Hydropneumatic Piston Accumulators
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1.1 Definition and Functionality

The piston hydro pneumatic accumulator, a component used to exchange energy using the hydraulic system to which it is connected. It escapes energy at determined moments, the accumulate in the form of pressure energy of gas, it readily and integrally replenishes the system on demand, returning to the conditions of receiving again.

The piston accumulator is particularly constructed with two chambers, one of which is filled with gas at opportune pressure, and the second one connected to the hydraulic circuit. The gas pressure must be chosen in relation to the conditions of work of the accumulator, and constitutes the pre-loading pressure.

1.2 Constructive Characteristics

The piston accumulator consists of a steel cylinder, closed at both ends, in which slide an airtight aluminium piston. This divides the internal of the cylinder in two chambers, one filled with pre-charge gas and the other with oil, or generally speaking, with fluid from the system (Fig 1).

- **The piston** is made from aluminium in order to have rapid response time and not to generate pressure peaks during rapid cycles. It also has a cavity in order to lighten it, visible in Fig 1, facing the gas chamber, in order to increase the volume of accumulate. Even the surface in contact with the oil has a concave cavity. The purpose of this cavity is so that the oil pressure acts on almost the entire surface of the piston and not only in one spot when the piston is against the bottom end cover in the oil chamber.

- **Seal between piston and cylinder** is guaranteed by a special multi ring seal, which constitutes the key characteristic elements to the efficiency of the accumulator. This type of seal has allowed the piston accumulator to have essential characteristics regarding air tightness, component longevity and stroking. In fact, the differential pressure necessary to move the piston, that relates directly on the speed of response of the accumulator, is contained in moderate values, contrary as occurs in most seals for standard pistons.
  
  The maximum operating temperature with NBR seals is 80ºC. It is possible to operate at temperatures up to 150ºC using viton seals and reduced piston, as the expansion factors of aluminium and steel are different, it is therefore necessary to compensate the thermo effect.

  In piston accumulators, the duration and number of operations effected without evidence of variation in pressure in excess of 5% in the value off the pre-charge surcomes without penetration, above a certain quantities of oil in the gas chamber.

  It is usually preferable to assume the variation of pre-charge as a valuation of the longevity of the accumulator as long as this check is carried out fast and simply.

  Through practical results, obtained from application experience, as well as laboratory test, it was proved that 1.000.000 operations can be achieved without maintenance or intervention of recharging.

- **The cylinder body of the accumulator** is made from low carbon steel, equivalent to mechanical characteristics of 97/23/CE. The internal surface of the cylinder is honed to 0.2 micron of roughness.

For particular reasons, the cylinder and end covers can either be superficially treated or made from stainless steel.

- **The gas side** end cover is screwed to the cylinder body, the seal is guaranteed by a toroidal gasket, complete with anti-extrusion ring. In the standard version this end cap has a threaded seat in which the pre-charged valve is situated.

- **The oil side** end cover is also screwed to the cylinder body and is complete with relative seal. This end cap has a coupling to connect it to the system, either threaded or flanged, in accordance to the clients requirements.
2.1 Ratio of compression.

The volume of oil that can be stored by an accumulator also depends on the value of compression (Ratio between as and fluid) that the accumulator can endure. For example if we pre-charge a 35 litre accumulator with a pressure of 30 bar and we then fill it with oil at a pressure of 210 bar we will at the end have 30 litres of oil in the accumulator, whilst the gas would result content in a volume of 5 litres. The compression ratio in this case 7:1 and be had available 30 liters of oil to the would discharge side of the accumulator. In the case of a bladder type accumulator, a compression ratio of 7:1 cannot be tolerated (in fact it is recommended not to exceed 4:1) this could cause premature failure of the rubber separation bladder.

2.2 Osmosis

Even if the piston accumulator has a part in motion, it must not be allowed that the gas filters through to the oil, since the pocket type is prone to the phenomenon of osmosis. In applications where the accumulator has to remain on pressure for long periods of time (in case of an emergency) oil can slowly leak through the bladder, up to 10% of the pre-charge gas. This would require periodic maintenance in the form of pre-charge or replacement of the bladder itself.

2.3 Storage

To keep a piston accumulator inoperative in storage will not have a harmful effect and does not implicate time problems, if from time to time it is given a pre-charge, to prevent air ingress which could contain moisture which could cause corrosion to the internal of the cylinder. As with the pocket type accumulator it is not advisable to keep it in storage for long periods of time as this could cause the rubber to deteriorate, even though it is synthetic.

2.4 Volumetric performance

If an accumulator is charged with a certain volume of oil, lets say that its volumetric performance is equal to the unity, if it should be in a position to entirely restore the volume in the system in a successive instant, in other words, to obtain unitary volumetric performance, an accumulator must not have dead spaces. In this condition it is similar (Volumetric performance approximately 0.99-0.995). In the piston accumulator nothing prevents the piston to reach the end of the stroke, against the oil exit orifice, which cannot be said for bladder type accumulators, since a strong charge could cause the membrane to obstruct the oil orifice or deform. It is in fact recommended by the manufacturers not to discharge a pocket type accumulator beyond 9/10 of the volume of accumulable oil.

2.5 Assembly position

There does not exist any limitations, assuming any inclinations between vertical and horizontal positions for the EPE Piston accumulator, always obtaining the same volumetric performance and functionality. The same cannot be said for a bladder type accumulator, which depends on flexible motion that is affected by gravity. This could prevent restitution of all the accumulated oil, which could cause damage to the rubber bladder as a result of uneven distribution of forces.

2.6 Operational Safety

The assurance that a component of a system offers during its operation is essentially based on the functionality of its project and on the simplicity of its execution, signifying to be able effectively a more precise and severe quality control. A piston accumulator consists of a lapped cylinder and a piston with a seal, therefore being the critical elements, only the condition of the one surface, which is mechanical obtained and the characteristics of a sealing ring, it is possible to achieve the most severe quality standards, with which it offers the maximum operational safety. Whilst with the pocket accumulator, apart from the mechanical components, the most critical point remains the rubber diaphragm. This is obtained by press fusion and when the dimensions exceed a certain limit, it becomes very difficult to control the quality in the point of view of composition, resistance, imperfections and thickness. The point of concern is that a breakdown in the pocket immediately puts the accumulator out of service with the consequence of blocking the all hydraulic system. There is in facet no pre-warning of the breakdown: this is always almost certain to cause failure of the pocket and damage the all surface. It is important to observe, that is the piston accumulator is about to breakdown, it will start will gradual and progressive leaks, followed by a drop in response speed or efficiency of the unit, as well as a drop in pre-charge pressure. With this, there is ample warning to take necessary measures to prevent big consequences.

2.7 Capacity

With the difficulties mentioned above to obtain a perfectly homogenized bladder, without imperfection when the dimensions exceed a certain limit, the bladder accumulators have rather low volumetric values: usually 50 litres is the maximum limit. There is no limit for piston accumulators, manufactured by EPE with a standard limit of 300 litres.

2.8 Monitoring

With a piston accumulator, it is easy to monitor the position of the piston for the entire or part of its stroke, with the result knowing how much oil has accumulated, indicated by on-off signals, amalogical or digital, on the control system. This monitoring system, serves to utilize the maximum stroke with the result of obtaining maximum quantity of fluid accumulated, to action the start and stop of the pump, to indicate anomalies and to visualize the quantity of fluid available.

2.9 Maintenance

The lifespan of a piston accumulator is conditioned according to the condition of the seal, which is necessary to replace only once the efficiency drops, to regain an efficient component at a modest cost. This cannot be said for a bladder type, not only for the high cost of the replacement, also the difficulty in replacing and the need to remove the accumulator from the installation to carry out maintenance.
3.1 Auxiliary Pressure Source

In a system that operates with a certain amount of intermittence, the pump is required to intervene for short intervals with significant volume and pressure values. The use of an accumulator as a means of auxiliary feed, reasonably reduces the size of the required pump, in as much as it is solely used to charge the accumulator during stopped periods of the system, whilst it is the accumulator that provides the higher capacity of oil required by the system during the functional period. In this type of application, it can also happen that the system requires a quicker response, than an effective availability of oil pressure must be available when required. In similar circumstances, the time lapse between the start up of the pump (Simultaneous to the requirement of pressure) and the instant that the system itself reaches the required conditions.

3.2 Pressure drop Compensator

In a closed system, where it is absolutely necessary to maintain a determined pressure value for an indefinite period of time, independent from any fluid feed to any other utility, the presence of an accumulator guarantees the required results, eliminating any fluctuation in pressure.

3.3 Leakage Compensator

During the in operational periods of the pump, the accumulator replenishes part of the oil in the system, compensating for any leakages. This greatly reduces the frequency of interventions to the pump, which is only required to re-charge the accumulator in the event that the pressure drops below the minimum required value.

3.4 Circuits with two pressure values

This is typical case in presses used for rubber and plastic where there is a need for increased speed and moderate pressure during the first phase of the stroke, and a slow motion but with high pressure in the final stage of the stroke. Whilst the arm of the press is activated by the high pressure pump, the same motor also activates the low pressure pump, which re-charges the accumulator. The discharge of this last motion supplies oil for the faster movement at a lower pressure, without any assistance from the pump. This decreases the size of the installation.
3.5 Compensation Elements
Pressure – Volume

The presence of an accumulator tends to eliminate any danger derived from uneventful increase in pressure in the system, be it through thermal effect, as a consequence of piston movement or any other possible cause. In the case of an hydraulic control system of a roll mill for example, the instant that the ingot is fed into the rolls, a super-pressure in the hydraulic system is created. This has to be absorbed by a battery of accumulators if it is to avoid any variation in the force of the cylinder or any other harmful consequence, be it to the system or the product.

Fig. 6

3.6 Emergency Source

A sudden breakdown in the system could incapacitate the hydraulic circuit to any intervention, as a result of a pressure drop. Only using one or more accumulators, or even better, a battery (accumulators + additional bottles could at least guarantee one emergency operation) consenting for example the intervention of protection and security devices. This is very important in the case of the control of the regulation rods in nuclear reactors or the directional system or braking system in heavy vehicles. In these cases the dimensioning of the accumulator or battery, should be made by valuating the volume of liquid necessary in relation to the number of emergency manoeuvres required.

Fig. 7

3.7 Separator of two different fluids

This is the case where it would be required to transfer the pressure from one fluid to another absolutely avoiding direct contact of the two fluids.

Fig. 8

3.8 Hydraulic line shock damper

Each time a liquid mass has to vary its velocity an energy equal to the variation of the quantity of movement of the fluid: Can only be eliminated, without consequence, by absorbing it with hydraulic accumulators. An important application is used on pipe lines used for refuelling aircraft at major airports or on piping systems at refineries.

Fig. 9

3.9 Pulsation Attenuator and shock absorber

This is a typical application in reciprocating pumps to regulate the stream of liquid in the system. In fact, piston, diaphragm, pneumatic and dosage pumps, produce a pulsating pressure in the hydraulic circuit, which in the long term, can effect the good operation and longevity of the components. The installation of a piston accumulator on the suction line and in close proximity to the pump, will reduce oscillations to within acceptable values.

Fig. 10
4.1 Project Data

When sizing a piston accumulator, independently from the application, it is necessary to precisely define the following operational parameters.

- Minimum working pressure \( P_1 \)
  In the minimum pressure at which the system will still function.

- Maximum working pressure \( P_2 \)
  To the maximum pressure at which the system will function. The value of \( P_2 \) must always be less than or equal to the maximum working pressure of the accumulator.

- Volume \( \Delta V \)
  Is the volume accumulated or restored
  \[ \Delta V = V_1 - V_2 \]
  where
  \( V_1 \) (Volume of gas at \( P_1 \))
  \( V_2 \) (Volume of gas at \( P_2 \))

- Minimum temperature of gas \( T_1 \)
  Is the minimum working temperature of the gas.

- Maximum temperature of gas \( T_2 \)
  Is the maximum temperature of the gas.

- Mode and/or field of implementation ADIABATIC or ISOTHERMIC transformation

The compression and decompression of nitrogen contained in the accumulator is regulated by the perfect gas laws. If the compression or the decompression is slow (in excess of 3 minutes) such to allow the gas to maintain the temperature close to constant, you will have ISOTHERMIC transformation (Pressure stabilizer, forces balancer, volume compensator, feed in the lubrication circuits) inasmuch as the change of gas volume follows the law of Bayle Mariotte.

\[ V_1 \times P_1 = V_2 \times P_2 \]

In other cases (energy reserve, pulsation compensator, water hammer absorbers etc.) the heat exchange with the ambient is negligible given the speed with which it operates. You therefore have contemporary pressure and temperature variations of the gas, with which you have ADIABATIC transformation, governed by the law:

\[ V_1^n \times P_1 = V_2^n \times P_2 \]

Where the coefficient \( n \) takes on values from 1 to 1.4 during the process of compression or decompression (See fig. 11 and fig. 13).

4.2 Pre-charge pressure \( P_0 \)

The definition of the pre-charge pressure of the accumulator has a fundamental importance in order to obtain maximum efficiency in conditions that do not prejudice the longevity of its components. The maximum accumulate or replenishment of liquid we have in theory, with a pre-charge \( P_0 \) equal to the minimum pressure of exertion \( P_1 \). In practice the pre-charge pressure (at the maximum exertion pressure \( P_0 \)) should be at least less than \( 3 \div 5 \) bar of the minimum pressure of exertion, to avoid that the piston strike, the oil side flange and damage the components during replenishment of fluid.

It is advisable that the minimum pre-charge pressure (At the minimum exertion pressure \( T_1 \)) be in excess of friction force and also the weight of the piston itself in a case of horizontal installation or the fluid side in the upright position.

For specific requirements consult our Technical Service Dept. For particular applications, and in the following cases, the recommended pre-charge values are:

\[ P_0 = 0,95 \div 0,97 \times P_1 \]

The value of \( P_0 \) is referred to the maximum working temperature of the gas, foreseen by the user.

The pre-charge and the control are usually affected at a different temperature that the maximum working temperature \( T_2 \), in which the pre-charge pressure \( P_0 \) at a pre-charge or control becomes:

\[ P_{\text{pre-charge/ control}} = P_0 \times \frac{293 + T_2 (\degree C)}{273 + 12 (\degree C)} \]

Example for a pre-charge effectuated at 20º C:

\[ P_0 \text{ at } 20\degree C = P_0 \times \frac{293}{273 + T_2 (\degree C)} \]

N.B. The pre-charge pressure of EPE accumulators supplied directly from the factory, are referred to a temperature of 20º C.

Pulsation compensator and shock absorber:

\[ P_0 = 0,6 \div 0,75 \times P_m \text{ or } P_0 = 0,8 \times P_1 \]

Where:

\( P_m \) = medium working pressure

Hydraulic line shock damper:

\[ P_0 = 0,6 \div 0,9 \times P_m \]

Where:

\( P_m \) = medium working pressure of free flow.
4.3 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:

\[ P_0 \cdot V_0 = P_1 \cdot V_1 = P_2 \cdot V_2 \]

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

\[ \Delta V \text{ = Volume of discharged or stored liquid (litres).} \]

\[ P_0 = \text{Precharge pressure (bar).} \]

\[ P_1 = \text{Minimum operating pressure (bar).} \]

\[ P_2 = \text{Maximum operating pressure (bar).} \]

\[ n = \text{Polytropic exponent.} \]

The curve of volume variation as a function of pressure is dependent 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):

\[ \text{Note: In all calculations, pressures are expressed as absolute bar (pressure of a fluid or a gas refer to the void) and Temperature as Kelvin degrees (°K=273 + °C).} \]

4.4 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,

\[ V_1 = \frac{V_0}{P_1} \text{ and } V_2 = \frac{V_0}{P_2} \]

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):

\[ \Delta V = V_1 \cdot V_2 = \frac{V_0 \cdot (P_1 - P_2)}{P_1 \cdot P_2} \]

so that:

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

Accumulator volume \( V_a \) will be:

\[ V_a = \frac{\Delta V}{P_a \left( \frac{1}{P_1} - \frac{1}{P_2} \right)} \]

which could be also written:

\[ V_a = \frac{V_0}{P_a \left( \frac{1}{P_1} - \frac{1}{P_2} \right)} \]

which shows that accumulator volume increases when \( \Delta V \) is increasing, when \( P_a \) is decreasing and when the difference between the two operation pressures \( P_1 \) and \( P_2 \) is decreasing.

The values of \( \Delta V \) and \( V_a \) could be deduced more quickly from the diagrams on pages 12 and 13.
4.4.1 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 \( \text{OD} = 77.7 \text{ mm}, 120 \text{ m long and inside which some oil is flowing at a pressure of 30 bar and a temperature of } T_1 = 10^\circ\text{C} \) and \( T_2 = 45^\circ\text{C}. \) Permissible change of pressure ± 8%.

The volume variation will be:

\[
\Delta V = V_f \left( T_2 - T_1 \right) \left( \beta - 3 \cdot \epsilon \right)
\]

where:

\[
V_f = \text{piping volume (litres)},
\]

\[
T_2 = \text{max temperature (C)},
\]

\[
T_1 = \text{min temperature (C)},
\]

\[
\beta = \text{cubic expansion coefficient of fluid } \left( \frac{1}{\text{C}} \right),
\]

\[
\epsilon = \text{linear expansion coefficient of piping } \left( \frac{1}{\text{C}} \right),
\]

\[
P_1 = \text{min, permissible operating pressure (bar)},
\]

\[
P_2 = \text{max, permissible operating pressure (bar)},
\]

\[
\Delta V_0 = 0.95 \cdot \Delta V
\]

Problem solution requires the use of an accumulator station with 3 accumulators type AP50P250...

or: 1 accumulator and 2 additional bottles 50 litres.
2 accumulators from 80 litres
1 accumulator from 150 litres

4.4.2 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 cm³/minute.

Curing time is 60 minutes.

\[
\Delta V = Q \cdot t = 0.002 \times 60 = 0.12 \text{ lt.}
\]

\[
P_1 = 198 \text{ bar} 199 \text{ (absolute bar)}
\]

\[
P_2 = 200 \text{ bar} 201 \text{ (absolute bar)}
\]

\[
P_0 = 0.95 \times 198 = 188 \text{ bar} 189 \text{ (absolute bar)}
\]

\[
V_0 = 0.95 \cdot \Delta V
\]

\[
= 0.95 \cdot 12.8 \text{ lt.}
\]

The capacity of the standard accumulator closest to the calculated value is 15 litres. So the chosen accumulator is AP15P375...

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:

\[
\frac{\Delta V}{Q} = \frac{189 - 189}{199 - 201} = 0.16 \text{ lit.}
\]

\[
\Delta V = \int \left( P_0 \frac{1}{P} - P_2 \right) \frac{1}{P} \text{ d}P
\]

\[
\int = 0.16 \text{ lit.}
\]

4.5 Volume calculation (adiabatic condition)

Starting from the basic formula:

\[
\Delta V = \int \left( P_1 \frac{1}{P} - P_2 \right) \frac{1}{P} \text{ d}P
\]

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

\[
\Delta V = \int \left( P_1 \frac{1}{P} - P_2 \right) \frac{1}{P} \text{ d}P
\]

\[
\int = 0.7143 \text{ lit.}
\]

\[
V_1 = \int \left( P_1 \frac{1}{P} - P_2 \right) \frac{1}{P} \text{ d}P
\]

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 4.6 and 4.7).
4.6 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 4.4).

The relationship between pressures and volumes is:

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

where:

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

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

$V_o = \text{volume calculated neglecting thermal variation (litres)}$.

$V_{OT} = \text{increased volume for thermal variation (litres)}$

**Example:**

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

- Stored volume $\Delta V = 1.7 \text{ Lt. in 2 s}$
- Min. pressure $P_1 = 50 \text{ bar 51 absolute bar}$
- Max. pressure $P_2 = 115 \text{ bar 116 absolute bar}$
- Operating temperature = $+25°C + 70°C$

The precharge pressure referred to maximal temperature is:

$P_0 = 0.95 P_1 = 47 \text{ bar 48 absolute bar}$

Volume, calculated in adiabatic conditions, will be:

$$V_r = \frac{\Delta V}{\frac{P_2}{P_1} - \left(\frac{P_2}{P_1}\right)^{\frac{1}{15}} - \frac{1}{(51)^{\frac{1}{15}}} - \frac{48}{(116)^{\frac{1}{15}}} - 3.99 \text{ litres}}$$

Keeping in mind the temperature, we have:

$V_{OT} = V_o \frac{T_2}{T_1} = 3.99 \text{ litres}$

The precharge pressure at $20°C$ will be:

$P_{opr} = 48 \times \frac{293}{343} = 41 \text{ abs. bar} - 40 \text{ relative bar}$

The accumulator type is 4P5P375...

4.7 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 $P_2 > 200$ bar, both for adiabatic as well as for isothermal conditions.

Isentropic correction coefficient $C_i$

Adiabatic correction coefficient $C_a$

Value of $V_r$ becomes:

$V_r = V_o \frac{T_2}{T_1}$ (adiabatic)

$V_{opr} = V_r \frac{T_2}{T_1}$ (adiabatic)

Yielded volume $\Delta V$ becomes:

$\Delta V = \Delta V \cdot C_i$ (adiabatic)

where:

$V_r = \text{real volume of accumulator to be used for operating pressures } P_1 \text{ and } P_2$.

$\Delta V = \text{real yield obtained from accumulator for the same pressures}$.

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

fig. 14

fig. 15
4.8 Emergency energy reserve

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

Volume will be given by:

\[ V_0 = \frac{\Delta V \cdot P_1^{n_{polytropic}}}{P_1} \]

and stored volume by:

\[ V_s = \frac{\Delta V \cdot P_2^{n_{adiabatic}}}{P_2} \]

where:

\[ n_{adiabatic} = 1.4 \] (adiabatic coefficient, quick discharge phase)
\[ n_{polytropic} = 1 \div \frac{1.4}{1.4} \] (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:

\[ \Delta V = V_0 \cdot P_0 \cdot \frac{P_1^{n_{adiabatic}}}{P_2^{n_{polytropic}}} \]

Example:

An accumulator must discharge 4.6 litres of oil in 3 seconds with a change of pressure from \( P_2 = 280 \) bar to \( P_1 = 208 \) bar.

The loading time is 4 minutes. Define the capacity, keeping in mind that ambient temperature will change from 20°C to 50°C.

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

\[ V_0 = \frac{\Delta V \cdot P_0}{\sqrt[3]{P_1}} \]

\[ = \frac{4.6}{\sqrt[3]{280}} \cdot \frac{P_0}{P_1} = 27.5 \text{ l/min} \]

\( P_0 = 280 \text{ abs. bar} \)
\( P_1 = 208 \text{ abs. bar} \)
\( n_c = 1.1 \) (from Figure 13)
\( T_1 = 273 + 20 = 293 \text{ K} \)
\( T_2 = 273 + 50 = 323 \text{ K} \)

The precharge pressure at 20°C will be:

\[ P_{P20°C} = 199 \times \frac{283}{293} = 180.5 \text{ bar} \]

The accumulator type is AP4DP375...

4.9 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:

\[ V_0 = \frac{\Delta V}{P_1} \cdot \frac{P_2^{n_{polytropic}}}{P_1^{n_{adiabatic}}} \]

where:

\( q \) = pump displacement (litres)
\( A = C \cdot (\text{piston surface} \times \text{stroke}) \)
\( Q = \text{flow rate} \left( \frac{\text{litres}}{\text{min}} \right) \)
\( n = \frac{\text{stroke}}{\text{min}} \)
\( P = \text{average working pressure (bar)} \)
\( P_1 = P \times X \) (bar)
\( P_2 = P \times X \) (bar)
\( X = \frac{P_{P20°C}}{100} \) deviation from average pressure
\( \alpha = \text{remaining pulsation } \pm \% \)

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

Example:

Assume a 3-piston pump, single acting, with a flow rate \( Q = 8 \text{ m}^3/\text{h} \) and operating pressure of 20 bar. Calculate the volume necessary to limit the remaining pulsation to \( \alpha = \pm 0.25 \% \). Pump R.P.M. 1480, Working temperature 40°C.

\[ P = 20 \text{ bar} \]
\[ Q = \frac{8000}{60 \times 1480 \times 3} = 0.03 \text{ lit} \]
\[ P_1 = (200 \div 0.5) - 130.6 \text{ bar} \]
\[ K = 0.12 \]
\[ P_2 = (200 \div 204.6) \text{ bar} \]
\[ X = \frac{0.25 \times 200}{100} = 0.5 \text{ bar} \]

\[ V_0 = \frac{1.12 \times 0.03}{280} \text{ l/min} \]

\[ P_{P20°C} = 141 \times \frac{283}{310} = 32 \text{ abs. bar} \]

The most suitable accumulator is the low pressure type: AP1_5P375...
4.10 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, \( \Delta P \), 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:

\[
\Delta P_{\text{max}} = 2 \gamma L v \frac{\Delta P}{t}
\]

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

\[
V_A = \frac{Q^2 \gamma L v}{7.2 \Delta P_x 10^9} \left( \frac{P_1}{\gamma} \right)^{0.5} \left( \frac{P_1}{P_2} \right)^{0.5}
\]

where:

- \( V_A \) = accumulator gas capacity (litres)
- \( Q \) = flow rate in the piping (m³/h)
- \( L \) = total length of piping (m)
- \( \gamma \) = specific gravity of liquid (kg/m³)
- \( V \) = \( \frac{Q^2 \gamma L v}{7.2 \Delta P_x 10^9} \) = flow velocity (m/s)
- \( E = \frac{\pi d^2}{4} \) = internal pipe section (mm²)
- \( d \) = internal pipe diameter (mm)
- \( \Delta P \) = allowable overpressure (bar)
- \( P \) = \( P_1 + \Delta P \) = line's 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 \( Q = 17 \text{ m}^3/\text{h} \), operating pressure \( P_1 = 15 \text{ bar} \), allowable overpressure \( \Delta P = 2 \text{ bar} \), valve closure time \( t = 0.8 \text{ s} \).

\[
\Delta P_{\text{max}} = 2 \times 1000 \times 450 \times 0.94 \times 0.8 \times 10^{-10} = 10.57 \text{ bar}
\]

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

\[
V_A = \frac{17 \times 1000 \times 450 \times 0.94}{2 \times 10^{-10}} = 116.5 \text{ litres}
\]

4.11 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 \( V_A \) 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:

\[
P_0 = 0.97 P_1
\]

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.

\[
V_{\text{tot}} = V_A + V_B
\]

where:

\[
V_A = \frac{\Delta V + \left( V_{\text{tot}} - V_A \right)}{0.75}
\]

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

\[
V_B = V_{\text{tot}} - V_A
\]

Example:

Suppose a \( \Delta V = 30 \text{ Its} \) must be obtained in 2 seconds going from a pressure \( P_2 = 180 \text{ bar} \) to \( P_1 = 160 \text{ bar} \).

Temperatures:

\[
\theta_1 = 20^\circ \text{C} \quad \theta_2 = 45^\circ \text{C}
\]

\[
P_{\text{tot},1} = 0.97 \times 160 - 155 \text{ bar}
\]

\[
V_B = \frac{\Delta V}{P_2} \left( \frac{P_2}{P_1} \right)^{0.5}
\]

\[
= \frac{30}{156} \times \left( \frac{156}{161} \right)^{0.5} = 362.4 \text{ l}
\]

\[
V_A = 362.4 \times \frac{318}{263} = 415.8 \text{ l}
\]

One accumulators AP100P250..., are used with total \( V_A = 100 \text{ Its} \), plus 6 bottles of 50 Its. type BB52P360...
5.1 Technical Characteristics

<table>
<thead>
<tr>
<th>Working pressures PS:</th>
<th>up to 375 bar (others on request)</th>
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<tbody>
<tr>
<td>Test pressures PT:</td>
<td>1.43 x PS</td>
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<tr>
<td>Minimum working temperature:</td>
<td>-20 °C</td>
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<tr>
<td>Maximum working temperature:</td>
<td>+120 °C (150 °C on request)</td>
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<td>Nominal capacity:</td>
<td>up to 300 litres</td>
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<td>Bores:</td>
<td>60,100,180,250,350</td>
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</table>

5.2 Materials

Accumulator Body: Low carbon steel, EN 10216-3TC type P335N, seamless tube, internally lapped with a maximum roughness of Ra 0.2. Stainless steel AISI 316L on request.

Gas side end cap: Low carbon steel. Stainless steel on request.

Oil side end cap: Low carbon steel. Stainless steel on request.

Piston: Aluminum EN AW-2011

For protective coating consult our Technical Service.

Gasket: Standard P (Perbunan- NBR)

On request V (Viton or other compounds)

Anti-extrusion and guide rings: PTFE

Gas Valve: Low carbon steel with 5/8 UNF fitting and coated in white zinc chromate.

5.3 Tests and Certification

- CE (PED) the accumulators serried AP are designed and homologated to use group 2 fluids (Not hazardous) in conformance with EUROPEAN DIRECTIVE 97/23/EC.

To use group 1 fluids consult our technical service.

The accumulators are pressure vessels and as such are subject to national government regulations in every country they are 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.

- ATEX. EPE ITALIANA can supply the series of accumulators in accordance to directive ATEX 94/9/CE (attachment VIII) and to the harmonized norm EN, 13463-1, relative to not electric equipment for uses in environment with atmosphere potentially explosive that are included into the classification ATEX CE 12GcT4.

As well EPE ITALIANA provides other tests and certification for countries in which the CE norm is not accepted:

- GOST -R for Russia
- ML (ex SOL) for China
- RINA for use on ships
- ASME for the United States, Canada, South Africa etc.

- For other countries in which specific test are not required, the accumulator are however always manufactured according to the European norm, but supplied without CE markings and with a factory test certificate.

Relative documentation is supplied in an envelope attached to the goods.

The strict EPE quality standard and relative test, guarantee a sale operation of these accumulators (the operator must thoroughly familiarize himself with the operational and maintenance manual). The accumulators are pressure vessels and must be tested to the national government regulations in every country they are installed.

5.4 Velocity

The range of EPE accumulators allows to choose 2 diameter bores for the same capacity, the choice, as well as being economic, it is influenced by available installation space and the amount of oil required in operation of the time cycle. In fact, it is necessary to ensure that the piston velocity does not exceed 2 meters for second. For higher speeds consult our Technical Service.

Even the fluid flow must be chosen in relation to the acceptable loses, however the velocity of the fluid is not to exceed 10m for second. In the case where piston accumulator is connected to additional bottles, the tubing and connectors are to be chosen so as not to allow the gas flow at a velocity in excess of 30m for second.

5.5 Filtration

As with all oleodynamic components, even the accumulators, to guarantee a longer working life, it is necessary that the fluid under pressure does not contain contaminants such as metal particles, water etc. As much as the fluid may be pure it must conform to ISO4406 norm and the quality of the filters must conform to appropriate ISO standard. The grade of filtration is dependent on the components of the system and the application. The minimum grade request for hydraulic systems is equivalent to class 19/15, ISO 4406 which is 25 micron with B=75 ISO 4572.

5.6 Pre-charge

The EPE accumulators with the gas side connectors complete with pre-charge valve (V), if not otherwise requested during ordering, are supplied with a pre-charge of nitrogen at 30 bar.

CAUTION: Use only nitrogen NOT oxygen or compressed air (Danger of explosion)
5.7 Order code

**Series**

Piston accumulator = AP

**Capacity**

Nominal capacity in litres fluid side:
- diam. 60 = 0.1 - 0.25 - 0.8 - 1
- diam. 100 = 1 - 1.5-2-2.5-3-4-5-6-8-10
- diam. 180 = 6-8-10-15-20-25-30-40-50-60-80
- diam. 250 = 30-40-50-60-80-100-120-150-180
- diam. 350 = 100-120-150-180-200-250-300

Other capacity on request.

**Gasket material**

Gasket materials: Perbunan = P
Viton = V

Perbunan, elastomer in nitril rubber nitrilica suitable for working temperatures of –20 °C and petroleum based fluid, mineral oil, lubricants, diesel oil, etc.

Viton, elastomer suitable for temperatures –20 °C to +120 °C and fluidos high temperatures or specific.

Other compounds and temperature on request.

**Maximum working pressure**

Maximum working pressure in bar:
- diam. 60 = 2
- diam. 100 = 5
- diam. 180 = 8
- diam. 250 = 10
- diam. 350 = 20

The pressure is limited to 210 bar in cases where connection type L is chosen (flange SAE 3000).

Other pressures on request.

**Body and flange materials**

Carbon steel whit a coat of rust inhibitor = C
Carbon steel chemically nickel plated th. 25 = M
Stainless stell AISI 316–L = PB

Other materials and treatment on request.

**Nominal internal diameter**

Internal diameter in mm = 60 – 100 – 180 – 250 – 350

**Type of connection side**

Without connection = O
Female thread NPT F = P
Female thread ISO 228 = G (standard)
Female thread SAE = S

**Dimension of connection side**

For the type of connection: 0 = 0
G = 1
F = 2
C = 3

**Test and certification**

Factory testing = F
GOST = G
RINA = R

**Variant and/or accessories**

Electric control of position of piston
- last 300 mm gas side = C
- last 600 mm gas side = D

Transducer of position potentiometric = P
Transducer of position out 0-10 V = TX
Transducer of position out 4-20 mA = D2

Exit roadveh indicator = U

Other pressures on request.

**Dimension of connections gas side**

V = 0 (Standard pre–charge valve whit 5/8 UNF thread)

For the type of connection: 0 = 0
G = 1
F = 2

**Type of connection gas side**

Without connection = O
Female thread NPT F = P
Female thread ISO 228 = G (standard)
Female thread SAE = S

**For the type of connection side**

B = To specify DIMENSION / RATING

**For the type of connection gas side**

B = To specify DIMENSION / RATING

For the type of connection: O = 0
G = 1
F = 2

**For the type of connection**

B = To specify DIMENSION / RATING

Es. 1 ANSI300 = 1/300
Es. DN50 PN16 = 50/16

**Dimension of design**

For the type of connection: O = 0
G = 1
F = 2

**Type of connection side**

Standard pre–charge valve whit 5/8 UNF thread = V (standard)
Standard pre–charge valve whit 5/8 UNF thread in stainless steel = VX

Without connection = O
Female thread ISO 228 = G
Female thread NPT F = P
Female thread ISO SAE 228 whit camfer for OR = A

Holes for flange SAE 300, metric screw = L
Holes for flange SAE 6000, metric screw = H
Holes for flange ANSI, metric screw = B
Holes for flange Uni = U
Holes for flange for special flange = F

Other connections on request.
### 6.1 Dimension

<table>
<thead>
<tr>
<th>Nominal internal diameter</th>
<th>Maximum pressure bar</th>
<th>Capacity/Fluid Bore mm</th>
<th>Capacity Gas Bore mm</th>
<th>External diameter mm</th>
<th>Length mm</th>
<th>Standard connection fluid pipe</th>
<th>Standard connection gas pipe</th>
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## Dimension and components

### 6.2 Spare parts

![Diagram of mechanical components]

### 6.3 Order code

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</table>

*Note: Values and codes may vary depending on the specific model and manufacturer.*
7.1 Technical Characteristics

Batteries of accumulators are used when the capacity or volumes required are in excess of the capacity of one available accumulator in our range or when the pressure values P1 and P2 are relatively close when a large volume in respect to $\Delta V$ is required. In this last case it would be more convenient achieving the volume of nitrogen by using additional bottles of nitrogen, connected to the defined accumulator.

EPE is in a position to supply batteries of any dimensions, in execution with standard accumulators, or else with piston accumulators connected to nitrogen cylinders, complete with valves and/or safety devices.

7.2 Constructive Characteristics

EPE Technical Services are capable to fulfill any request, proposing competitive solutions validated with calculation programs and avant-garde simulations.

7.3 Designations

<table>
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<tr>
<th>BA</th>
<th>2/4</th>
<th>P</th>
<th>300</th>
<th>A 1544</th>
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<tbody>
<tr>
<td>accumulator station = BA</td>
<td></td>
<td></td>
<td>Total volume Vo accumulator + bottles in litres = 300</td>
<td></td>
</tr>
<tr>
<td>Number of accumulators</td>
<td></td>
<td>Number of additional bottles = 2/4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piston accumulators = P</td>
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</table>

7.4 Example

Fig. 16

Fig. 17
8.1 Version BB
Type forged steel with two heads.

8.1.1 General
Cylinders manufactured in forged steel, concur additional nitrogen cylinders for piston/pocket accumulators. Version BB is only manufactured with a capacity of 52 litres and with certification CE. The external surface is sandblasted and painted with a coat of epoxy polyamides RAL8012. Upon request the cylinders BB, can be supplied with nickel plating on the external surface.

8.1.2 Technical Characteristics
Working pressure PS: 360 bar
Test pressure PT: 515 bar
Minimum working temperature : - 40 °C
Maximum working temperature : + 120 °C
Nominal capacity: 52 litres

8.1.3 Order code

<table>
<thead>
<tr>
<th>Material of body and connection</th>
<th>Connection</th>
<th>Test certification</th>
<th>Other requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>C = Carbon steel with a coat of rustinibitor painting</td>
<td>G2 = 1 1/2 BSP</td>
<td>ATEX CE 94/9/EC</td>
<td>Used for total volume require, our Technical service with dedicated software.</td>
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<td>N = Alloyed steel with nichel-plating on the outside only (25 µm)</td>
<td>R0 = Blind adapter</td>
<td>-</td>
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<tr>
<td>V = Alloyed steel with special-external painting</td>
<td>R1 = adapter, 1/2 BSP</td>
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</table>

8.1.4 Dimension

For this reason we recommend the use of piston accumulators connected to additional nitrogen bottles in order to re-dimension the capacity of the accumulator. For calculations be it of the accumulator or total volume require, our Technical service with dedicated software.

8.2 Version AB
Type accumulator without the pistons and the workmanship to the inside.

8.2.1 General
When the pressure difference between the maximum and minimum is relatively small and the quality is of replenishment, fluid is reasonably big; an accumulator of big dimensions is needed.

8.2.2 Technical Characteristics
Working pressure PS: Up to 375 bar (others on request)
Test Pressure Pt: 1,43 X PS
Minimum Working Temperature: -20 °C
Maximum Working Temperature: +120 °C
Nominal capacity: Up to 300 Litres
Nominal Diameters: 60,180,18,250,350

8.2.3 Materials
Body: Low carbon steel EN 10216/3TC type P335N with epoxy polyamides RAL8012 primer.
Stainless steel AISI 316-L on request.
End caps: Low carbon steel.
AISI 316-L on request.
Gasket: Standard P (Perbunan – NBR)
On request: V (Viton) or other compounds

8.2.4 Tests and certification
– CE (PED) the bottles serried AP are designed and homologated to use group 2 fluids (Not hazardous) in conformance with EUROPEAN DIRECTIVE 97/23/EC.
To use group 1 fluids consult our technical service. The bottles are pressure vessels and as such are subject to national government regulations in every country they are installed.
For all the European Countries, design, construction and bottle 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 bottles 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 bottle after the test is marked with the mark CE followed by the number that identify the Notify Body.
For these bottles, both high pressure and low pressure, the documentation necessary includes the conformity declaration and the manual’s operator.
– ATEX. EPE ITALIANA can supply the series of bottles in accordance to directive ATEX 94/9/CE (attachment VIII) and to the harmonized norm EN, 13463-1, relative to not electric equipment for uses in environment with atmosphere potentially explosive that are included into the classification ATEX CE 12GcT4.
As well EPE ITALIANA provides other tests and certification for countries in which the CE norm is not accepted:
– GOST - R for Russia
– ML (ex SQL) for China
– RINA for use on ships
– BS-L Lloyd’s register for construction of ships
– ASME for the United States, Canada, South Africa etc.
– For other countries in which specific test are not required, the bottle are however always manufactured according to the European norm, but supplied without CE markings and with a factory test certificate.
Relative documentation is supplied in an envelope attached to the goods.
The strict EPE quality standard and relative test, guarantee a safe operation of these bottles (the operator must thoroughly familiarize himself with the operational and maintenance manual). The bottles are pressure vessels and must be tested to the national government regulations in every country they are installed.
### Additional Bottles

#### 8.2.5 Order code

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<th>G</th>
<th>4</th>
<th>G</th>
<th>4 – 8</th>
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</table>

**Series**

- Additional bottle - AB

**Capacity**

- Nominal capacity in litres fluid side:
  - diam. 350 = diam. 250 = diam. 180 = diam. 100 = diam. 60 =
- Maximum working pressure in bar:
  - Other capacities on request.

**Gasket materials**

- Gasket materials: Perbunan = P
- Viton = V
- Perbunan, elastomer in nitril rubber nitrilica suitable for working temperatures -20–120 °C and fluids at high temperatures or synthetic.
- Other compounds on request.

**Maximum working pressure**

- Maximum working pressure in bar:
  - diam. 60 = 375
  - diam. 100 = 375
  - diam. 180 = 250 – 375
  - diam. 250 = 250 – 350
  - diam. 350 = 220 – 350
- The pressure is limited to 210 bar in cases where connection type L is chosen (flange SAE 3000).
- Other pressures on request.

**Body and flange materials**

- Carbon steel white a coat of rust inhibitor = C
- Carbon steel chemically nickel plated th. 25u = N
- Stainless steel AISI 316-L = X
- Other materials and treatment on request.

**Nominal internal diameter**

- Internal diameter in mm = 60 – 100 – 180 – 250 – 350

**Type of connection side A**

- Without connection = O
- Female thread ISO 228 = G (standard)
- Female thread NPT F = P
- Female thread ISO 228 whit chamfer for or = A
- Holes for flange SAE 3000, metric screw = L
- Holes for flange SAE 6000, metric screw = H
- Holes for flange ANSI, metric screw = B
- Holes for flange UNI – U
- Holes for flange special flange = F
- Female thread metric = M
- Female thread SAE = S
- Other connections on request.

**Test and certification**

- Factory testing = 0
- GOST = R = 1
- ML (ex SQL) = 3
- RINA = 4
- BS–LOYD’S REGISTER = 5
- GERMANISCHER LLOYD = 6
- ASME = 7
- PED (97/23/CE) = 8
- ATEX (94/9/CE) = 9
- Other to be specified = 10

**Dimension of connections side B**

For the type of connection:

- G = P = A = L – H : 1/8” = 1
- 1/4” = 2
- 3/8” = 3
- 1/2” = 4 (standard for diam. int. 60)
- 3/4” = 5
- 1” = 6 (standard for diam. int. 100)
- 1 1/16” = 7
- 1 1/16” = 8 (standard for diam. int. 180–250–350)
- 2” = 9
- 2 1/2” = 10

- B = To be specify DIMENSION / RATING
- Es. 1” ANSI 300 = 1/300
- U = To be specify the DN / PN
- Es. DN50 PN16 = 50/16
- F = – To specify diameter flange hole, number, dimension and depth of fixing holes, wheel center and reces of OR
- M = – To specify the DIAMETER / PITCH
- Es. M18x1.5 = 18/1.5
- S = – To specify the DIAMETER “inch” / PITCH “inch”
- Es. (SAE6) 9/16–18 = 9/16–18

**Type of connection side B**

- Without connection = O
- Female thread ISO 228 = G
- Female thread NPT F = P
- Female thread ISO 228 whit chamfer for OR = A
- Holes for flange SAE 3000, metric screw = L
- Holes for flange SAE 6000, metric screw = H
- Holes for flange ANSI, metric screw = B
- Holes for flange UNI – U
- Holes for flange special flange = F
- Female thread metric = M
- Female thread SAE = S
- Other connections or pre-charge valves on request.

**Dimension of connection side A**

For the type of connection:

- G = P = A = L – H : 1/8” = 1
- 1/4” = 2
- 3/8” = 3
- 1/2” = 4 (*)
- 3/4” = 5
- 1” = 6 (**)
- 1 1/4” = 7
- 1 1/2” = 8 (***)
- 2” = 9
- 2 1/2” = 10
- (*) (standard for int. diam. 60)
- (**) (standard for int. diam. 100)
- (***) (standard for int. diam. 180–250–350)
### 8.2.6 Dimension

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20
9.1 General
The clamping of piston accumulators must be done in such a way not to induce external forces on the body or the mountings of the accumulator. Especially for horizontal assemblies, and for heavier types, it is necessary to use securing devices that support the accumulator and avoid dangerous vibrations.

9.2 Constructive characteristics
The mounting "U" bolts for piston accumulators are manufactured from zinc coated carbon steel and re complete with 2 nuts and zinc coated flat washers. Upon request they can be supplied in stainless steel.

9.3 Dimensions and order code

<table>
<thead>
<tr>
<th>External diameter</th>
<th>Order code</th>
<th>A</th>
<th>D</th>
<th>H</th>
<th>H1</th>
<th>H2</th>
<th>I</th>
<th>N</th>
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<td>A</td>
<td>164</td>
<td>133</td>
<td>123</td>
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<td>105</td>
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<td>75</td>
<td>70</td>
<td>8</td>
<td>26</td>
<td>10</td>
<td>40</td>
<td>15</td>
</tr>
<tr>
<td>210 220</td>
<td>A</td>
<td>248</td>
<td>219</td>
<td>176</td>
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<td>125</td>
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<td>B</td>
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<td>8</td>
<td>32</td>
<td>10</td>
<td>150</td>
<td>30</td>
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<td>A</td>
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<td>287</td>
<td>526</td>
<td>145</td>
<td>428</td>
<td>M 24</td>
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<tr>
<td></td>
<td>B</td>
<td>220</td>
<td>75</td>
<td>8</td>
<td>32</td>
<td>10</td>
<td>150</td>
<td>30</td>
</tr>
</tbody>
</table>

9.4 Example of mounting

9.5 Assembly equipment.
The sleeve equipment to reassemble the piston accumulators is necessary every time an accumulator needs to be stripped for maintenance (For example, when replacing piston seals) and then re-fitting the piston to the accumulator.

9.6 Order code

<table>
<thead>
<tr>
<th>Nominal internal diameter of the piston</th>
<th>Sleeve order code</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
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<tr>
<td>100</td>
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<td>180</td>
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</tr>
<tr>
<td>250</td>
<td>11558</td>
</tr>
<tr>
<td>350</td>
<td>11559</td>
</tr>
</tbody>
</table>

9.7 Example of utilization

Fig. 18

Fig. 19
10.1 General

It is used for the periodic check of accumulator pre-charge and for the inflation of accumulators themselves after the replacement of the bladder or it is used for the change of pre-charge value. For the inflation it is necessary a connection to a bottle filled with industrial dry nitrogen with a pressure higher than the precharge value required, provided with pressure reducer (mandatory, for safety reasons, during the inflation of accumulators with PS < 210 bar). Furthermore the use of a pressure reducer make easier the slow and graduated inflow of nitrogen on the bladder avoiding in this way the possibility of damaging of the bladder itself.

10.2 Construction

STANDARD VERSION includes:
- Valve body complete with ring nut connection to accumulator gas valve, pressure gauge, bleed and non return snap-in hose connection.
- One connection nipple to pressure reducer.
- Set of spare gaskets.
- Case.

ON REQUEST:
- ADAPTER for special accumulator gas valves.
- CHARGING HOSE with length of 6 m.

10.3 Technical features

Max working pressure: 600 bar

Accumul. connection: 5/8" UNF (standard)
7/8" UNF (adapter 50508)
Ø 7,7x1/32" (Vg8); 1/4" ISO 228; (on request)

Bottle connection: See designation (ch 10.5), drawings and table ch. 10.7 page 35

Pressure gauges:
- Ø 63 connection 1/4" ISO 228
- Full scale 25 bar for low pressure accumulators

Weight: 1.8 kg (case included)

10.4 Spare parts

Gasket set 2160
Non-return valve 2162
Central pin 2165
Complete bleed 2164
Charging hose 2166
Pressure gauge 2163

10.5 Identification code

The example below shows equipment for filling and checking with pressure gauge of 250 bar, with accumulator connection 5/8" UNF and standard bottle connection, complete with 3 m hose and case.

SAMPLE OF DESIGNATION:

<table>
<thead>
<tr>
<th>Type</th>
<th>Pressure gauge (bar)</th>
<th>Connection to accumulator</th>
<th>Connection to bottle 1) (according to Country standards)</th>
<th>Charging hose (metres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>25</td>
<td>S = 5/8&quot; UNF (standard)</td>
<td>1 = Italy 2 = Austria 3 = Belgium 4 = Argentina 5 = Brazil</td>
<td></td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>A = ø 7,7x1/32&quot; (Vg8)</td>
<td>6 = South Africa 7 = Canada 8 = Russia 9 = Japan 10 = Taiwan</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B = 7/8&quot; UNF (adapter 10143)</td>
<td>11 = China 12 = Korea</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C = 1/4&quot; ISO 228 (adapter 50510)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>D = ø 7,7x1/32&quot; (Vg8) (long thread) (adapter 50508)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Other types on request

Subject to change
Pre-loading and checking set

10.6 Connection charging hose - pressure reducer

The use of pre-loading set for the inflation of accumulators "low pressure" series requires, for safety reasons, the use of a pressure reducer mounted on the nitrogen bottle calibrated at a pressure equal or lower than the max working pressure PS marked on the accumulator body.

The connection nipple between charging hose and reducer is showed by the side of the page and it is normally supplied with the pre-loading set.

10.7 Connection charging hose - additional bottle

For "high pressure" accumulators and, in general, for all the types with PS ≥ 210 bar, it is possible to connect the nitrogen bottle through the proper nipple without the use of pressure reducer.

The proper pressure has to be chosen according to the origin Country of nitrogen bottle, as showed on the table below.

The number of the column indicated with x stands for the fig. of the nipple valid for such Country and coincide with the number used for the indication of bottle connection in the designation code (ch. 10.5).

Each nipple has an own code (indicated on) to be used for spare parts order and not on the designation of the pre-loading set.

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>Fig. No.</th>
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<tbody>
<tr>
<td><em>Argentina</em></td>
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<tr>
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</tr>
<tr>
<td><em>Austria</em></td>
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</tr>
<tr>
<td><em>Belgium</em></td>
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<tr>
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<td><em>Czech Republic</em></td>
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<tr>
<td><em>Denmark</em></td>
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<td><em>Japan</em></td>
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<td><em>Korea</em></td>
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<td><em>Switzerland</em></td>
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<tr>
<td><em>Turkey</em></td>
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<tr>
<td><em>USA</em></td>
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<tr>
<td><em>Venezuela</em></td>
<td>X</td>
</tr>
</tbody>
</table>

Subject to change
11.1 General

The EPE piston accumulators come equipped with, after being tested and thoroughly checked at the factory, perfectly correspondent to the order specifications stamped on the name plate fitted at the gas valve section of each accumulator. The following is stamped on the name plate:

- Maximum working pressure PS in bar
- Value of pre-charge Po in bar (sticky label)
- Accumulator manufacturers number.
- The trade mark CE with certifying authority Nº (only when the standards are applied)
- Date of manufacture month/year
- Fluid groups
- Name, logo, nationality, manufacturers and telephone number

ATTENTION: The maximum working pressure stamped on the accumulator should be equal or higher than the calibration pressure of the income limit valve of the hydraulic circuit.

Before carrying out interventions (repairs, replacements etc.) on and installation, filled with an accumulation, it is necessary to completely discharge the liquid pressure and gas pressure. The conformity and test certificates are supplied with eh accumulator, unless otherwise stated.

11.2 Preliminary Checks

To the reception you assure that:

- The accumulator did not sustain damages during transportation.
- The specifications on the name plate correspond to the order.

11.3 Installation

The best efficiency is generally obtained by installing the accumulator as near as possible to the utility. The optimal installation position is vertically, with the nitrogen valve in the upper position, however a horizontal installation is also acceptable.

It is recommended that:

- Leave necessary space for use of pre-charge equipment.
- The pre-charge fastening method using supplied "U" bolts like in Fig. 18 (See chapter 9). The hydraulic connections must not carry the weight of the accumulator.
- It is absolutely prohibited to weld mounts or alter the body of the accumulator.
- Provide a filter on pressure side of hydraulic system
- Provide a check valve between pump and accumulator.
- Ensure that the pressure limitation valve of the circuit is directly connected to the accumulator and calibrated to an inferior value of the operational pressure stamped on the accumulator specification plate.

It is advisable to provide an interception and discharge valve, in order to isolate the accumulator (to check for repairs) during the operation of the plant. All these functions are obtainable with the application of the connector block EPE series BS, eliminating bulky connectors (See chapter 13 catalog 1007 related to bladder accumulators).

11.4 Commissioning

The AP series accumulators are supplied, unless otherwise specified, with a pre-charge pressure of 30 bar.

Before commissioning, it is necessary to verify that:

- The pre-charge pressure corresponds to the value requested and or provided.

We generally remember:

Po = 0.95 – 0.97 P1 (Energy reserve etc.)
Po = 0.8 P1 (Anti-pulsation)
Po = 0.6 – 0.9 P1 (Anti water hammer)

An incorrectly chosen pre-charge pressure is frequently the cause of bad operation of the plant and can negatively influence the longevity of the accumulator. The pre-charge value indicated on the name plate (For all accumulators provided with pre-charge) is relative to a temperature of 20 °C

For accumulators provided without pre-charge, or subsequent to repairs, it is necessary to inflate with nitrogen and verify with appropriate apparatus type PC/… following procedure indicated in chapter 12.

FOR PRE-CHARGE USE ONLY AND EXCLUSIVELY DRY NITROGEN IN BOTTLES.

11.5 Maintenance

- Regularly verify pre-charge pressure during the first week of commissioning the plant. If no leaks are found, execute successive checks after 3 months and successively after 6 or 12 months, according to experiences and conditions of utilization.
- Carry out periodical visual examination of accumulator in order to check for corrosion and or deformation.
- Conform to government requirements regarding periodic checks of pressure vessels.

11.6 Repairs

Before disassembly the plant, ensure that there is no residual hydraulic pressure.

Completely discharge nitrogen before any maintenance operation. To disassembly and replace components, refer to chapter 13. Use only original EPE spare parts

11.7 Out of Commission

In case the accumulator has to be put out of york, it is necessary to ensure that it is completely discharged and the pre-charge valve is completely blown down.
12.1 General

For correct function of the accumulator, it is necessary to maintain the pre-charge pressure that has to be periodically checked with pre-charge apparatus accessory and check PC250. The same equipment, besides the repair, can be used for various other functions etc. It is necessary to connect, with a flexible hose, to a nitrogen cylinder fitted with a pressure reducing valve so that nitrogen can enter the accumulator very slowly. NITROGEN MUST BE USED, NEVER COMPRESSED AIR OR OXYGEN.

12.2 Pre-charge and re-set

If the pre-charge is lower than the prescribed value (or if you should pre-charge after a repair) proceed as follows:
- Remove gas valve protection cap.
- Before assembling the equipment PC250 ensure that knob A is unscrewed and relief B is closed
- Screw by hand, using knurled nut D, and device on gas valve.
- Assemble the adaptor to the nitrogen cylinder or pressure-reducing valve.
- Connect one side of flexible pipe to adaptor.
- Connect loose end of flexible pipe to valve C after removing cap.
- Screw, without forcing, knob A, until reading a pressure (if accumulator was already pre-charged)
- Slowly open the cylinder pressure reducing valve and keep open until a pressure slightly higher than required, is reached and there after shut the valve
- Unscrew knob A and decompress the apparatus with relief B.
- Disconnect flexible pipe from check valve C.
- Close relief, refit cap on valve C and wait a few minutes so the at the pressure can stabilize.
- Re-screw in knob A until a pressure, slightly higher than required, is read.
- Adjust, by relieving pressure, the pre-charge valve and proceed to dismantle the apparatus by unscrewing nut D with following precautions:
  - Completely unscrew knob A without forcing.
  - Open relief B.
  - Check for leaks at the accumulator inflating valve, using soapy water.
  - Re-screw in valve cover

At this point the accumulator is ready to be put into operation.

12.3 Diminution of pre-charge.

If pre-charge value is higher than required, opening can drop the pressure relieve B until desired pressure is reached. It is advisable to relieve slowly and read definite temperature after a few minute after relieving pressure, thereafter the apparatus can be removed.

12.4 Verification of the pre-charge

The operation is simple but must be executed correctly as indicated:
- Isolate the accumulator from the plant and discharge the liquid contained under pressure.
- Remove gas valve protector cap.
- Before assembling apparatus PC250 ensure that knob A is unscrewed, that relief valve B is closed, that check valve C cap is screwed on.
- Screw by hand knurled nut D, the apparatus on the gas valve.
- Screw knob A, without forcing, until a pressure is read. If value corresponds with that prescribed, dismantle the apparatus, by unscrewing nut D, taking precaution of:
  - Completely unscrew, without forcing, knob A.
  - Open relief valve B.

IT IS NECESSARY TO USE A PRESSURE REDUCER TO INFLATE THE ACCUMULATORS (EG. GAMMA LOW PRESSURES) THAT HAVE A MAXIMUM EXERCISE PRESSURE INFERIOR TO THAT OF THE NITROGEN CYLINDER PRESSURE.

NB. The pre-charge apparatus PC250 is fitted with a gauge 0 ÷ 250 bars. For pressure checks higher than 250 bars, it is necessary to use suitable gauge. Even for low pressures the precision of measurement is better using a dedicated gauge eg. With a pressure of 30 bars it is advisable to use a bottom scale of 60 bar.
13.1 Maintenance

The best system to guarantee perfect efficiency in the piston accumulator is to periodically check every 3 months, the pressure of the pre-charge. By doing so, it is possible to obtain the state of health of the equipment. Whilst carrying out this check, the contingent ambient temperature must be noted, which could be different of that at the time that the pre-charge was affected and this could be the cause of an error. It is necessary to ensure that this measure is taken while the piston is at the extremity of its stroke on the oil side. This in fact was the same position at the time of pre-charge operations. The life span of the gasket depends on the condition of cleanliness of oil in the system. The presence of metal particles and impurities has an abrasive effect on the cylinder and above all on the seal. It is recommended the filter be used as a precautionary measure, be it for the piston accumulator and all the components (Valves pumps etc.)

13.2 Repairs

For the sudden break down or a planned check, it could be necessary to dismantle the accumulator and check the components. It is necessary to carry out the operations in order as indicated, remembering never to disassembly anything unless it has bee ensure that the liquid and gas pressure has bee completely relieved.

13.3 Disassembly the accumulator

- If it is possible not to dismantle the equipment from the plant, completely discharge the pre-charge. Charge, the accumulator with fluid under pressure in a way to bring the piston and the end of the stroke at the gas side.
- Completely discharge fluid pressure.
- Dismantle pre-charge valve
- Before removing flanges, tap the flanges with aluminum hammer in order to release tension on the side of the thread.
- Screw two screws into the threaded holes and using a bar as a lever, unscrew the flanges.
- Push out the piston if you have access at the sides or else pull piston out using an eyebolt.
- If the accumulator is attached to the plant, discharge all the fluid.
- Clean and degrease all stripped components and carry out all visual inspection.
- Check the internal surface of the cylinder body which should be bright and free from scratches

13.4 Replacement of gasket

Remove all gaskets from pistons and flanges taking precaution not to scratch or damage the faces.
Clean the faces
Use an original EPE gasket kit; lubricate all the gaskets and guide in the piston, taking care not to damage during assemble. Fit to respective faces.

13.5 Assembly of accumulators

- Position the assembly sleeve (See chapter 9.5 and 9.7) from the end where the piston is to be inserted, and after having lubricated; push the piston in towards the internal of the accumulator body.
- With the accumulator vertically positioned, with gas side towards the top, pour approximately 0.1 litre of mineral oil on the internal surface of the accumulator, in order to keep the gaskets lubricated the nitrogen chamber and to avoid oxidation as a result of eventual humid residue of gas.
- After having replaced gaskets and the empty extraction rings fitted on the closure flanges, re-screw them on the accumulator body.
- Re-assemble pre-charge valve.
- Execute pre-charge with nitrogen as indicated in Chapter 12.

13.6 Service EPE

For any question and to together find solutions to any of your problems, do not hesitate to contact the Technical Service or Sales Departments of EPE ITALIANA, either directly or through our branches and representatives all over the world.

EPE Italiana Srl
Viale delle Rimembranze di Greco, 45
I-20125 Milano - Italy
Tel. +39 02 67071076
Fax +39 02 67071055
e-mail: epeitaliana@epeitaliana.it
http:www.epeitaliana.it
Australia

Stauff Corporation Pty Ltd
24-26 Doyle Avenue
P.O. Box 227
Unanderra NSW 2526
Tel.: 0061 2 42711877
Fax: 0061 2 42718432
E-mail: stauff@stauff.com.au

Belgium + Luxembourg

EMAC S.A.
Industrialaan 1, Zone Maalbeek
1702 Groet-Bijgarden
Tel.: 0032 2 4810211
Fax: 0032 2 4810301
E-mail: bpg@emac.be

Bielorussia

Hydro-Connect OOD
Kalinovski st. 53/3
22103 Minsk
Tel.: 00375 17 2659420
Fax: 00375 17 2659976
E-mail: info@hydro-connect.com

Brazil

HT-Hidraulonica ICI Ltda
Rua: E. Volpini, 45 - Sao J, Batista
CEP: 3515-190 Belo Horizonte - Minas Gerais
Tel.: 0055 31 34941657
Fax: 0055 31 34941831
E-mail: gsp@hidraulonica.com.br

Colombia

Hydraulica y Neumatica Ltda
Cra. 50F No.7 Sur-17
Apartado Aereo No.49204 Medellin
Tel.: 0057 4 3621600
Fax: 0057 4 3620969
E-mail: turbinas@hidraulicayneumatica.com.co

Slovakia Republic + Hungary

Hydraulik Innovation Gmbh
Obertreitenerstrasse, 17a
4000 Traun/Linz
Tel.: 0043 7229 516600
Fax: 0043 7229 516614
E-mail: Hydrinno@aon.at

China

Stauff (Shanghai) International Trading Co., Ltd
Shanghaid Mansion,
331 Binhou Rd., Pudong, Shanghail 200126
Tel.: 0086 21 58456619
Fax: 0086 21 58456680
E-mail: stauffsh@public.sta.net.cn

Denmark

PMC Technology A/S
Klausdalbrovej, 11 - 2860 Sborg
Tel.: 0045 70 211221
Fax: 0045 70 211222
E-mail: info@pmctechnology.dk

France

Abdon S.A.R.L.
11, Rue Louis Blanc - 13400 Aubagne
Tel.: 0033 4 42842046
Fax: 0033 4 42842072
E-mail: christian.abdon@wanadoo.fr

Great Britain

EPE (U.K.) Ltd
16 Manor Industrial Estate
Flinth, Flintshire, CHW 5LY
Tel.: 0044 1352 730720
Fax: 0044 1352 730820
E-mail: epe.uk@btconnect.com

Greece

Hydraulic Techn. O.E.
Sarafianos Bross
Monastiraki 100 - 54627 Thessaloniki
Tel.: 0030 2310 525523
Fax: 0030 2310 516531
E-mail: tisip@otenet.gr

Athens Hydromyntic S.A.
56. Athirion Avenue - 10441 Athens
Tel.: 0030 210 2521155
Fax: 0030 210 5221485
E-mail: hydrodynt@otenet.gr

Holland

EPE Goldman B.V.
Admiraal Trompstraat, 4
3115 HH Schiedam
Tel.: 0031 10 4269999
Fax: 0031 10 4269080
E-mail: sales@epe-goldman.com

India

EPE Process Filters & Accumulators Pvt. Ltd.
59-A, C.E., Gandhinagar, Balanagar
Hyderabad 500 037
Tel.: 0091 40 23085750
Fax: 0091 40 23086781
E-mail: business@epe-india.com

Israel

OZ Hydraulics & Pneumatics Ltd
No.5 Horkanus, North Ind. Area
72293 Lod
Tel.: 00972 8 9777640
Fax: 00972 8 9777679
E-mail: oz-hydraulics@oz-hyd.co.il

Korea

Lee Hwa Special Trading Co., Ltd
RA 1332 Chungang Complex, Guro-Dong
Guro-Ku, Seoul 152-721
Tel.: 0082 2 26165511
Fax: 0082 2 26167545
E-mail: KE6946333@chillian.net

Malaysia

Powermatics Hydraulics & Engineering (M) Sdn. Bhd.
No 7, Lingkuk Keluy 2, Kaw Perindustrian Bukit
Raja, 41500 Klang, Selangor
Tel.: 0060 3 33448000
Fax: 0060 3 33448000
E-mail: sales@powermatics.com

Mexico

Alfa Hidraulica S.A.
A. Gonzales 244 col. Sta M. Aztahuacan
C.P. 09570 - D.F.
Tel.: 0052 555 6923077
Fax: 0052 555 6923495
E-mail: alfah@prodigy.net.mx

Morocco

GT Maroc S.A.R.L.
47, Zanakt Marrmoucha
La Villette - 26300 Casablanca
Tel.: 00212 2 2623667
Fax: 00212 2 2623811

Norway

Servit Motion Control AS
Haugenveien, 2 - 1402 Oslo
Tel.: 0047 64 979979
Fax: 0047 64 979989
E-mail: servit@servit.no

Poland

F.E.H. Fabrika Elementow Hydrolikai S.A.
Ul. Wolska Polskiego, 29
34100 Wadowice
Tel.: 0048 33 8234441
Fax: 0048 33 8233840
E-mail: poron@poran-wadowice.pl

Singapore

PH Hydraulics & Engineering PTE, LTD
27 Gull Lane, Jurong
629421 Singapore
Tel.: 0065 6861 2000
Fax: 0065 6861 5000
E-mail: phh@ph-singnet.com.sg

Slovenia

Le-Tekhniq, d.o.o.
Sucova ulica 27
4000 Kranj
Tel.: 00386 4 2641211
Fax: 00386 4 2641222
E-mail: hydro@le-tehnika.si

Kladivar Ziri
Industrijska c. 2, p.p. 14
4226 Ziri
Tel.: 00386 4 5159100
Fax: 00386 4 5159130
E-mail: kladivar@kladivar.si

South Africa

Goldquest International Hydraulics Ltd
P.O. Box 4299 - 26 Barney Road
2094 Benrose - Johannesburg
Tel.: 0027 11 6142004
Fax: 0027 11 6142033
E-mail: admin@goldquest.co.za

Spain

Tecasona Suministros S.A.
Avda. Carlos Marx, 80
Poligono Ind. Horno de Alcedo - 46026 Valencia
Tel.: 0034 96 3182010
Fax: 0034 96 3182275
E-mail: tecasona@tecasosa.com

Switzerland

Hinel AG
Industriestrasse, 2 - 3178 Bösingen
Tel.: 0041 31 7478881
Fax: 0041 31 7478827
E-mail: Hinel@datacomm.ch

Taiwan

Limit Tein Industrial Co., Ltd
3P-7, No. 4, Lane 609, Sec. 3 - Chung Shin Rd.
Sanchung City, Taipei Hsien, 241, R.O.C.
Tel.: 00886 2 29955022
Fax: 00886 2 29955055
E-mail: limititein@ms33.hinet.net

Thailand

Pneumax Co., Ltd
104/21 Moo 8, Chaloem Phrakiat R.9 Rd.
Pratvet, Bangkok 10520
Tel.: 0066 2 7268000
Fax: 0066 2 7268260
E-mail: import@pneumax.co.th

Turkey

Mert Teknik Fabrika Malzemeleri
Ticaret ve Sanayi A.S.
Tersane Cad. 43 - Karakoy - 26447 Istanbul
Tel.: 0090 212 2528435
Fax: 0090 212 2456369
E-mail: info@mert.com