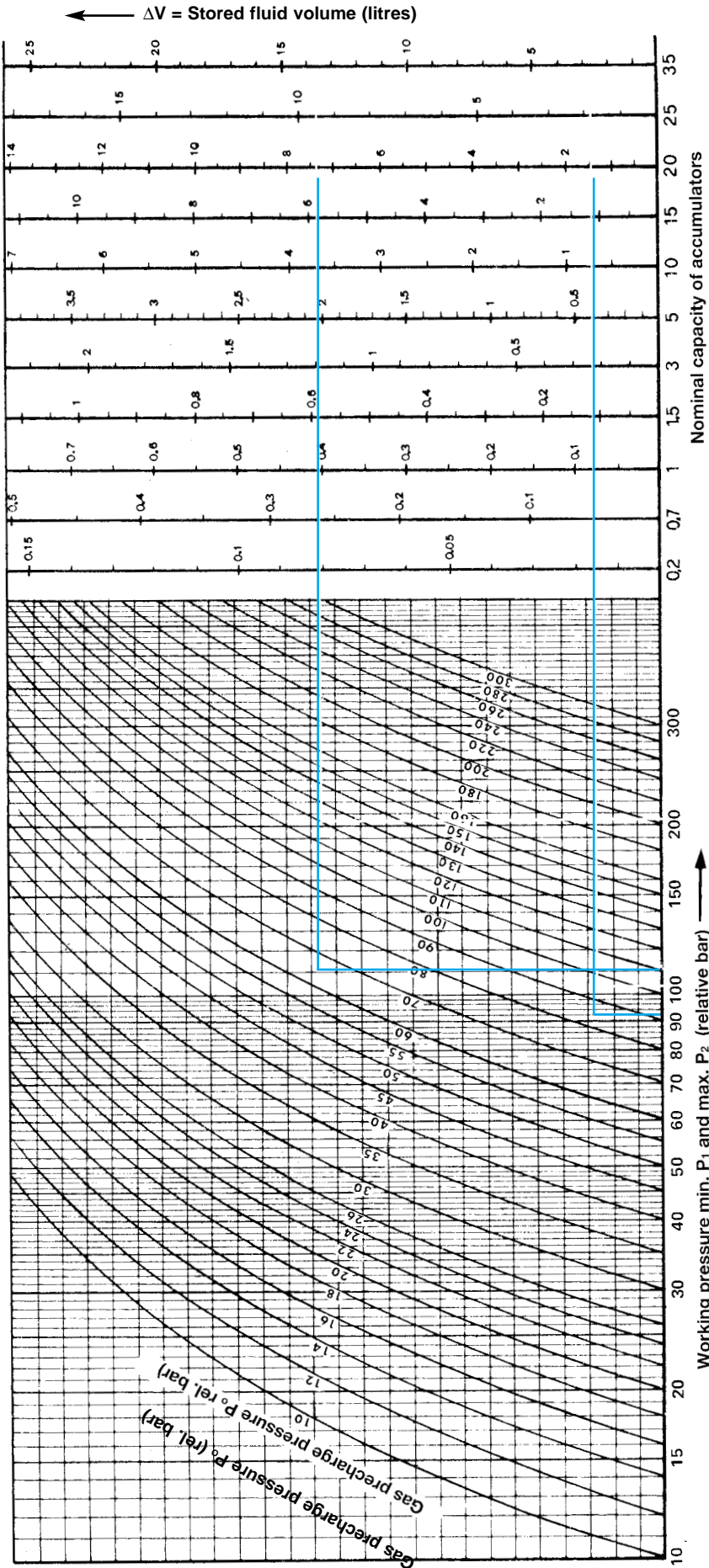
Data:  
Max. working pressure **P<sub>2</sub> = 8.5 bar**  
Min. working pressure **P<sub>1</sub> = 3.8 bar**  
Precharge pressure **P<sub>0</sub> = 3.5 bar**  
Accumulator capacity **V = 15 litres**

Starting from the 2 intersection points of curve of P<sub>0</sub> = 3.5 with the ordinates of P<sub>1</sub> = 3.8 and P<sub>2</sub> = 8.5 trace 2 straight lines parallel to the abscissa axis reaching the scale of ΔV corresponding to 15 litres.

Yielded volume, included between the two straight lines, is approximately **6.7 litres**.



### 3.12.2 Selection of volumes (isothermal conditions) - high pressure graph



**Example I:**  
Evaluation of accumulator volume

Data:  
Max. working pressure  $P_2 = 190$  bar  
Min. working pressure  $P_1 = 100$  bar  
Precharge pressure  $P_0 = 90$  bar  
Required liquid volume  $\Delta V = 7$  litres

Starting from the 2 intersection points of curve of  $P_0 = 90$  with the ordinates of  $P_1 = 100$  and  $P_2 = 190$  trace 2 straight lines parallel to the abscissa axis reaching the scales of  $\Delta V$ . Stored volume, for each capacity, is the one included between the two traced straight lines. In our case the accumulator giving the storage closest to the required one, that is  $\geq 7$  lts., has the capacity of **20 litres**.

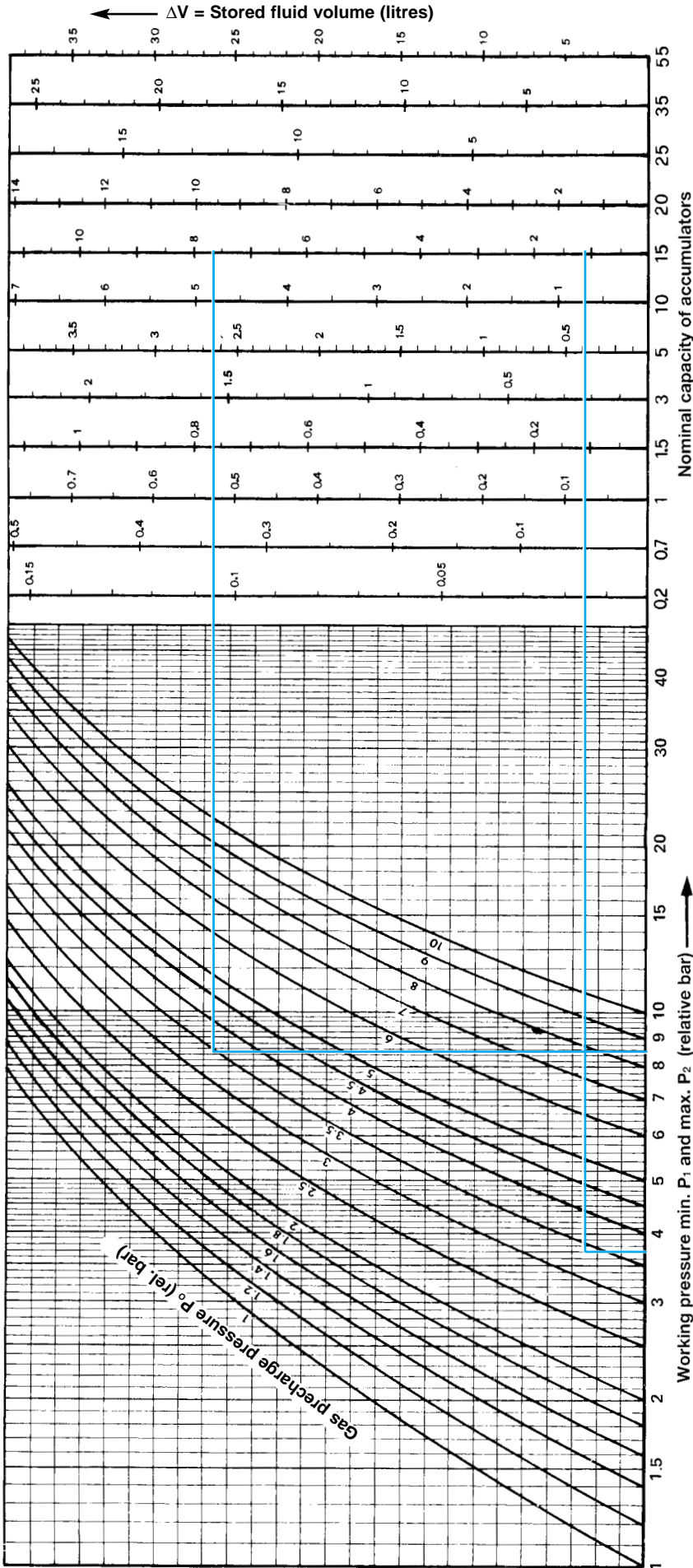
**Example II:**  
Evaluation of stored liquid  $\Delta V$

Data:  
Max. working pressure  $P_2 = 190$  bar  
Min. working pressure  $P_1 = 100$  bar  
Precharge pressure  $P_0 = 90$  bar  
Accumulator capacity  $V = 1.5$  litres

Starting from the 2 intersection points of curve of  $P_0 = 90$  with the ordinates of  $P_1 = 100$  and  $P_2 = 190$  trace 2 straight lines parallel to the abscissa axis reaching the scale of  $\Delta V$  corresponding to 1.5 litres.  
Yielded volume, included between the two straight lines, is approximately **0.615 litres**.



### 3.13.1 Selection of volumes (adiabatic conditions) - low pressure graph



#### Example I: Evaluation of accumulator volume

Data:  
Max. working pressure  $P_2 = 8.5 \text{ bar}$   
Min. working pressure  $P_1 = 3.8 \text{ bar}$   
Precharge pressure  $P_0 = 3.5 \text{ bar}$   
Accumulator capacity  $\Delta V = 1.3 \text{ litres}$

Starting from the 2 intersection points of curve of  $P_0 = 3.5$  litres with the ordinates of  $P_1 = 3.8$  and  $P_2 = 8.5$  trace 2 straight lines parallel to the abscissa axis reaching the scales of  $\Delta V$ .  
Stored volume, for each capacity, is the one included between the two traced straight lines. In our case the accumulator giving the storage closest to the required one, that is 1.3 lts., has the capacity of **5 litres**.

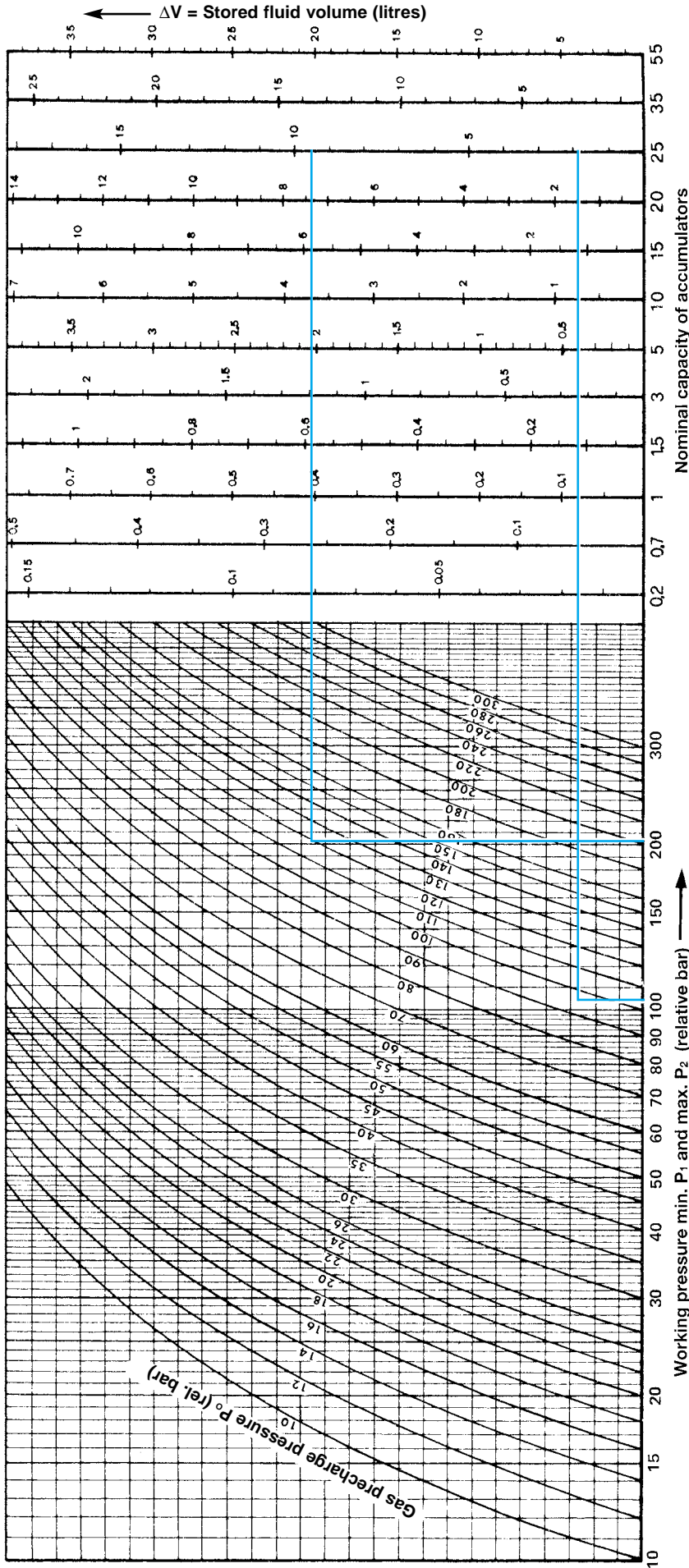
#### Example II: Evaluation of stored liquid $\Delta V$

Data:  
Max. working pressure  $P_2 = 8.5 \text{ bar}$   
Min. working pressure  $P_1 = 3.8 \text{ bar}$   
Precharge pressure  $P_0 = 3.5 \text{ bar}$   
Accumulator capacity  $V = 15 \text{ litres}$

Starting from the 2 intersection points of curve of  $P_0 = 3.5$  with the ordinates of  $P_1 = 3.8$  and  $P_2 = 8.5$  trace 2 straight lines parallel to the abscissa axis reaching the scale of  $\Delta V$  corresponding to 15 litres.

Yielded volume, included between the two straight lines, is approximately **5.3 litres**.

### 3.13.2 Selection of volumes (adiabatic conditions) - high pressure graph



#### Example I: Evaluation of accumulator volume

Data:  
Max. working pressure  $P_2 = 190$  bar  
Min. working pressure  $P_1 = 100$  bar  
Precharge pressure  $P_0 = 90$  bar  
Accumulator capacity  $\Delta V = 7$  litres

Starting from the 2 intersection points of curve of  $P_0 = 90$  with the ordinates of  $P_1 = 100$  and  $P_2 = 190$  trace 2 straight lines parallel to the abscissa axis reaching the scales of  $\Delta V$ . Stored volume, for each capacity, is the one included between the two traced straight lines. In our case the accumulator giving the storage closest to the required one, that is  $\geq 7$  lts., has the capacity of **25 litres**.

#### Example II: Evaluation of stored liquid $\Delta V$

Data:  
Max. working pressure  $P_2 = 190$  bar  
Min. working pressure  $P_1 = 100$  bar  
Precharge pressure  $P_0 = 90$  bar  
Accumulator capacity  $V = 1.5$  litres

Starting from the 2 intersection points of curve of  $P_0 = 90$  with the ordinates of  $P_1 = 100$  and  $P_2 = 190$  trace 2 straight lines parallel to the abscissa axis reaching the scale of  $\Delta V$  corresponding to 1.5 litres.

Yielded volume, included between the two straight lines, is approximately **0.49 litres**.

### 3.14 Flow rate

After the size of accumulator has been defined, as previously stated, it is necessary to check whether the required flow rate (l/min) is compatible with the permissible flow rate for that accumulator, according to the following table.

Maximum flow rate can be achieved with the accumulator installed in vertical position with the gas valve on top. Furthermore it is indispensable that a residual volume of liquid  $\geq 0,1 \times V_0$  remains in the accumulator.

Type	Mean flow rate (l/min)	Max permmiss. flow rate (l/min)
AS 0.2	70	160
AS 0.7-1-1.5	150	300
AS 3-5	300	600
AS 10-55	500	1000

### 3.15 Bladder material

The choice of elastomer used for the bladder depends on the liquid to be used and on the operating temperatures (and, at times, storage). In the chart below, each polymer has a designated letter which, in the order code, denotes the material used for the bladder, the gaskets and rubber-coated parts. For special liquids, we recommend you to contact our technical information service.

Code letter	Polymer	ISO	Temperature range (°C)	Some of the liquids compatible with the polymer
<b>P</b>	Standard nitrile (Perbunan)	NBR	-20 +85	Mineral, vegetable, silicon and lubricating oils, industrial waters, glycols, nonflammable liquids (HFA - HFB - HFC), aliphatic hydrocarbons, butane, diesel oil, kerosene, fuel oils, etc.
<b>F</b>	Low temperature nitrile	NBR	-40 +70	The same as with standard nitrile + a number of different types of Freon. (This contains less acrylonitrile than the standard and is therefore more suitable for low temperatures, but its chemical resistance is slightly lower).
<b>H</b>	Nitril for hydrocarbons	NBR	-10 +90	Regular and premium grade slightly aromatic gasoline (and all the liquids for standard nitrile).
<b>K</b>	Hydrogenated nitrile	HNBR	-30 +130	The same as with standard nitrile but with excellent performance at both high and low temperatures.
<b>A</b>	For food stuff	NBR	-20 +85	Foods (specify which type when order).
<b>B</b>	Butyl	IIR	-30 +90	Phosphoric esters (HFD-R), hot water, ammonia, caustic soda, some kinds of freon (22-31-502), glycol-based brake fluids, some acids, alcohols, ketones, esters, skydrol 7000, etc.
<b>E</b>	Ethylene-Propylene	EPDM	-20 +90	Brake fluids, hot water, leaching fluids, detergents, water-glycol (HFC), many acids and bases, saline solutions, skydrol 500, etc.
<b>N</b>	Chloroprene (Neoprene)	CR	-20 +85	Freon (12-21-22-113-114-115), water and aqueous solutions, ammonia, carbon dioxide, mineral, paraffin and silicon oils.
<b>Y</b>	Epichloridrin	ECO	-30 +110	Lead-free gasoline, mineral oils.

### 3.16 Durability of the bladder

It is essential, in order to make the correct choice, to take into consideration the working conditions that the accumulator will be operating in, because these can considerably affect the durability of the bladder. Assuming that the liquid used is **clean** and compatible with the bladder material, there are a number of factors which can affect the life of the bladder:

- **The precharge pressure  $P_0$ .** In most cases the values recommended in section 3.2 are valid although, as the pressure and, above all, the velocity of the yield required increase, there is the danger that in each cycle the bladder will knock against the poppet valve. In these case is possible to use  $P_0 = 0,8 \div 0,7 P_1$ .
- **The  $P_2/P_0$  ratio.** Any increase in this, will increase the stress the bladder is subjected to in each cycle. Only for special applications it is possible to exceed the ratio  $P_2/P_0 = 4$  (in this case consult our Technical Service Department).
- **The maximum operating pressure  $P_2$ .** Any increase in this will subject the bladder to greater stress.
- **Flow rate.** Flow rate does not affect bladder working life if values given in table 3.14 are not exceeded. When approaching the maximum values, make sure that remains a residual volume of liquid  $\geq 10\%$  of volume  $V_0$  in the accumulator, in both loading and unloading phases.
- **The frequency** or the number of cycles per day.
- **Installation.** The vertical position with gas valve on top is the recommended arrangement. When position is horizontal the bladder tends to rest and rub against the accumulator body. This could result in quicker wear.
- **The operating temperature.** This is one of the factors which most affects the life of the bladder: at very low temperatures the bladder tends to become brittle; as the temperature rises, reaching, or going beyond the limits for the elastomer, the stress of the bladder is subjected to increases exponentially, which can lead to fracturing within a short time. It should be remembered that the temperature in the accumulator is in many cases higher than the one of the system, and that it rises with each increase of  $P_2$ , of  $P_2/P_1$ , and with the volume of the accumulator (in other words, larger is the accumulator, less is the capacity of dissipate heat).

All the EPE bladder models, in the standard nitrile rubber P version, have undergone the following fatigue test:  $P_0 = 65$  bar;  $P_1 = 90$  bar;  $P_2 = 200$  bar; frequency 10 cycles/min; oil temperature 45 °C; duration > 10<sup>6</sup> cycles.



### 3.17 Material of accumulator shell and valves

In standard version, the shell is made of carbon steel and painted on the outside with a coat of rust inhibitor; the valves are made of phosphated carbon steel.

This configuration is suitable for **fluids of group 2** and the whole assembly is indicated in the identification code by the letter **C**.

For special applications, shell and valves, usually in carbon steel, can be nickel coated.

Minimal thickness 25 micron. Identification code letter **N** (specify different thickness separately).

In some cases the execution is completely in stainless steel (indicated by letter **X**).

If specifically requested, the fluid port and/or the gas valve can be supplied in a different material to the one used for the accumulator shell. **Only in this case**, it is necessary to add to the identification code the letter indicating each valve. (see section 3.19).

### 3.18 Testing

Accumulators are pressure vessels subjected to the specific current regulations, or accepted, of the Countries that will be installed.

For all the **European Countries**, design, construction and accumulator test must be done according to the Directive of pressure equipment 97/23/EC. EPE ITALIANA, also in virtue of quality system used EN ISO 9001:2000, works according to **modules H and H1** of total quality guarantee and design control issued by the Notify Body. The above mentioned directive includes the pressure equipment that exceed 0,5 bar. So all the accumulators are involved in this directive even though it provides different procedures of test and certification.

Concerning this, keep in mind that accumulators **up to 1 litre volume included**, even if it is manufactured according to the Directive 97/23/EC, are not marked EC and are not provided with the conformity declaration.

For volumes **higher than 1 litre** each accumulator after the test is marked with the mark **CE** followed by the number that identify the Notify Body.

For these accumulators, both high pressure and low pressure, the documentation necessary includes the conformity declaration and the manual's operator.

It is also possible supply accumulators in accordance with Directive **ATEX 94/9/EC** (enclosure VIII) and with harmonized regulations EN 13463-1 related to equipment not electrical for uses in environment with atmosphere potentially explosive that are included into the classification ATEX EC II2GcT4.

EPE ITALIANA provide also other tests and certifications for those Countries in which EC regulations are not accepted:

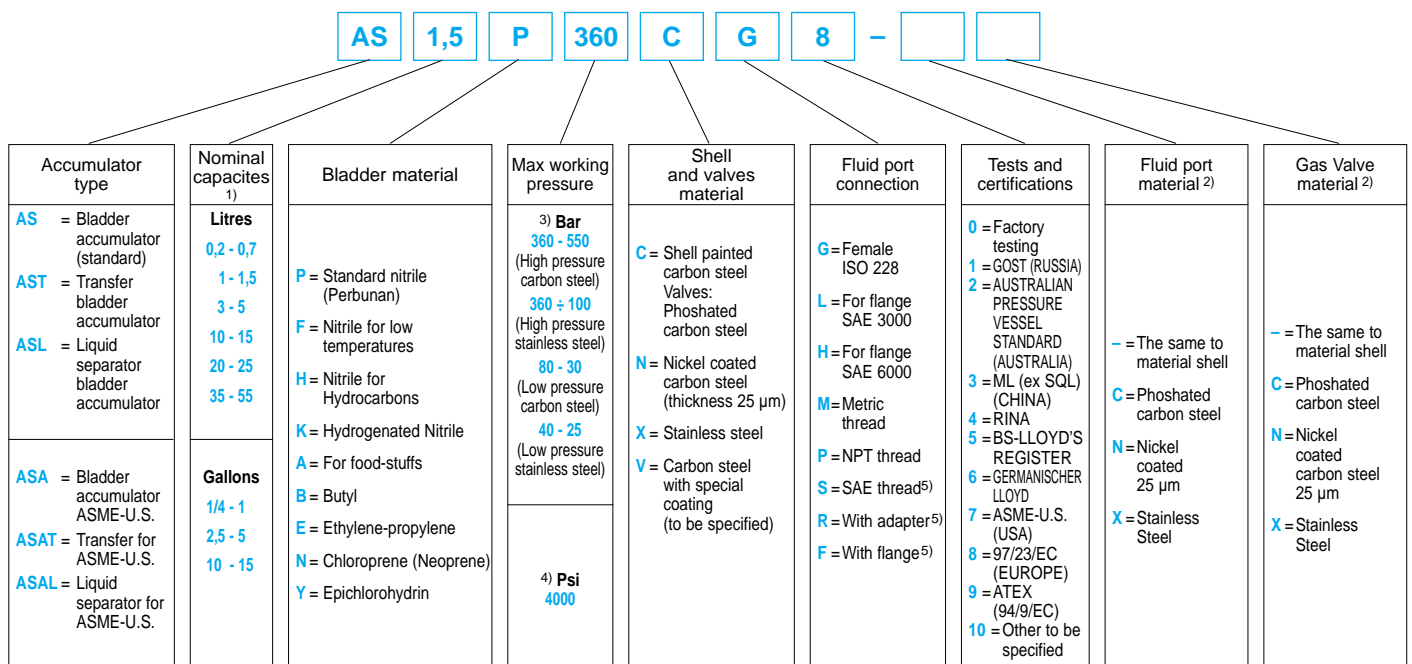
- ASME-U.S. for USA, Canada, South Africa, etc..
- ML (ex SQL) for China.
- Australian Pressure Vessel Standard AS1210-1997 for Australia.
- GOST for Russia.
- RINA and in some cases BS-L Lloyd's Register and Germanischer Lloyd for naval construction.
- For other Countries, in which is not required a specific test, accumulators are in any case manufactured according to the European Directive but are supplied without EC mark and with factory test only.

The documentation related to each regulation is normally provided in a proper envelope along with the goods. If it's not available, will be sent by post or in another way as soon as possible.

In order to define correctly both the price and the availability, **it is necessary that in the inquiry is mentioned the required certification.**

### 3.19 Model Code

Please note that when compiling the model code **the capacity, operating pressure, the shell material**, etc. should be selected from **those available in each range** of accumulator only (see pages 18 ÷ 22). The precharge pressure should be specified separately, as the flange or fluid port adapter or the adapter on the gas side.



1) Capacity in gallons only for the series ASA.  
2) Specify both when **at least one** is made of different material from the accumulator shell  
3) Use the proper value among those indicated on pages 18÷21 related to the chosen version  
4) Pressure in Psi only for the series ASA.  
5) To be specified separately

## 4.1 Technical features

<b>Max working pressure PS:</b>	360 bar
<b>Test pressure PT:</b>	PS x 1,43 bar
<b>Temperature range min. and max TS:</b>	-40°C ÷ +120°C (subject to restrictions due to bladder material)
<b>Nominal capacities:</b>	0,2 ÷ 55 litres

## 4.2 Construction features

### THE STANDARD VERSION (AS) INCLUDES:

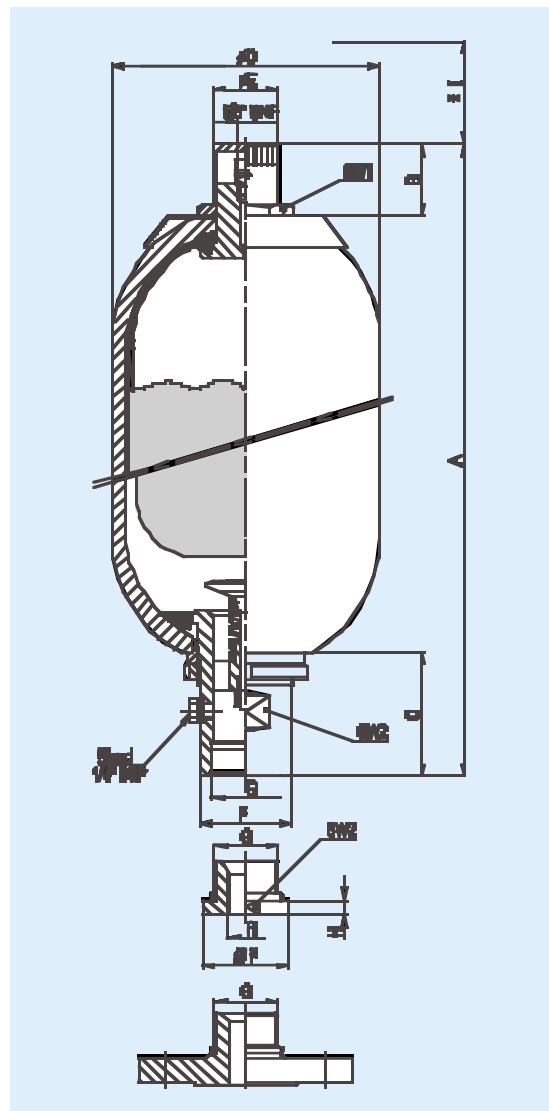
- Shell in hardened and tempered carbon steel, sandblasted and painted outside with a coat of rust inhibitor.
- Valves in phosphated carbon steel.
- Female ISO 228 G threaded fluid port connection.
- Bladder and gaskets in standard nitrile rubber (P).
- Testing and certification according to directive 97/23/EC.
- Preloading with nitrogen at **30 bar** (other values available if specified in order).

**N.B.** Technical features of **AS** standard version are also valid for **AST** and **ASL** versions except for the structure of gas side valve (see pages 36 and 37).

### ON REQUEST the accumulator can be supplied with the following features:

- SHELL AND VALVES PROTECTED with a chemical coating of nickel (25 microns thick. Specify other thickness if required).
- SHELL AND VALVES IN STAINLESS STEEL  
**0.2 lts.** capacity: max working pressure **210 bar** and **360 bar**.  
**0.7-1-1.5-3 lts.** capacities: max working pressure **150 bar**.  
**5 lts.** capacity: max working pressure **120 bar**.  
**10-55 lts.** capacities: max working pressure **100 bar**.  
 For other pressure values contact our Technical Department.
- BLADDER IN BUTYL, NEOPRENE, ETHYLENE-PROPYLENE, HYDROGENATED NITRILE, NITRILE FOR LOW TEMPERATURES (-40°C), NITRILE FOR HYDROCARBONS, EPICHLOROHYDRIN FOR FOODSTUFFS.
- WORKING PRESSURE PS = 550 BAR for capacities 0,2 and 0,7 litres in carbon steel.
- SAE 3000 or SAE 6000 FLUID PORT CONNECTION (see page 24).
- NPT, SAE or METRIC THREADED FLUID PORT CONNECTION.
- ADAPTER R with ISO 228 thread for the diameters indicated in the table, with other threads to be specified or blind.
- FLUID PORT FLANGED CONNECTION (specify PN and DN and flange standards. For order code see page 24)<sup>1)</sup>.
- GAS SIDE FLANGED CONNECTION for special applications<sup>1)</sup>.
- SAFETY VALVE gas side or liquid side or only with the adapter for this valve (see pages 26-27)<sup>1)</sup>.
- SPECIAL ANTI-PULSATION CONNECTION liquid side (see page 25)<sup>1)</sup>.
- TESTINGS AND CERTIFICATIONS DIFFERENT FROM EC (Ask for availability).

1) Specify features separately.



## 4.3 Dimensions <sup>2)</sup>

Type	Max work. pressure (bar)	Gas volume (Litres)	Dry weight (kg)	Fluid port connection		A	B	C	øD	øE	øF	H	I*	SW 1	SW 2
				G BSP ISO228	R BSP ISO228										
<b>AS 0,2</b>	360-550	0,2	1,7	1/2"	—	250 ± 2	22	40	53 + <sub>0</sub> <sup>1</sup>	20	26	—		24	23
<b>AS 0,7</b>	360-550	0,65	4,2	3/4"	0=blind 3/8" 1/2"	280 ± 3	47	52	90 ± 1	25	36	11	140	32	32
<b>AS 1</b>	360	1	5,2			295 ± 5									
<b>AS 1,5</b>	360	1,5	6,3			355 ± 5									
<b>AS 3</b>	360	2,95	11	1 1/4"	0=blind 3/8" - 1/2" - 3/4"	553 ± 8	65	65	114 ± 1	25	53	11	140	32	50
<b>AS 5</b>	360	5	15			458 ± 10									
<b>AS 10</b>	360	9,1	33	2"	0=blind 3/8" 1/2" 3/4" 1" 1 1/4" 1 1/2"	568 ± 15	60	101	224 ± 2	55	77	11	140	70	70
<b>AS 15</b>	360	14,5	43			718 ± 15									
<b>AS 20</b>	360	18,2	48			873 ± 15									
<b>AS 25</b>	360	23,5	59			1043 ± 15									
<b>AS 35</b>	360	33,5	78			1392 ± 20									
<b>AS 55</b>	360	50	108			1910 ± 20									

\* 1 = Overall dimensions of pre-loading unit.

2) = Data related to standard version in carbon steel PS = 360 bar.

Subject to change





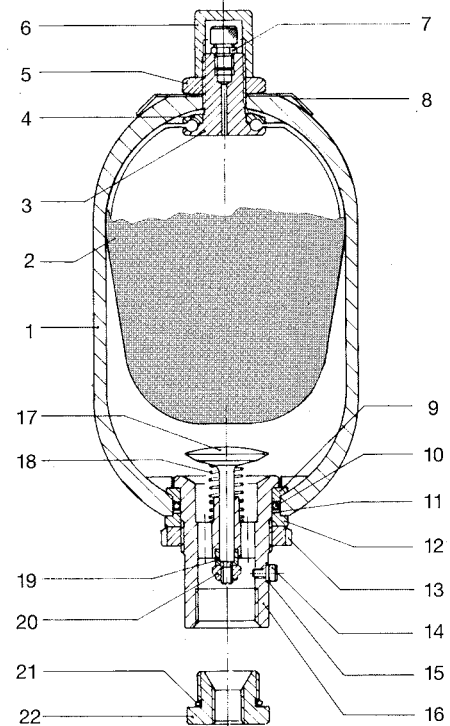
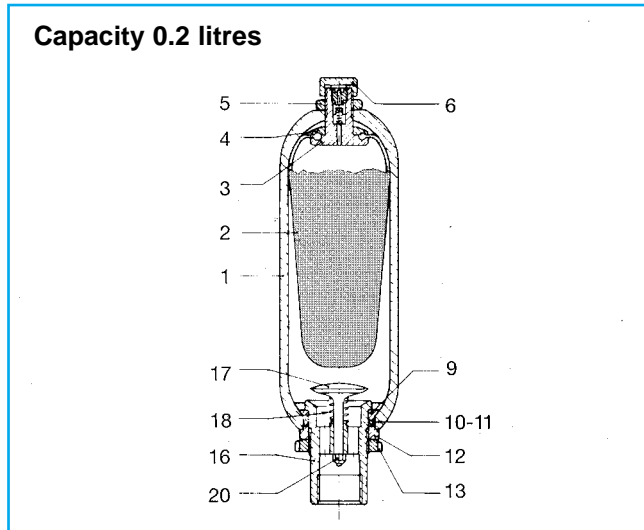
### 4.4 Components and spare parts

Table 4.4.1 provides a list of accumulator components and, for each model, the part number to be used when ordering spare parts: **THIS NUMBER IS VALID FOR STANDARD VERSIONS ONLY.**

For all versions differing from standard it is necessary to give the **manufacturer's serial number and the material.**

The bladder must be ordered according to the instructions provided on Page 37 or giving the accumulator identification code or manufacturer's serial number.

#### Capacities 0.7÷55 litres



#### 4.4.1 Spare parts list and part number

Item	Description	Pcs.	Models					AS 10-15-20 25-35-55
			AS 0,2	AS 0,7	AS 1 - 1,5	AS 3	AS 5	
1	Accumulator shell	1	Not supplied as spare part					
2	Bladder	1	See detailed designation on Pages 36-37					
3	Gas valve body	1	2001	10107			10202	10333
4	Rubber-coated washer	1	10024	10104	10106	10205	10334	
5	Gas valve locknut	1	10023	10109			10302	
6	Protection cap	1	10337	10103			10301	
7	Gas-fill valve	1	-	2072				
8	Name plate	1	-	10300-A	10300-B		10300-C	10300-D
9	Retaining ring	1	10035	10123	10127	10146	10222	10317
10	"O" ring	1	OR4112	OR4150		OR159	OR6212	OR181
11	Supporting ring	1	10038	10133		10150	10227	10320
12	Space ring	1	10037	10120		10145	10223	10319
13	Fluid port ring nut	1	10039	10122		10217		10321
14	Bleed screw	1	-	10128				10316-A
15	Seal ring	1	-	10129				10336-A
16	Fluid port body	1	10031	10115		10144		10311
17	Poppet	1	10028	10111		10221		10310
18	Spring	1	10029	10112		10149		10322
19	Brake bushing	1	-	10113		10226		10314
20	Selflocking nut	1	10033	10116		10211		10315
21	Adapter "O" ring	1	-	OR2093		OR3150		OR3218
22	Adapter	1	-	10131/Ø thread		10233/Ø thread		10323/Ø thread
Gas valve assembly (parts 3-4-5-6-7)		1	2002	2021	2022		2042	2062
Fluid port assembly (parts 9 ÷20)		1	2004	2023	2024	2025	2044	2064
Gasket sets		1	2010 { OR2050 10341 10342 OR4112 10038	2030 { OR2050 10341 10342 OR4150 10133 10129 OR2093	2031 { OR2050 10341 10342 OR159 10149 10129 OR3150	2050 { OR2050 10341 10342 OR6212 10227 10129 OR3150	2080 { OR2050 10341 10342 OR181 10320 10336 OR3218	

## 5.1 Technical features

<b>Max working pressure PS:</b>	30-80 bar
<b>Test pressure PT:</b>	PS x 1,43 bar
<b>Temperature range min. and max TS:</b>	-40°C ÷ 150°C (subject to restrictions due to bladder material)
<b>Nominal capacities:</b>	1.5-3-5-10-15-20-25-35-55 Litres
<b>Precharge pressure:</b>	≤ 15 bar

## 5.2 Construction features

### THE STANDARD VERSION (AS) INCLUDES:

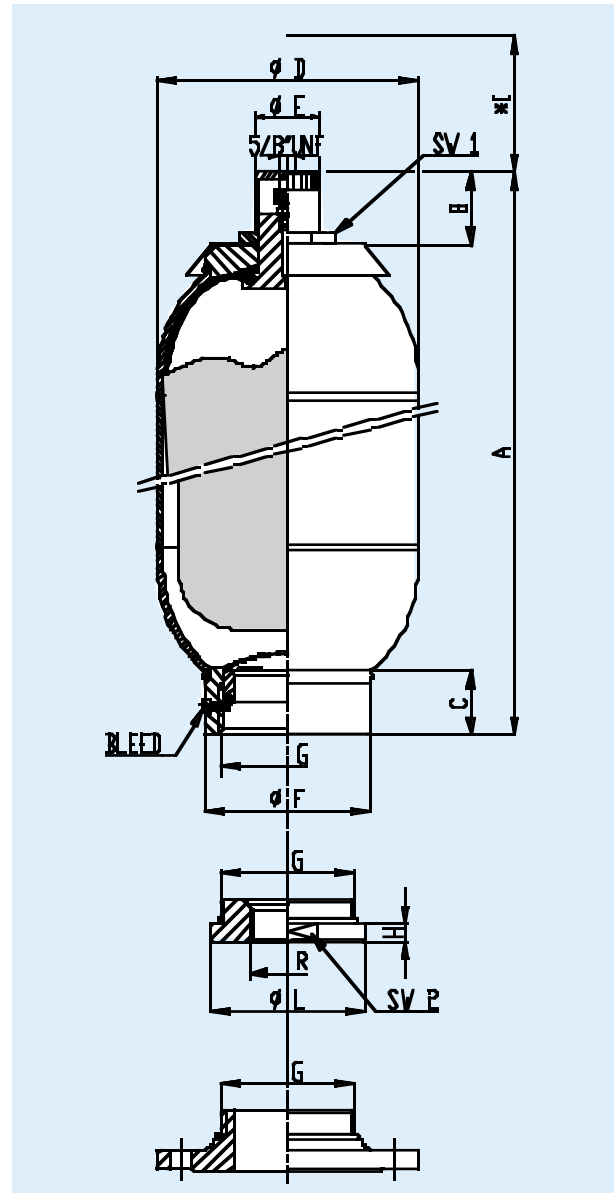
- Shell in welded carbon steel, sandblasted and painted outside with a coat of rust inhibitor.
- Gas valve in phosphated carbon steel.
- Female (G) ISO 228 threaded fluid port connection.
- Bladder in standard oil resistant nitrile rubber (P).
- Testing and certification according to directive 97/23/EC.
- Preloading with nitrogen at **5 bar** (other values available if specified in order).

**N.B.** Technical features of **AS** standard version are also valid for **AST** and **ASL** versions except for the structure of gas side valve (see pages 36 and 37).

### ON REQUEST the accumulator can be supplied with the following features:

- SHELL AND VALVES PROTECTED with a chemical coating of nickel (25 microns thick. Specify other thickness if required).
- SHELL AND VALVES IN STAINLESS STEEL  
1.5-3 and 5 lts. capacities: max working pressure **40 bar**.  
10 - 55 lts. capacities: max working pressure **25 bar**.  
For all sizes the certificate for the material and works test can be supplied.
- BLADDER IN BUTYL, NEOPRENE, ETHYLENE-PROPYLENE, HYDROGENATED NITRILE, NITRILE FOR LOW TEMPERATURE (-40°C), NITRILE FOR HYDROCARBONS, EPICHLOROHYDRIN FOR FOODSTUFF.
- WORKING PRESSURE 50 bar for capacities 10 ÷ 55 litres in carbon steel.
- ADAPTER R with ISO 228 thread for the diameters indicated in the table, with other threads to be specified or blind.
- FLUID PORT FLANGED CONNECTION (specify PN and DN and flange standards. For order code see page 24)<sup>1)</sup>.
- GAS SIDE FLANGED CONNECTION for special applications (specify flange data)<sup>1)</sup>.
- SAFETY VALVE gas side or liquid side or only with the adapter for this valve (see page 26-27)<sup>1)</sup>.
- SPECIAL ANTI-PULSATION CONNECTION liquid side (see page 25)<sup>1)</sup>.

1) Specify features separately.



## 5.3 Dimensions <sup>2)</sup>

Type	Max work. pressure (bar)	Gas volume (litres)	Dry weight (kg)	Fluid port connection		A	B	C	ø D	ø E	ø F	H	*I	ø L	SW 1	SW 2
				G ISO 228	R ISO 228											
<b>AS 1,5</b>	80	1,5	6,1	2"	0 = blind	330 ± 3	47	48	114 ± 1	25	75	11	140	74	32	70
<b>AS 3</b>		2,95	9,1		3/4"-1"-1"1/4	510 ± 5										
<b>AS 5</b>		5	15,7		2"1/2	1"-1"1/4-1"1/2										
<b>AS 10</b>	30	9,6	18	4"	0 = blind 1/2" 1"1/4 2" - 3"	475 ± 5	60	50	219 ± 2	55	130	14	140	130	70	120
<b>AS 15</b>		14,5	23			615 ± 5										
<b>AS 20</b>		18,8	28			755 ± 8										
<b>AS 25</b>		23,5	33			900 ± 8										
<b>AS 35</b>		33,5	47			1285 ± 10										
<b>AS 55</b>		50	65			1765 ± 10										

\* I = Overall dimensions of pre-loading unit.  
2) = Data related to standard version in carbon steel.