HYDAC INTERNATIONAL

Hydraulic Piston Accumulators

HYDAC PISTON ACCUMULATORS

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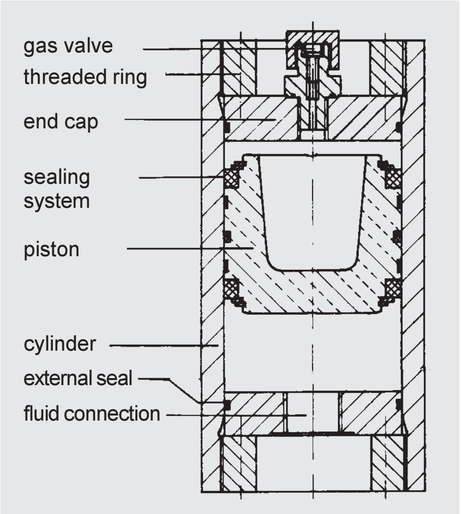
1. DESCRIPTION

1.1. FUNCTION

Fluids are practically incompressible and cannot therefore store pressure energy. The compressibility of a gas (nitrogen) is utilised in hydropneumatic accumulators for storing fluids.
HYDAC piston accumulators are based on this principle.
A piston accumulator consists of a fluid section and a gas section with the piston acting as a gas-proof screen. The gas section is pre-charged with nitrogen.
The fluid section is connected to the hydraulic circuit so that the piston accumulator draws in fluid when the pressure increases and the gas is compressed.
When the pressure drops, the compressed gas expands and the stored fluid is displaced into the circuit.

1.2. CONSTRUCTION



HYDAC piston accumulators consist of:

- a cylinder with very finely machined internal surface.
- end caps on the gas side and the oil side, held in place by threaded rings and sealed with O-rings.
- a floating light-metal piston which can easily be accelerated due to its low weight.
- a sealing system adapted to the particular application.

The piston floats on two guide rings which prevent metal-to-metal contact between the piston and the accumulator wall.

For use with certain aggressive or corrosive fluids, the parts coming into contact with the fluid can be nickel plated for protection, or made entirely from corrosion-resistant material.

Suitable materials are also available for low temperature applications.

1.3. SEALING SYSTEMS

Precise information about operating conditions is required in order to select the most appropriate sealing system. Important criteria for this selection are, for example:

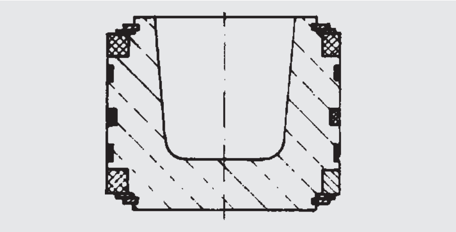
- design pressure
- effective pressure differential
- switching frequency or cycles
- temperature fluctuation
- operating fluid
- cleanliness of fluid (micron rating of filter)
- maintenance requirements

The sealing systems differ according to the type of piston used, each of which has its own type and arrangement of seals.

The following sealing materials are available, depending on the operating conditions:

- NBR/acrylonitrile butadiene rubber (PERBUNAN)
- FPM/fluoro rubber (VITON®)
- PUR/polyurethane

Standard piston
Design type 1

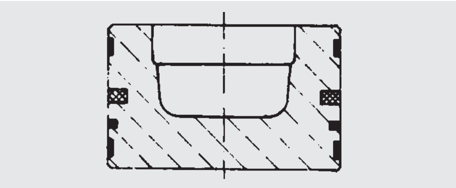


Application:
For general accumulator operation without special requirements

Note:
Piston friction must be taken into account for sizing purposes.

Application limitations:
Maximum piston velocity: 0.5 m/s

Design type 2

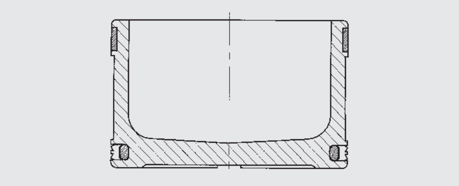


Application:
Low-friction design for high piston speeds and slow movements without stick-slip effect.

Note:
Filtration ≤ 20 µm absolute

Application limitations:
Maximum piston velocity: 3.5 m/s

Design type 3



Application:
Low friction design, simple-to-fit seals, slow movements without stick-slip effect.

Note:
Filtration: ≤ 20 µm absolute

Application limitations:
Maximum piston velocity: 0.8 m/s

1.4. MOUNTING POSITION

HYDAC piston accumulators operate in any position. Vertical installation is preferable with the gas side uppermost, to prevent contamination from the fluid settling on the piston sealings.

Accumulators with electrical limit switch monitoring must be mounted vertically.

1.5. ADVANTAGES OF HYDAC PISTON ACCUMULATORS

- complete range from 0.1–1200 litres nominal volume
- high ratios possible between pre-charge pressure and max. working pressure
- economical solutions due to back-up bottles for low pressure differentials
- high flow rates – up to 18000 l/min from one accumulator
- power savings
- high level of efficiency of the hydraulic installation
- gas-proof and leak-free
- no sudden discharge of gas when sealing is worn
- requires little space
- monitoring of the volume across the entire piston stroke or electrical limit switch

Further advantages of using the low-friction sealing system:

- minimum friction
- also suitable for low pressure differentials
- no start-up friction
- no stick-slip
- low noise, no vibration
- high piston velocity up to 3.5 m/s for piston type 2
- improved accumulator efficiency
- good life expectancy of sealing because of low wear
- suitable for high temperature fluctuations
- low maintenance requirement

1.6. TECHNICAL PREREQUISITES

HYDAC piston accumulators are suitable for high flow rates.

With the largest extended piston diameter made so far of 800 mm a flow rate of 1000 l/s can be achieved at a piston velocity of 2 m/s.

1.6.1 Effect of sealing friction

The permissible piston velocity depends on the sealing friction.

Higher piston velocities are possible where there is less sealing friction.

HYDAC piston accumulators of design type 2 allow velocities of up to 3.5 m/s.

1.6.2 Permissible velocities

Gas velocity
The flow velocities in the gas connection and pipe system should be limited to 30 m/s when using piston accumulators of the back-up type. Gas velocities of over 50 m/s should be avoided at all costs.

Oil velocity
In order to limit the pressure losses when the operating fluid is displaced, the flow velocity should not exceed 10 m/s in the adaptor cross-section.

1.6.3 Operational test and fatigue tests

Operational tests and fatigue tests are carried out to ensure continuous improvement of our piston accumulators.

By subjecting the accumulators to endurance tests under realistic as well as extreme working conditions, important data can be obtained about the long-term behaviour of the components.

Important information on gas density and the life expectancy of the seals is gained from such tests.

Vital data for use in accumulator sizing is gained by altering the working pressure and switching cycles.

1.6.4 **Fluids**

The following sealing materials are suitable for the fluids listed below:

NBR, resistant to:
- mineral oil (HL and HLP)
- non-flam fluids from the group HFA, HFB, and HFC
- water and seawater up to approx. 100 °C.

NBR, not resistant to:
- aromatic hydro-carbons
- chlorinated hydro-carbons
- amines and ketones
- operating fluids from the group HFD

FPM, resistant to:
- mineral oils (HL and HLP)
- operating fluids from the group HFD
- fuel, as well as aromatic and chlorinated hydro-carbons
- inorganic acids (but not all, please contact our technical sales department)

FPM, not resistant to:
- ketones and amines
- (anhydrous) ammonia
- organic acids such as formic acid and acetic acid

PUR, resistant to:
- mineral oils (HL and HLP)
- non-flam fluids from the group HFA

PUR, not resistant to:
- water and water-glycol mixtures
- alkalis
- acids

1.6.5 **Temperature ranges of the seals**

Material abbrev.	HYDAC code	Long-term temperature range
NBR	2	-30 °C...+ 80 °C
FPM	6	-15 °C...+160 °C
PUR	8	-30 °C...+ 80 °C

For temperatures outside these ranges, please contact our technical sales department for more information.

There are also special grades available depending on the application.

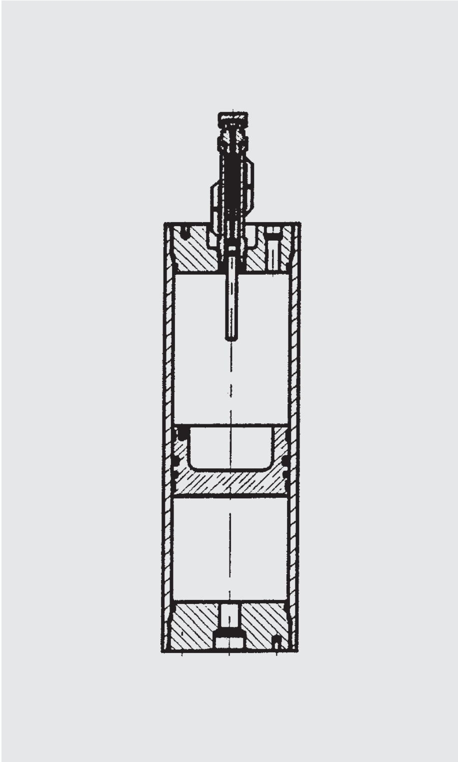
1.6.6 **Gas charging**

Only 99.995% nitrogen, which has been filtered at < 3 µm should be used.
Please contact us if using other types of gases.

Never use oxygen
RISK OF EXPLOSION!

1.7. PISTON POSITIONAL INDICATORS

1.7.1 **Electrical limit switch**



The electrical limit switch usually monitors the max. charged condition of the piston accumulator. It can, however, also permit control functions of the attached hydraulics to be carried out over a certain stroke length.

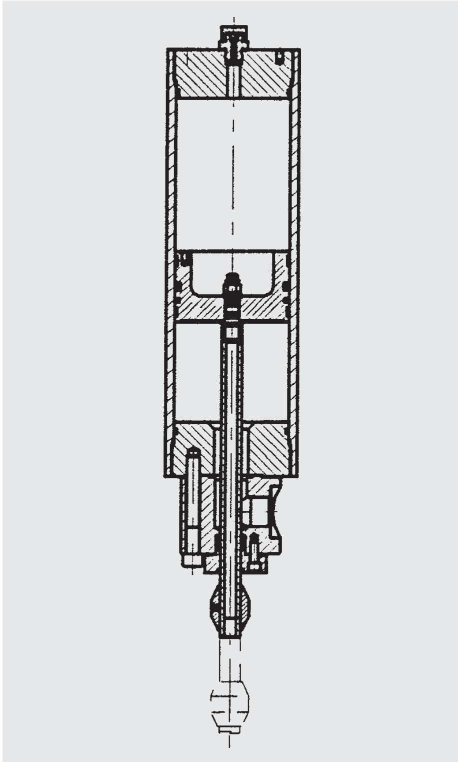
The limit switch consists of the switching rod with a permanent solenoid which is not attached to the piston and can only achieve a limited stroke, and an anti-magnetic housing and two or more switches.

On other models, switching is carried out by inductive proximity switches. Reset is achieved by force of gravity, a spring or by a patented hydraulic reset mechanism (special model). The function of the limit switch is not dependent on the mounting position (with the exception of the model with gravitational reset).

A vertical mounting position is preferable, due to the friction and possible wear and tear in the rod guide.

The maximum piston speed must not exceed 0.5 m/s over the stroke range of the limit switch.

1.7.2 **Protruding piston rod**



The protruding piston rod permits control of the position of the piston over the whole stroke. It consists of the piston rod, which is fixed to the piston and sealed in, and the so-called trip cam which actuates the limit switches.

The position of the piston can be monitored at any point using the trip cam. This facility is used mainly to switch the pump on and off.

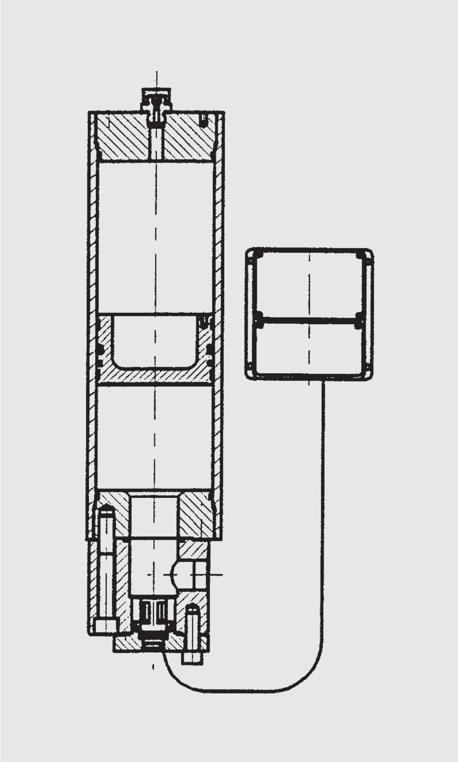
Normally, the piston rod protrudes from the shell on the fluid side to avoid possible points of leakage on the gas side. On the protruding piston rod version the hydraulic connection will be on the side, if the size of the end cap does not permit otherwise. In special cases the rod can protrude from the gas side.

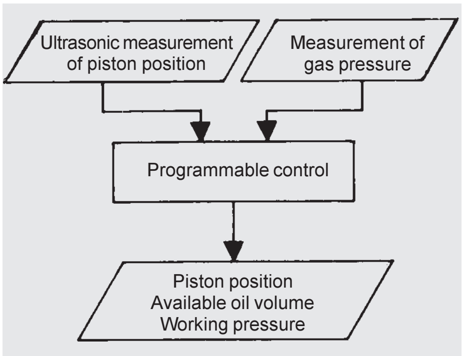
The protruding piston functions in any mounting position.

There must however be sufficient space available for the piston to move in and out.

The maximum piston speed must not exceed 0.5 m/s over the whole stroke.

1.7.3 **Ultrasonic measurement system**





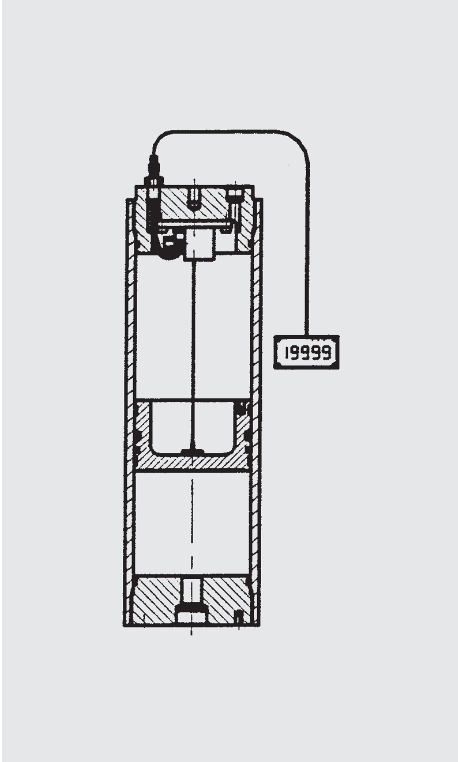
The piston position is determined by ultrasonic measurement.

It is only possible to take the measurements from the fluid side, because a continuous sound carrier medium is required for the ultra-sound. In order to eliminate false readings, if possible, the fluid must be free of air bubbles. The piston should be mounted so that no air can collect under the sensor.

The measurement data is evaluated by a microprocessor and is converted into a continuous measurement signal. It is possible to obtain interim measurement results to switch system parts e.g. turn the pump on and off.

The maximum pressure on the sensor must not exceed 350 bar.

1.7.4 **Cable tension measurement system**

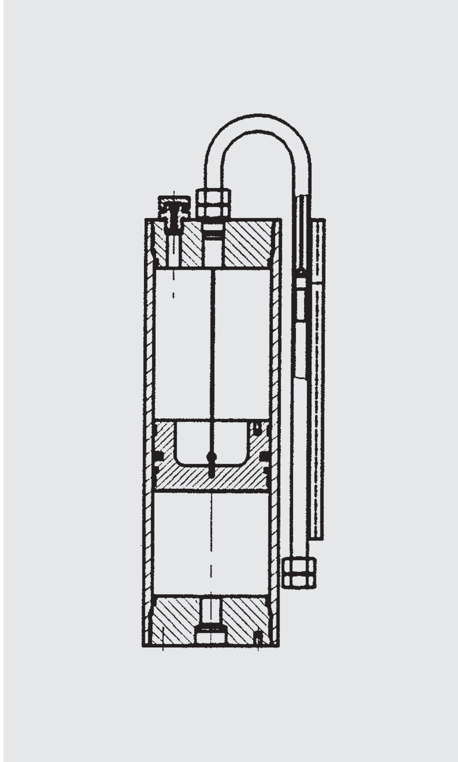


Using the cable tension measurement system, the position of the piston can be determined by means of a cable which has been fixed to the piston.

The cable is attached to a wheel which is tensioned by a spring. This wheel alters an electrical resistance via an attached rotary potentiometer during the piston movement, and this is fed to a pressure-tight cable gland through the end cap to a microprocessor. The electrical signal from the rotary potentiometer can display the position of the piston via the microprocessor. In addition, it is possible to obtain various piston positions for switching system parts e.g. turning the pump on and off. Alternatively the signal can be fed directly via a current/ voltage converter to a PLC.

The maximum pressure must not exceed 280 bar. The piston acceleration is limited to certain values according to measurement system forces, approx. 7…..30 g, and is limited to a maximum velocity of 0.5 m/s.
The measurement system is not suitable for high cycles and large cyclic conditions (maximum cycle = 5 min^{-1}). The piston should be mounted gas side uppermost, in exceptional cases it can be mounted horizontally. The cable tension measurement system can only be fitted onto the gas side of the piston accumulator.

1.7.5 **Magnetic flapper indication**



With magnetic flapper indication, the position of a piston can be determined by the colour of a set of magnetic flaps which turn as the piston moves and which are visible externally.

A non-magnetic tube is fitted to the piston accumulator containing a cable, one end of which is fastened to the gas-side of the piston, and the other end is attached to a magnet. Along the length of the piston accumulator a housing is also fitted which contains red/white magnetic flappers. As the magnet moves up or down its tube, the flappers turn to their opposite colour to indicate the piston's position. In addition, reed switches can be fitted to the tube to switch system parts and measurement scales can also be fitted.

The maximum piston speed must not exceed 0.5 m/s. No more than 5 cycles per day on average should be carried out. Piston accumulators with magnetic flapper indication must only be installed vertically, gas-side uppermost.

2. ACCUMULATOR SIZING

2.1. DEFINITION OF VARIABLES FOR SIZING A PISTON ACCUMULATOR

p_0 = gas pre-charge pressure

p_1 = min. working pressure

p_2 = max. working pressure

V_0 = effective gas volume

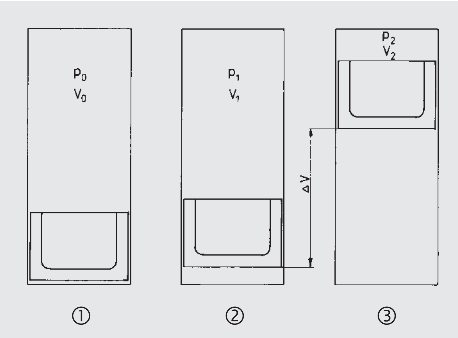
V_1 = gas volume at p_1

V_2 = gas volume at p_2

t_0 = gas pre-charge temperature

t_{min} = min. working temperature

t_{max} = max. working temperature



① The piston accumulator is pre-charged with nitrogen. The piston sits against the end cap and shuts off the fluid connection.

② The minimum working pressure should be approx. 5 bar above the gas pre-charge pressure. This should prevent the piston from striking the end cap every time it withdraws thereby causing the fluid pressure in the system to collapse.

③ Once the max. working pressure is reached the effective volume ΔV in the accumulator is available:

$\Delta V = V_1 - V_2$

2.2. SELECTION OF GAS PRE-CHARGE PRESSURE

The selection of gas pre-charge pressure defines the accumulator capacity. In order to obtain optimum utilisation of the accumulator volume the following gas pre-charge pressures are recommended:

$p_{0,t_{min}} \geq$ 2 bar (piston type 2)

$p_{0,\,t_{min}} \geq$ 10 bar (piston type 1)

$p_{0,\,t_{min}} \leq p_1$ - 5 bar

In extreme cases, at low charging (isothermal) and rapid discharging (adiabatic) of the effective volume, the gas pre-charge pressure $p_0 \geq p_1$ can be selected after accurate calculation.
The accumulator is supplied uncharged or with 2 bar conservation pressure.

2.2.1 Temperature effect

In order that the gas pre-charge pressures recommended here can be maintained even at relatively high operating temperatures, $p_{0\ charge}$ for charging and testing must be selected on a cold accumulator, as follows:

$$p_{0,t_0} = p_{0,t_{max}} \times \frac{t_0 + 273}{t_{max} + 273}$$

t_0 = gas pre-charge temp. (°C)

t_{max} = max. working temp. (°C)

t_0 = t_{charge} (gas pre-charge temperature °C)

In consideration of the temperature effect during accumulator sizing, p_0 at t_{min} must be selected as follows:

$$p_{0,t_{min}} = p_{0,t_{max}} \times \frac{t_{min} + 273}{t_{max} + 273}$$

2.3. ACCUMULATOR SIZING USING HYDAC PC SOFTWARE

Piston accumulators and piston accumulator systems can be sized accurately, quickly and effectively with the help of the HYDAC PC-Software ASP. By entering the required values, the program permits the optimisation of the accumulator size and also complicated function sequences. User flow rate, as well as pump flow, can be entered. Afterwards the data can be printed out on any standard printer.

The program can be obtained free of charge from the HYDAC accumulator division.

2.4. FORMULAE FOR SIZING ACCUMULATORS

The compression and expansion processes in a piston accumulator are subject to the laws of polytropic changes in the state of gas.
The following applies for ideal gases:

$p_0 \times V_0^n = p_1 \times V_1^n = p_2 \times V_2^n$,
where time is represented by the polytropic power "n".
For slow expansion and compression processes which occur almost isothermally, the polytropic power can be calculated at n = 1. For rapid processes an adiabatic change in state can be calculated at $n = \chi = 1.4$ (for nitrogen, as a diatomic gas). [1)]

For pressures above 200 bar the real gas behaviour differs considerably from the ideal one, which means the effective volume ΔV is reduced. In such cases a correction is made which takes into account the change in the χ value.

By using the following formulae the required gas volume V_0 for various applications can be calculated. Pressures of up to approx. 10 bar must be used in the formulae as absolute pressures.

Calculation formulae:

polytropic: $$V_0 = \frac{\Delta V}{\left(\frac{p_0}{p_1}\right)^{1/n} - \left(\frac{p_0}{p_2}\right)^{1/n}}$$

isothermal: (n = 1) $$V_0 = \frac{\Delta V}{\frac{p_0}{p_1} - \frac{p_0}{p_2}}$$

adiabatic: $(n = \chi = 1.4)$ $$V_0 = \frac{\Delta V}{\left(\frac{p_0}{p_1}\right)^{0.714} - \left(\frac{p_0}{p_2}\right)^{0.714}}$$

Correction factors to take into account the real gas behaviour [2)]:

for an isothermal change in state:

$$C_i = \left(\frac{V_{0\,real}}{V_{0\,ideal}}\right)_{isothermal}$$ or

$$C_i = \left(\frac{\Delta V_{ideal}}{\Delta V_{real}}\right)_{isothermal}$$

for an adiabatic change in state:

$$C_a = \left(\frac{V_{0\,real}}{V_{0\,ideal}}\right)_{adiabatic}$$ or

$$C_a = \left(\frac{\Delta V_{ideal}}{\Delta V_{real}}\right)_{adiabatic}$$

Checking the effective volume on a back-up model:

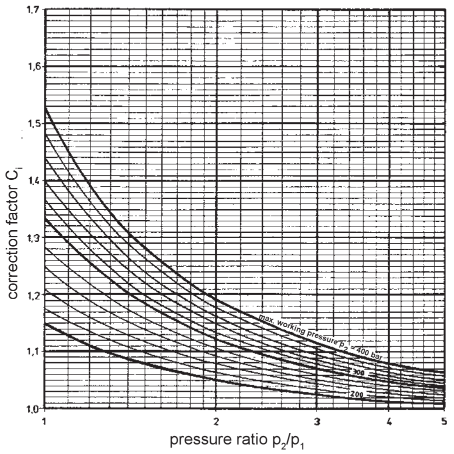
$$\Delta V' = V_0 \times \left(1 - \frac{p_0}{p_2}\right)$$

$$\Delta V' \leq 0.75 \times V_0$$

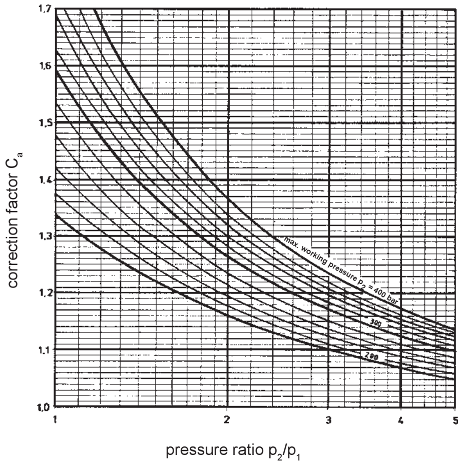
1) An estimate of accumulator size and a selection of pre-charge pressures can be made with the aid of points 2.2. and 2.2.1. Accurate sizing, taking into account further limiting conditions, can be carried out by us; we have appropriate computer programs available.

2) see 2.4.1 and 2.4.2.

2.4.1 Correction factors for an isothermal change in state



2.4.2 Correction factors for an adiabatic change in state



2.5. BACK-UP NITROGEN BOTTLES

The volume of nitrogen in the accumulator can only be compressed slightly at low pressure differentials between min. and max. working pressure. Therefore the effective storage volume of the accumulator is correspondingly small.

When sizing the so-called back-up version, the procedure is exactly the same as for the single accumulator, where V_0 represents the total volume of accumulator and nitrogen bottles.

The calculation is iterative; after each step check whether the effective accumulator volume is sufficient to accommodate the oil volume for isothermal charging from pre-charge pressure to working pressure.

Accurate sizing, taking into account further limiting conditions, can be carried out by us; we have appropriate computer programmes available.

2.6. CALCULATION EXAMPLE

Piston accumulator, back-up type.

35 litres operating fluid must be drawn off between max. working pressure of 200 bar and min. working pressure of 120 bar in approx. 2 seconds (adiabatic gas expansion). Re-charging of the operating fluid into the accumulator occurs within 4 minutes.

The working temperature is constant at 40 °C.

Given parameters:

max. working pressure:
p_2 = 201 bar

min. working pressure:
p_1 = 121 bar

effective volume:
ΔV = 35 l in 2 sec

max. working temperature:
t = 40 °C

Required:

a) accumulator size V_0' and gas volume V_0

b) gas pre-charge pressure p_0 at 20 °C

Solution:

Since this is a rapid discharge, an adiabatic change in state is assumed.
The calculation does not take into account the temperature effect.

a) 1.) Selection of gas pre-charge pressure at max. temperature:

$p_0 \sim p_1 - 5$ bar
$p_0 \sim 121 - 5 = 116$ bar

2.) Calculation of required gas volume (ideal gas):

$$V_{0\,ideal} = \frac{\Delta V}{\left(\frac{p_0}{p_1}\right)^{0.714} - \left(\frac{p_0}{p_2}\right)^{0.714}}$$

$$= \frac{35}{\left(\frac{116}{121}\right)^{0.714} - \left(\frac{116}{201}\right)^{0.714}}$$

$$= 118.7 \text{ l}$$

3.) Determination of correction factor for an adiabatic change in state:

$p_2/p_1 \sim 1.66$
$C_a = 1.195$
$V_{0\,real} = C_a \times V_{0\,ideal}$
$= 1.195 \times 118.7$
$= 141.8$ l

4.) Checking the accumulator size: Since the charge is assumed to be isothermal the gas pre-charge pressure must be increased to obtain the optimum accumulator size.

$$p_0 = \frac{\Delta V \times p_2}{\left[\left(\frac{p_2}{p_1}\right)^{0.714} - 1\right] \times V_0}$$

$$= \frac{35 \times 201}{\left[\left(\frac{201}{121}\right)^{0.714} - 1\right] \times 118.7}$$

$$= 135.8 \text{ bar}$$

5.) Check that accumulator size V_0' is larger than effective volume ΔV':
Selected from 3.) V_0 = 150 l

$$\Delta V' = V_0\left(1 - \frac{p_0}{p_2}\right)$$

$$= 150\left(1 - \frac{135.8}{201}\right) = 48.6 \text{ l}$$

$\leadsto V_0' = 50$ l

6.) Selected gas volume distribution:
1 piston accumulator SK … - 50
and
2 nitrogen bottles SN … -50

b) Calculation of gas pre-charge pressure p_0 at 20 °C:

$$p_{0,\,t_0} = p_{0,\,t_{max}} \times \frac{t_0 + 273}{t_{max} + 273}$$

$$p_{0,\,20\,°C} = 135.8 \times \frac{20 + 273}{40 + 273}$$

$$= 127.1 \text{ bar}$$

$$p_{0,\,20\,°C} = 126 \text{ bar overpressure}$$

3. TECHNICAL SPECIFICATIONS

3.1. MODEL CODE

(also order example) **SK350 – 20 / 1212 A – 350 AAG – VA – 18 A – 1**

Series — SK350

Nominal volume (l) — 20

Material and piston code — 1212

Piston design type (see point 1.3.)

Piston material
1 = aluminium
2 = C-steel (machined)
3 = VA-steel (machined)
4 = C-steel with surface protection
5 = C-steel (cold impact formed)

Material of cylinder and end caps
1 = C-steel
2 = C-steel with surface protection
3 = VA-steel
6 = TT-steel (low temperature)

Material of seals incl. piston
2 = NBR20
5 = NBR21 (low temperature)
6 = FPM (perfluoro elastomer VITON©)
8 = PUR (polyurethane)

Approval code — A
A = TRB (Germany)

Permissible working pressure (bar) — 350

Fluid connection — AAG
Type of connection (see table 1)
Standard or specification of the type of connection (see tables 2 + 3)
Size of connection (see tables 4 + 5)

Gas side connection or gas valve — VA
Type of connection (see table 1)
Standard or specification of the type of connection (see tables 2 + 3) (no letter if type V connection)
Size of the connection (see tables 4, 5 + 6)

Piston diameter — 18
04 = 40 mm
06 = 60 mm
08 = 80 mm
10 = 100 mm
12 = 125 mm
15 = 150 mm
18 = 180 mm
20 = 200 mm
25 = 250 mm
31 = 310 mm
35 = 355 mm
54 = 540 mm

Supplementary equipment — A
A = electrical limit switch – 35 mm stroke
B = electrical limit switch – 200 mm stroke
C = electrical limit switch – 500 mm stroke
K = protruding piston rod
M = magnetic flapper indication
S = cable tension measurement system
U = ultrasonic measurement system
E.. = special switch (fixed and adjustable)

Safety devices — 1
1 = burst disc (indicate nominal pressure)
2 = gas safety valve
3 = temperature fuse plug

Table 1, Connection type

Code	Description
A	Threaded connection (female)
B	Threaded connection (male)
F	Flange connection
H	Protruding flange
K	Combination connection
V	Gas valve type

Table 2, Standard or specification, threaded connection

Code	Description
A	Thread to ISO 228 (BSP)
B	Thread to DIN 13 or ISO 965/1 (metric)
C	Thread to ANSI B1.1 (UN..-2B, seal SAE J 514
D	Thread to ANSI B1.20.3 (NPTF)
S	Special type

Table 3, Standard or specification, flange connection

Code	Description
A	Flange to DIN standards
B	Flange to ANSI B 16.5
C	SAE flange 3000 psi
D	SAE flange 6000 psi
E	High pressure block flange (MM-Rexroth, AVIT, HAVIT) PN320
S	Special flange

Table 4, Threaded model connection sizes

Type	Code, Size										
Tab.2	A	B	C	D	E	F	G	H	J	K	L
A	G 1/8	G 1/4	G 3/8	G 1/2	G 3/4	G 1	G1 1/4	G1 1/2	G2	G2 1/2	G3
B	M10x1	M12x1.5	M14x1.5	M16x1.5	M18x1.5	M22x1.5	M27x2	M33x2	M42x2	M48x2	M60x2
C	5/16-24UNF	3/8-24UNF	7/16-20UNF	½-20UNF	9/16-18UNF	¾-16UNF	7/8-14UNF	1 1/16-12UN	1 3/16-12UN	1 5/16-12UN	1 5/8-12UN
D	1/16-27NPTF	1/8-27NPTF	¼-18NPTF	3/8-18NPTF	½-14NPTF	¾-14NPTF	1-11½ NPTF	1¼ -11½ NPTF	1½-11½ NPTF	2- 11½ NPTF	2 ½ - 8NPTF

Table 5, Flange model connection sizes

Type	Code, Size										
Tab.3	A	B	C	D	E	F	G	H	J	K	L
A	DN15	DN25	DN40	DN50	DN65	DN80	DN100	DN125	DN150	DN200	
B	½" - 1500#	1"- 1500#	1 ½" - 1500#	2"- 1500#	2 ½"- 1500#	3"- 1500#	½"- 2500#	1"- 2500#	1 ½"- 2500#	2"- 2500#	2 ½"- 2500#
C	½"	¾"	1"	1 ¼"	1 ½"	2"	2 ½"	3"	3 ½"	4"	5"
D	½"	¾"	1"	1 ¼"	1 ½"	2"					
E	DN32	DN40	DN50	DN65	DN80	DN100	DN125	DN150			

Table 6, Gas valve model

Code	Description
A	Gas valve G3/4 male with M28x1.5/M8.
B	Gas valve end connection M28x1.5/M8
C	Gas valve ½"-20 UNF male with M16x2 (ISO 10945)
D	Gas valve M14x1.5 male with external M16x1.5
E	Gas valve G3/4 male with 7/8-14 UNF-VG8

3.1.1 **Nominal volume [litres]**
see table 5.1.

3.1.2 **Effective gas volume V_0 [litres]**
These differ slightly from the nominal volume and are based on the calculations of the effective volume.

The gas volume V_0 is larger than the nominal volume given in tables 5.1. – 5.3. by the amount given below:

Piston diameter D1[mm]	Type 1 [l]	2 [l]	3 [l]
60	–	–	–
80	–	0.044	0.081
100	0.183	0.091	0.270
125	–	0.257	0.563
150	–	0.655	0.823
180	1.016	0.659	1.322
200	–	0.988	2.171
250	3.003	2.531	3.573
310	–	6.168	–
355	5.627	4.434	–
540	–	35.683	–

3.1.3 **Effective volume ΔV [litres]**
The volume (on the fluid side) between the working pressure p_2 and p_1.

3.1.4 **Permissible operating temperature (fluid)**
-10 °C to +80 °C
263 K to 353 K
(standard material)
Others on request.

4. RECOMMENDATIONS

4.1. GENERAL

The operating instructions for the installation and maintenance of hydraulic accumulators as laid out in brochure no. DEF 3.201.M must be followed.

On no account must any welding, soldering or mechanical work be carried out on the accumulator shell. Once the hydraulics have been connected, all air should be completely vented. Work on systems with accumulators (repairs, connecting pressure gauges etc) must only be carried out once the fluid pressure has been released.

4.2. EXTRACT FROM THE APPROVAL SPECIFICATIONS

4.2.1 Germany

As pressure vessels, hydraulic accumulators are subject to the (German) Pressure Vessel Regulations (DruckbehV). The design, manufacture and testing is in accordance with AD notices. The installation, equipping and operating of accumulators is controlled by the "Technical Regulations – Pressure Vessels" (TRB). Piston accumulators are divided into groups according to the permissible operating pressure p in bar, the capacity l in litres and the pressure capacity p x l.

The tests prescribed for each group are listed in the table below.

The Pressure Vessel Regulations (DruckbehV) remain in force until 29.05.2002 in parallel with the Pressure Equipment Directive 97/23/EC (transitional regulation), see point 4.2.3.

HYDAC piston accumulators fitted with a HYDAC safety and shut-off block comply with the safety regulations to TRB. Please see also our brochure "Safety and Shut-off Block SAF 10/20/32" No. E 3.551.

4.2.2 Other countries

Pressure accumulators which are installed outside Germany are supplied with the test certificates required in the particular country. Please state requirements at time of ordering. The TUV certificate is not universally recognised in all countries.
HYDAC pressure vessels can be supplied with virtually any test certificate.
In some of these the permissible working pressure can differ from the nominal pressure.
The following table contains the codes used in the model code for different countries:

Australia	F
Austria	D
Belgium	H
Brazil	A1
Canada	S1
China	A9
CIS	A6
Czech. Rep.	A3
Denmark	A5
EU member states	U
Finland	L
France	B
Germany	A
Great Britain	K
India	N
Italy	M
Japan	P
Luxembourg	A
Netherlands	C
New Zealand	T
Norway	A1
Poland	A4
Portugal	A1
Rep. of Ireland	K
Romania	K
Slovakia	A8
South Africa	A1
Spain	A2
Sweden	R
Switzerland	G
USA	S
others on request	

U-Stamp certificate

HYDAC Technology GmbH of D-66280 Sulzbach/Saar is authorised (with effect from 21 August 1985) by the National Board of Boiler and Pressure Vessel Inspectors, in conformity with the appropriate specifications of the American Society of Mechanical Engineers (ASME), to use the Code Symbol

U

as a stamp and for registration purposes.


THE NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS
Certificate of Authorization
For Registration

This is to certify that
HYDAC TECHNOLOGY GMBH
Industriegebiet
Sulzbach/Saar D-66280
GERMANY

is hereby authorized to register ASME Code Symbol Stamped item(s)
U
with The National Board of Boiler and Pressure Vessel Inspectors in accordance with the applicable rules and provisions set forth in the National Board Rules and Regulations, Art. IV and letter of instruction. Construction and inspections shall have been made strictly in accordance with the provisions of the ASME Code and National Board Rules and Regulations.

This authorization is issued or renewed on September 30, 1994 and expires on September 30, 1997 by

THE NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS

Chairman

Executive Director

4.2.3 European pressure equipment directive PED (DGRL/DEP)

On 29 November 1999 the directive 97/23/EC (pressure equipment directive) came into force. This directive applies to the design, manufacture and conformity assessment of pressure equipment and assemblies with a maximum permissible pressure of over 0.5 bar. It guarantees the free movement of goods within the European Community. EU member states must not prohibit, restrict or obstruct the circulation and commissioning of pressure equipment on account of pressure related hazards, if the equipment complies with the requirements of the pressure equipment directive and has the CE mark, and is subject to a conformity assessment.

According to Article 3, Paragraph 3, hydraulic accumulators with a capacity $V \leq 1$ l, a maximum permissible pressure $PS \leq 1000$ bar and a pressure capacity $PS \times V \leq 50$ bar x l do not receive a CE mark. Operational safety and repeat testing are controlled as before by national laws.

Group	Tests before commissioning at manufacturer's	at user's	Recurrent testing
II $p > 25$ bar and $p \times l \leq 200$	Manufacturer confirms satisfactory manufacture and testing by stamping 'HP' or by certificate	Inspection certificate (accuracy test, test of equipment and installation) by authorities	Test periods must be set by user according to experience of operating method and operating fluid
III $p > 1$ bar, $p \times l > 200$ and $p \times l \leq 1000$	Preliminary inspection by authorities Construction and pressure testing and certification through manufacturer (registration of design), or through authorities (individual certificate)	Inspection certificate from authorities	As for group II
IV $p > 1$ bar and $p \times l > 1000$	As for group III	As for group III	Internal test: every 10 years for non-corrosive fluids otherwise every 5 years. Pressure test: every 10 years. Testing to be carried out by authorities (TUV)

5. DIMENSIONS

5.1. PISTON ACCUMULATOR

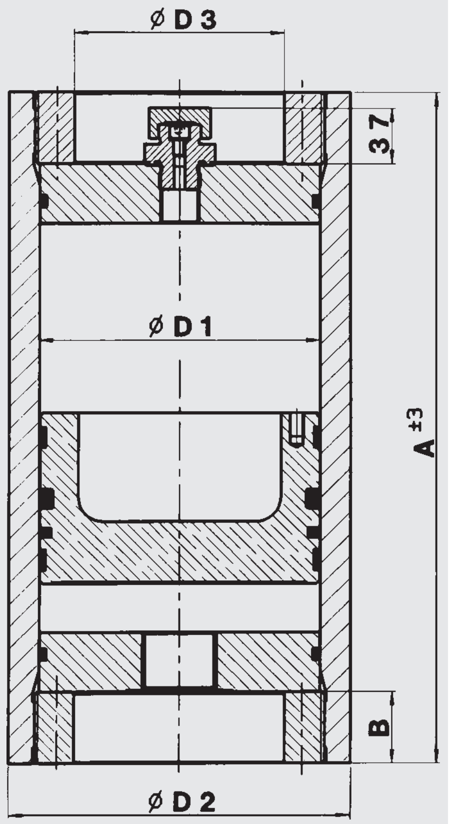


Fig. 1

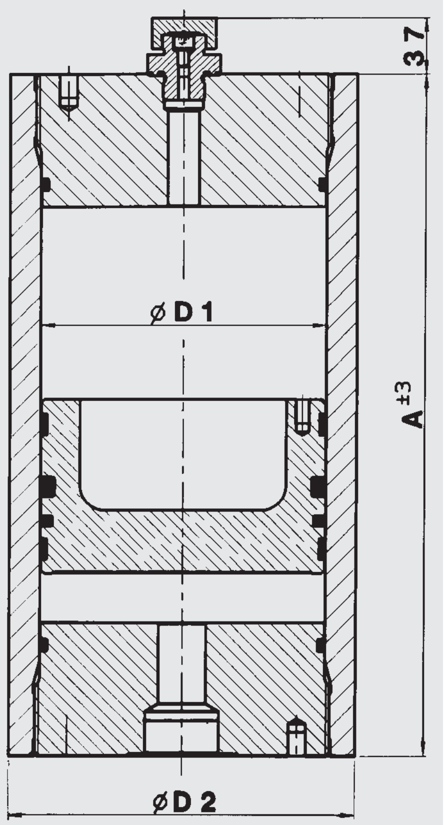


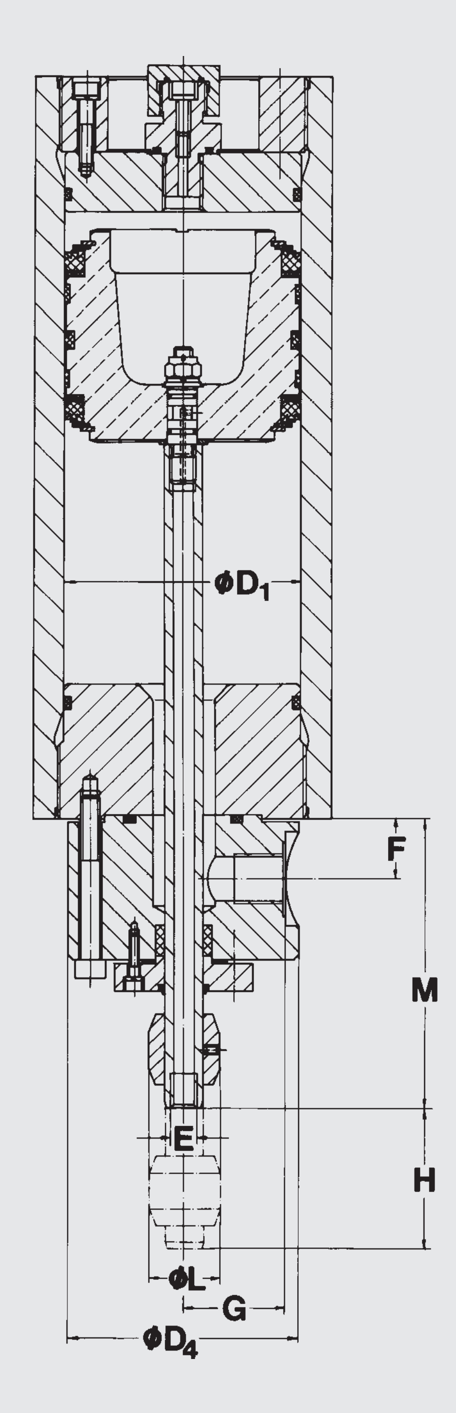
Fig. 2

Nominal volume 2) [litres]	Series	ø D1 [mm]	ø D2 [mm]	A ±3 [mm]	Country code A				Fig.
					Permiss. working press.2) [bar]	ø D3 [mm]	B [mm]	Wt. [kg]	
0.2 0.5 1	SK350	60	80	218 325 502	350	–	–	7 9 12	2
0.5 1 2	SK350	80	100	250 350 550	350	–	–	11 13 18	1, 2
2.5 5 7.5	SK350	100	126	532 850 1170	350	65	32	28 40 52	2
2 5 15	SK350	125	160	345 590 1405	350	–	–	37 52 102	2
6 20 40	SK350	150	180	545 1335 2470	350	–	–	58 105 175	2
10	SK210 SK350		210 220	655	230 350			106	
20	SK210 SK350	180	210 220	1050	230 350	–	–	129	2
50	SK210 SK350		210 220	2225	230 350			251	
20	SK210 SK350		230 235	945	210 350			148	
40	SK210 SK350	200	230 235	1580	210 350	–	–	208	2
100	SK210 SK350		230 235	3490	210 350			387	
50	SK210 SK350		294 315	1450	210 350			411	
80	SK210 SK350	250	294 315	2060	210 350	212	64	549	1, 2
120	SK210 SK350		294 315	2875	210 350			733	
120 150 200	SK350	310	350	1970 2370 3050	350	–	–	494 560 670	2
130	SK210 SK350		404 434	1847 1875	210 350		87 91	689 1003	
180	SK210 SK350	355	404 434	2352 2381	210 350	285	87 91	804 1198	1, 2
250	SK210 SK350		404 434	3060 3088	210 350		87 91	967 1470	
100 200 400	SK350	540	635	1375 1815 2685	350 350 350	410	145	2603 2976 3714	1

2) others on request

Other sizes available on request.
Intermediate sizes are possible, depending on the length/diameter required.
Please contact our technical sales department.

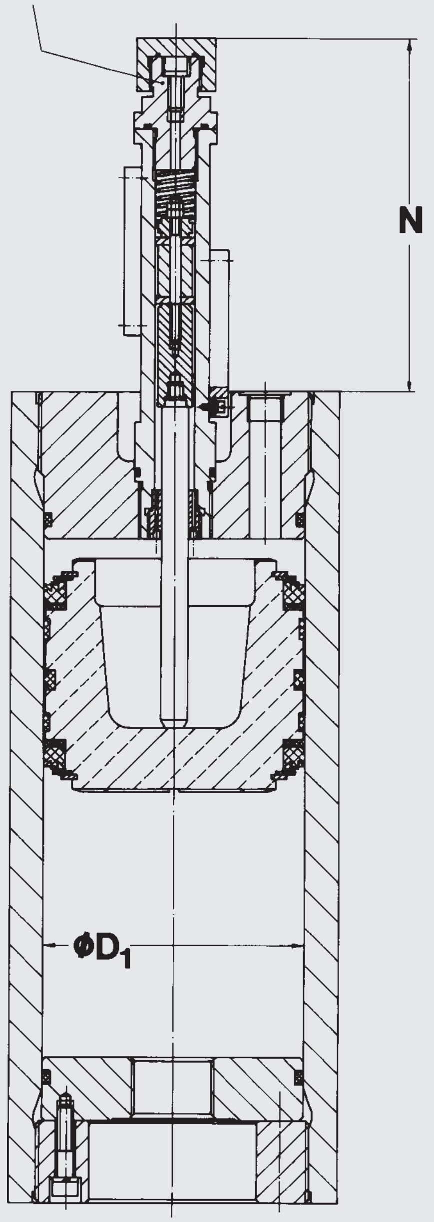
5.2. PISTON ACCUMULATOR WITH PROTRUDING PISTON ROD

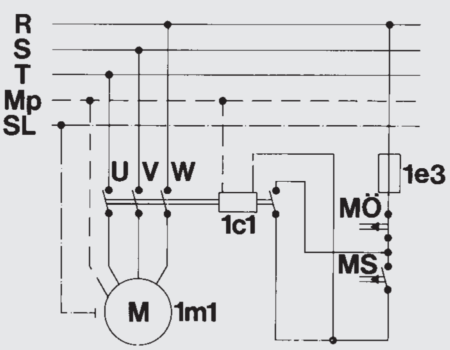


Nominal [2] volume [litres]	Series	ø D1 [mm]	M [mm]	ø D4 [mm]	H [mm]	F [mm]	G [mm]	E [ISO228]	ø L [mm]	Additional weight [kg]
0.2 0.5 1	SK350	60[1]								
0.5 1 2	SK350	80[1]								
2.5 5 7.5	SK350	100	214	100	318 636 956	35	42	G1/8	38	7 7.5 8
2 5 15	SK350	125	214	100	177 422 1237	35	42	G1/8	38	7 7.5 9
6 20 40	SK350	150	276		341 1131 2266					14 20 30
10	SK210 SK350	180	283 276	156	393	55	63	G1/2	60	13 19
20	SK210 SK350		283 276		788					19 22
50	SK210 SK350		283 276		1963					29 32
20	SK210 SK350	200	283 276		655					16 24
40	SK210 SK350		283 276		1290					20 28
100	SK210 SK350		283 276		3200					35 43
50	SK210 SK350	250	283 276	200	1092		85			31 38
80	SK210 SK350		283 276		1702					33 40
120	SK210 SK350		283 276		2517					35 42
120 150 200	SK350	310	276		1568 1968 2648					39 40 42
130	SK210 SK350	355	304 294	270	1313	64	110		77	89 89
180	SK210 SK350		304 294		1818					96 97
250	SK210 SK350		304 294		2526					106 105
100 200 400	SK350	540	294		435 875 1745					80 87 100

[1] not possible for these piston sizes
[2] others on request

5.3. PISTON ACCUMULATOR WITH ELECTRICAL LIMIT SWITCH





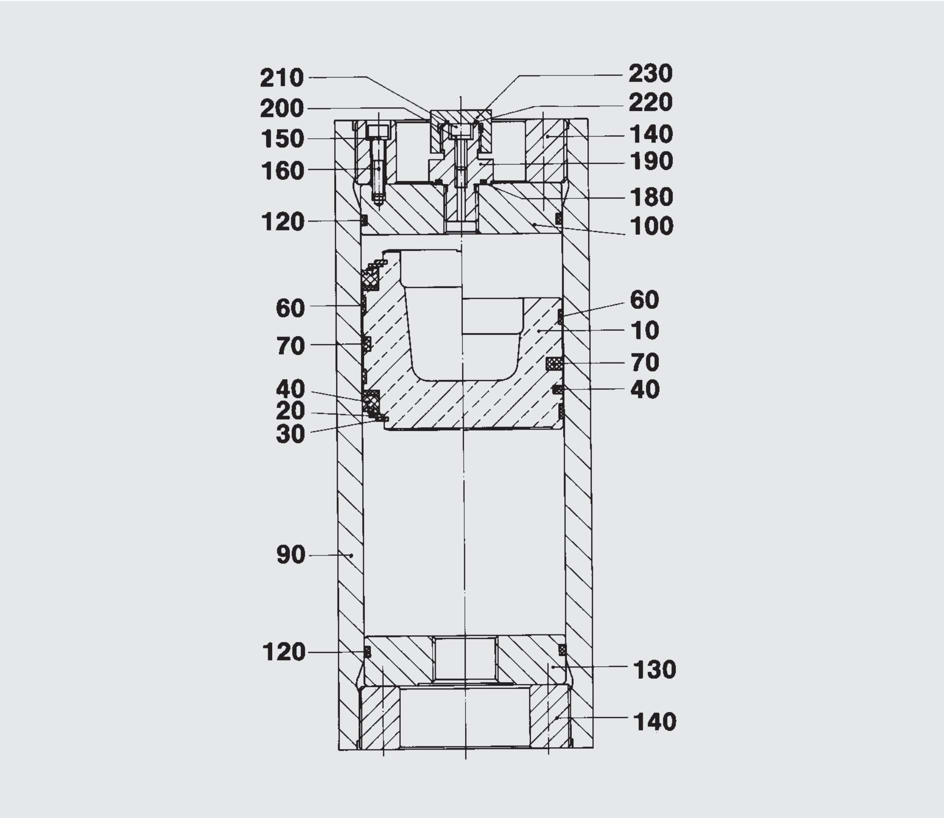
1m1 = motor
1c1 = motor protection
1e3 = control cut-out
Mö = solenoid switch – normally closed contact
Ms = solenoid switch – normally open contact

Nominal volume [2] [litres]	Series	ø D1 [mm]	N A [mm]	N B [mm]	N C [mm]	Additional weight A [kg]	Additional weight B [kg]	Additional weight C [kg]
0.2 0.5 1	SK350	60			–			
0.5 1 2	SK350	80			–	2	4.3	–
2.5 5 7.5	SK 350	100						
2 5 15	SK350	125	209	439				
6 20 40	SK350	150			679			
10	SK210 SK350							
20	SK210 SK350	180						
50	SK210 SK350					4	6.3	8.7
20	SK210 SK350							
40	SK210 SK350	200	171	401	641			
100	SK210 SK350							
50	SK210 SK350							
80	SK210 SK350	250						
120	SK210 SK350		145	375	615	5	7.3	9.7
120 150 200	SK350	310						
130	SK210 SK350							
180	SK210 SK350	355						
250	SK210 SK350		103	333	573	7	9.3	11.7
100 200 400	SK350	540						

[2] others on request

6. SPARE PARTS

6.1. PISTON ACCUMULATOR



Complete piston (table 7)

Piston dia-meter [mm]	Type	NBR Part no.	FPM Part no.	PU Part no.
60	1	–	–	–
	2	–	–	–
	3	–	–	03009372
80	1	–	–	–
	2	00352225	02101559	–
	3	03016255	–	02119931
100	1	00236288	00236615	–
	2	00356847	00359860	–
	3	03016163	–	02115547
125	1	–	–	–
	2	03016232	03016253	–
	3	03016254	–	03016150
150	1	–	–	–
	2	03016228	03016229	–
	3	03016230	–	03016231
180	1	00291679	00291680	–
	2	00350244	00353976	–
	3	03016169	–	02121568
200	1	–	–	–
	2	03016214	03016215	–
	3	03016216	–	03016218
250	1	00292061	00292062	- -
	2	00353980	00353981	- -
	3	03009544	–	03016171
310	1	–	–	–
	2	03016195	03016197	–
	3	–	–	–
355	1	00290846	02101561	–
	2	00356382	00354079	–
	3	–	–	–
540	1	–	–	–
	2	03016174	03016175	–
	3	–	–	–

Complete seal kit (table 8)

Piston dia-meter [mm]	Type	NBR Part no.	FPM Part no.	PU Part no.
60	1	–	–	–
	2	–	–	–
	3	–	–	03016210
80	1	–	–	–
	2	02123890	02123891	–
	3	03016247	–	03013230
100	1	00298217	00298218	–
	2	00363268	00363269	–
	3	03010398	–	02123414
125	1	–	–	–
	2	03016212	03016234	–
	3	03016233	–	02128104
150	1	–	–	–
	2	03016235	03016237	–
	3	03016236	–	03016239
180	1	00298219	00298220	–
	2	00363270	00363271	–
	3	03010399	–	02123415
200	1	–	–	–
	2	03016240	03016242	–
	3	03016241	–	03016243
250	1	00298221	00298222	–
	2	00363266	00363267	–
	3	03010401	–	03016213
310	1	–	–	–
	2	03016200	03016201	–
	3	–	–	–
355	1	00298223	00367492	–
	2	00363272	00363273	–
	3	–	–	–
540	1	–	–	–
	2	03016176	03016178	–
	3	–	–	–

6.1.1 **Piston type 1**

Description	Qty.	Item
Complete piston consisting of:		
Piston	1	10
Support ring	2	20
Retaining ring	2	30
Packing seal	2	40
Guide ring *	2	60
Profile seal assembly	1	70
Complete seal kit consisting of:		
Packing seal	2	40
Guide ring *	2	60
Profile seal assembly	1	70
O-ring	2	120
O-ring	1	180
Seal ring	1	200
O-ring	1	220

6.1.2 **Piston type 2**

Complete piston consisting of:		
Piston	1	10
Seal ring	1	40
Guide ring	2	60
Middle ring	1	70
Complete seal kit consisting of:		
Seal ring	1	40
Guide ring	2	60
Middle ring	1	70
O-ring	2	120
O-ring	1	180
Seal ring	1	200
O-ring	1	220

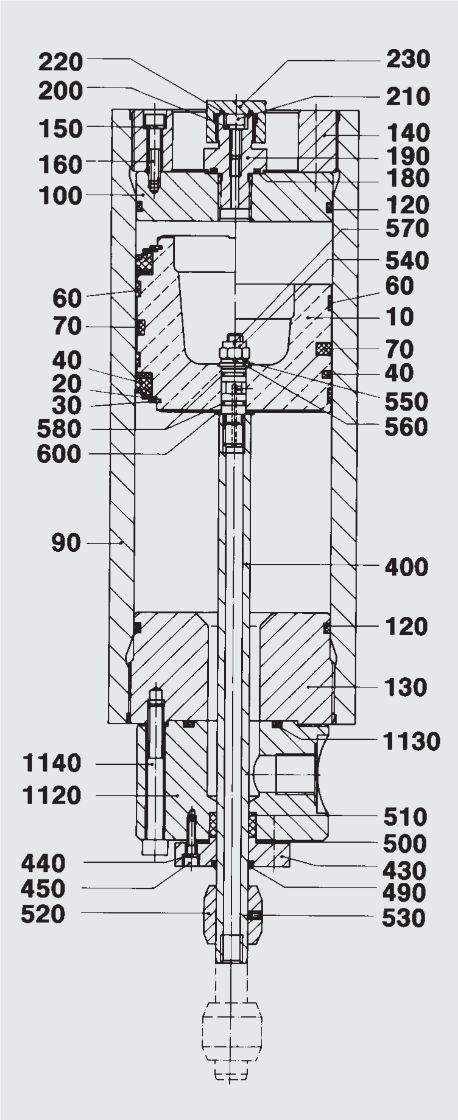
Pressure resistant parts cannot be supplied as spares.

* not present on piston diameter 80 mm.

6.1.3 **Piston type 3**

Complete piston consisting of:		
Piston	1	10
Seal ring	1	40
Guide seal	1	60
Complete seal kit consisting of:		
Seal ring	1	40
Guide ring	1	60
O-ring	2	120
O-ring	1	180
Seal ring	1	200
O-ring	1	220

6.2. PISTON ACCUMULATOR WITH PROTRUDING ROD



Complete piston (table 9)

Piston diameter (mm)	Type	NBR Part no.	Viton Part no.
100	1	02100483	03016261
	2	02116964	03016262
125	1	–	–
	2	03016263	03016264
150	1	–	–
	2	03016265	03016266
180	1	00291687	00291688
	2	00354292	00354293
200	1	–	–
	2	03016267	03016268
250	1	00292069	00292070
	2	00356204	00356205

Supplementary seal kit (table 10)

Piston diameter (mm)	Type	NBR Part no.	Viton Part no.
100	1+2	02101354	02101355
125	2	03016270	03016271
150	2	03016272	03016273
180	1+2	02101356	02101357
200	2	03016274	03016275
250	1+2	02101050	02101358

6.2.1 **Piston type 1**

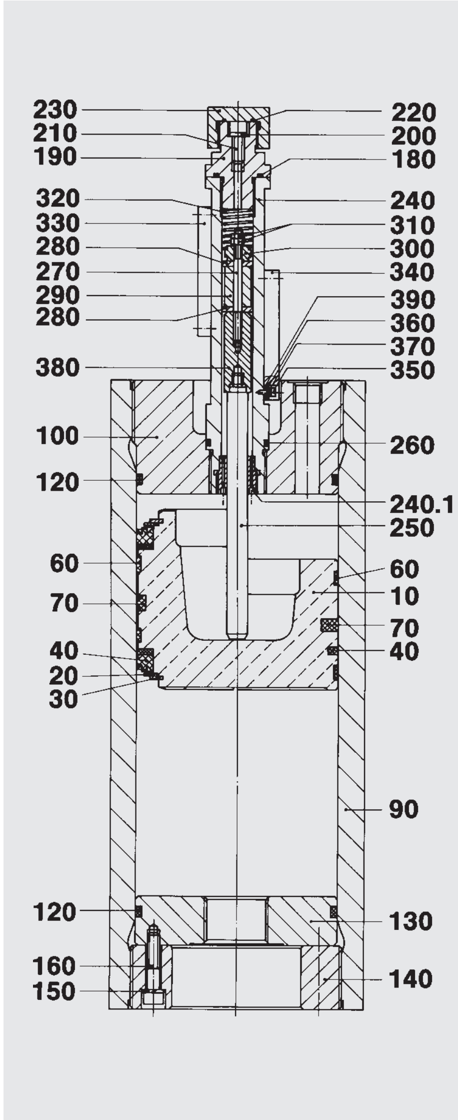
Description	Qty.	Item
Complete piston consisting of:		
Piston	1	10
Support ring	2	20
Retaining ring	2	30
Packing seal	2	40
Guide ring	2	60
Profile seal kit	1	70
Supplementary seal kit consisting of:		
Skimmer	1	490
Rubber packing seal kit	1	510
O-ring	2	580
O-ring	1	1130

6.2.2 **Piston type 2**

Description	Qty.	Item
Complete piston consisting of:		
Piston	1	10
Seal ring	2	40
Guide ring	2	60
Centre seal	2	70
Supplementary seal kit consisting of:		
Skimmer	1	490
Rubber packing seal kit	1	510
O-ring	2	580
O-ring	1	1130

Pressure resistant parts cannot be supplied as spares.

6.3. PISTON ACCUMULATOR WITH ELECTRICAL LIMIT SWITCH



6.3.1 **Piston type 1, 2 and 3**

Description	Qty.	Item
Complete piston see table 7		
Seal kit see table 8		
Supplementary seal:		
O-ring	1	260

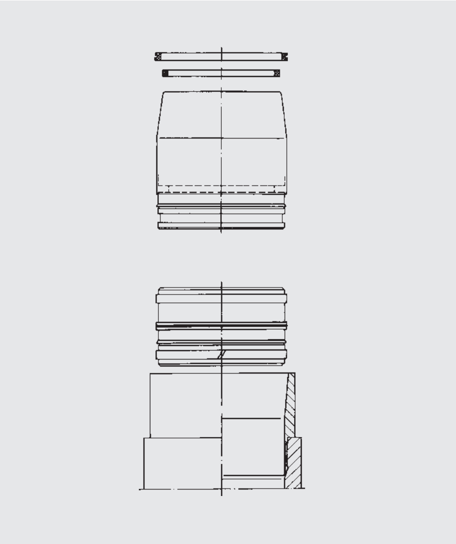
Supplementary seal (table 11)

Piston diameter (mm)	Type	NBR Part no.	Viton Part no.
all diameters	1	00601078	00601109
	2		
	3		

6.4. ASSEMBLY RECOMMENDATION

Before assembling or dismantling an accumulator or accumulator system, the system must always be de-pressurized.

The gas and fluid side must be de-pressurized and the gas valve unscrewed or opened before the accumulator is dismantled.
Before the end caps are removed, ensure that the piston is moving freely. This may be achieved by using a rod. Only authorised personnel should repair piston accumulators with locked pistons, as there may be a risk of injury due to stray components.



Assembly sleeves for piston accumulators (table 12)

Piston Ø	to fit the seals type 1	type 2	type 3
60	–	00297430	02107565
80	–	00244991	02104701
100	–	00352198	03016277
125	–	00370734	03016278
150	–	02124157	03016279
180	00243016	00350148	03016280
200	–	03016276	03016281
250	00290035	00290035	03016282
310	–	02127304	–
355	00290984	00354147	–
540	–	–	–

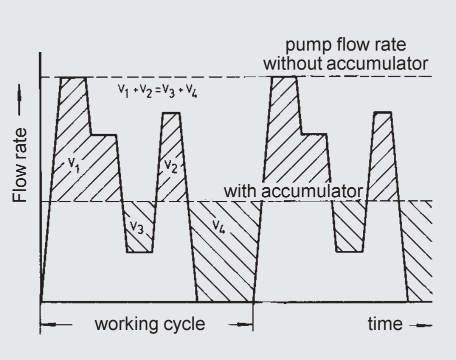
Piston Ø	to mount the piston
60	02120188
80	00359614
100	00290056 (M105x2) 02117672 (M110x3)
125	02128223
150	02124161
180	00290049 (M186x3) 02122356 (M190x4)
200	03016284
250	00290046
310	02127305
355	00290985
540	00291449

7. APPLICATIONS

7.1. TYPICAL APPLICATIONS

7.1.1 Energy storage

In systems with widely differing oil requirements or long cycles the only economical solution is to use a hydro-pneumatic accumulator.
During low oil consumption the accumulator is charged.
If requirements exceed the pump flow rate, the appropriate amount will be drawn from the accumulator.

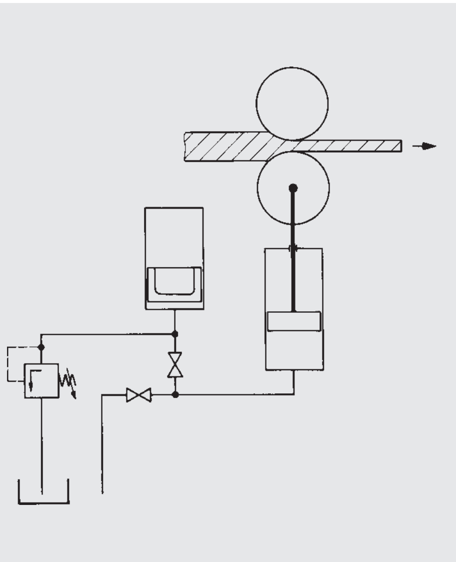


The use of smaller oil pumps, drive motors and oil tanks results in less power being required, less heat being generated, installation and maintenance being simplified, and purchasing and running costs being reduced.

7.1.2 Force equilibrium

The backing rollers used in rolling machines are hydraulically pre-stressed in order to stabilise the pre-set roller clearance. The pressure necessary for this is maintained at a constant level by accumulators. HYDAC piston accumulators therefore take the place of cumbersome counter balances.

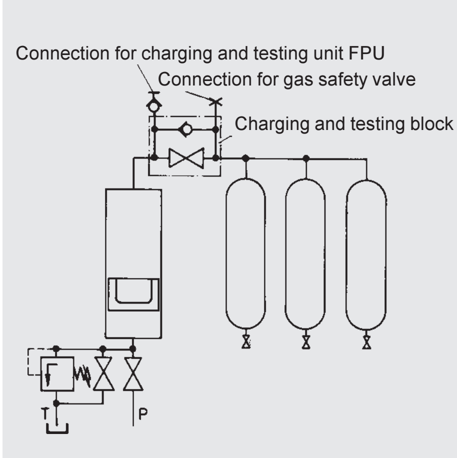
Advantage:
Inertia-free counterbalancing response, lower base load required, space saving, gentle shock-absorbing, simple operation and servicing.



7.1.3 Pressure increase

With the aid of a HYDAC nitrogen charging unit and piston accumulators, together with a charging and test block, it is possible to use the system to increase the pressure

(see brochure no. E 2.201).



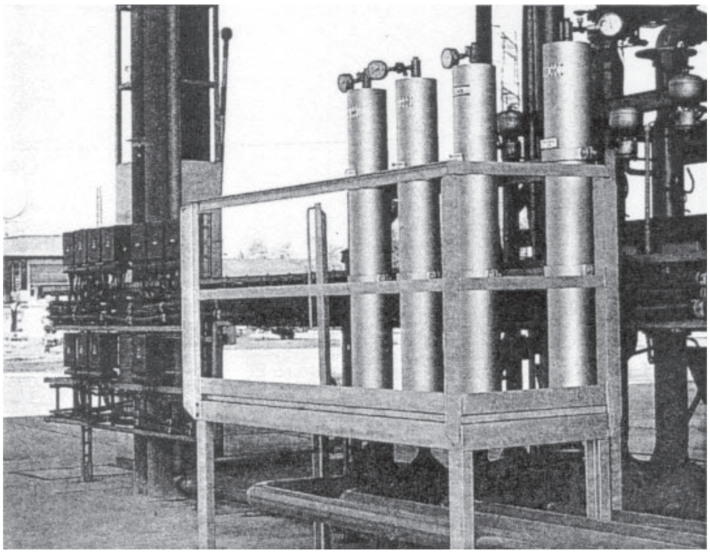
As commercial nitrogen bottles are usually only supplied with a maximum pressure of approximately 200 bar, which is often insufficient to achieve the necessary pre-charge pressure, the piston accumulator station, with the aid of the pump unit and the charging and testing block, is used to increase pressure.

The procedure for achieving greater pressure is as follows:

- Nitrogen is transferrred to the station from the commercial nitrogen bottle via the charging and test unit with the shut-off valve of the charging and test block closed.
- Once pressure compensation has taken place, the gas in the accumulator is compressed by the hydraulics in the system and is released back into the nitrogen bottles via the check valve.
- Then oil is discharged and gas is released from the nitrogen bottles.
- This process is repeated until the required pre-charge pressure p_0 is reached. The piston must be in its starting position and the shut-off valve open to check the pre-charge pressure.
- Before commissioning the station, the shut-off valve on the charging and test block must be opened.

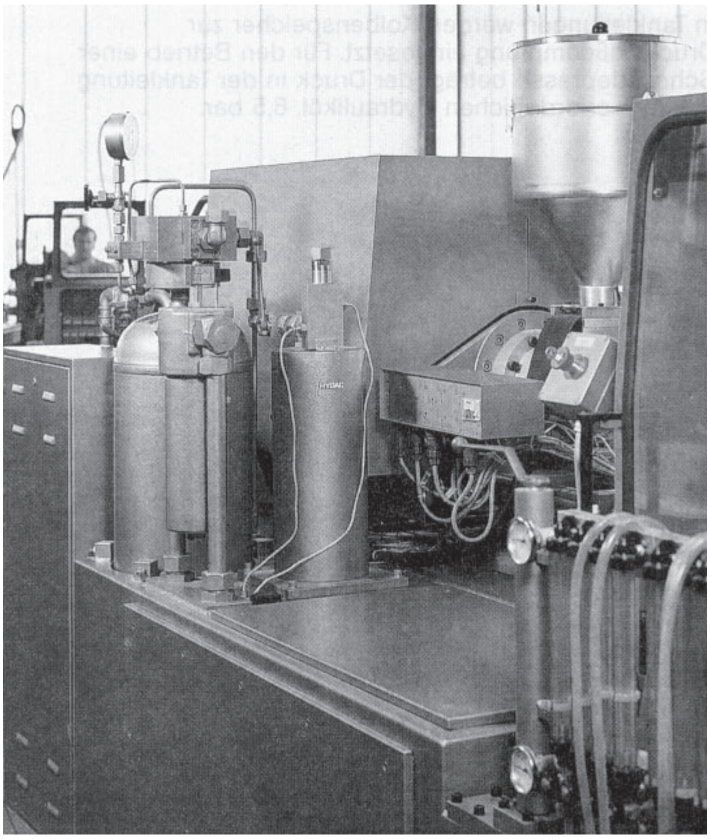
7.2. APPLICATIONS EXAMPLES

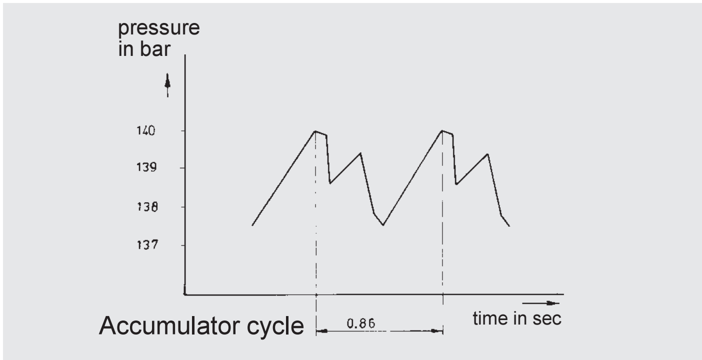
On **fuel loading installations** pressure peaks occur in the fuel lines, caused by the rapid closing (emergency shut-off) of valves and the associated reflection of the pressure wave. The use of piston accumulators dampens these pressure peaks and prevents damage to the valves.



High speed injection moulding machine

Short cycles and low pressure differentials are typical for this high speed injection moulding machine.

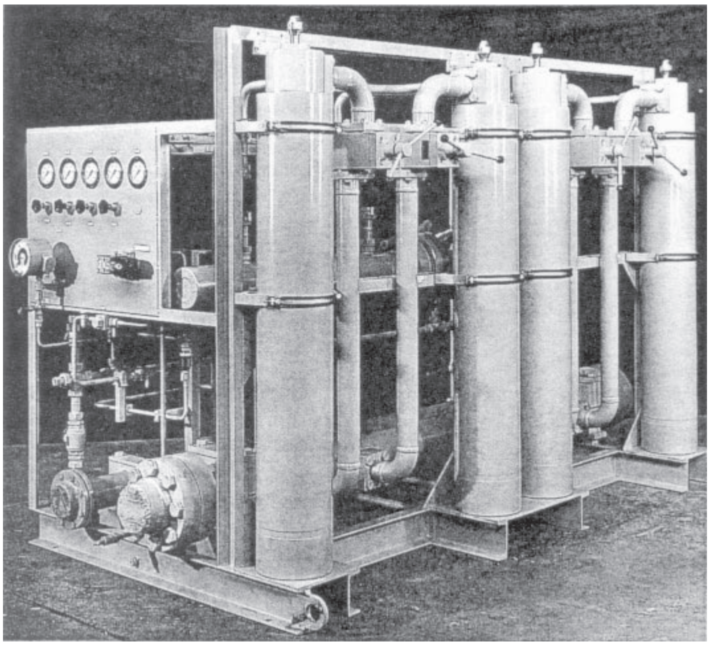




HYDAC piston accumulators of the back-up type, with easy glide, low-friction seals, are required for handling the high flow rates during the injection process.

This reduces the power requirement to a fraction of that required by machines without accumulators. The pump start-up time is kept to a minimum by the electrical limit switch.

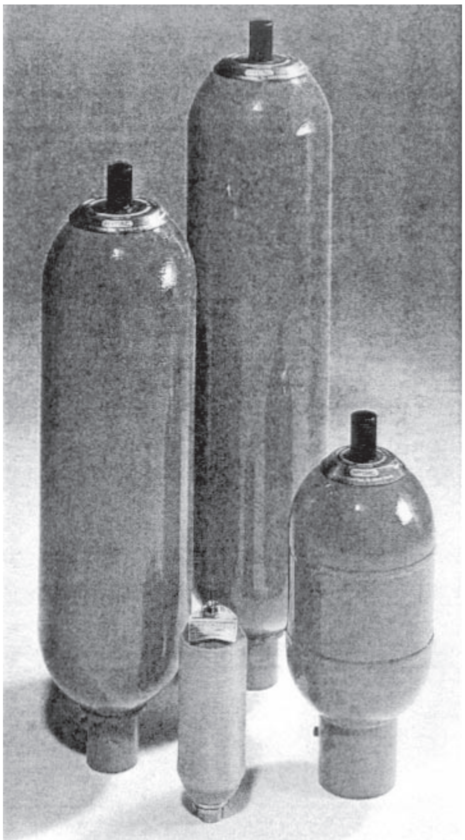
The smooth operation of the HYDAC piston accumulator improves the quality and dimensional accuracy of the injection moulded product.



Piston accumulator stations

HYDAC supply complete accumulator stations, ready for operation, including all necessary valves, ball valves and safety devices – both single accumulators and back-up versions with nitrogen bottles to increase the effective volume.

8. ACCUMULATOR RANGE



Hydraulic Bladder Accumulators

Nominal volume: 0.5 - 450 litres
Pressure range: 35 - 550 bar
Special models up to 1000 bar

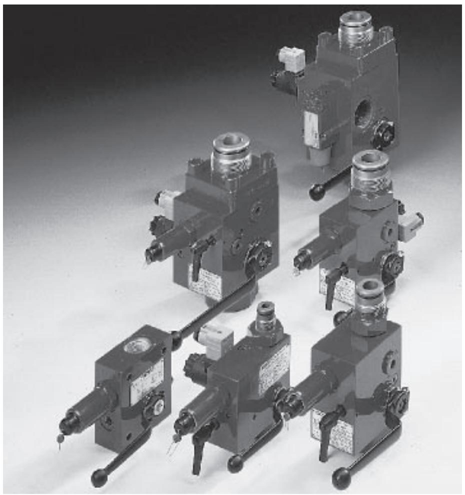
Hydraulic Dampers

Pulsation damper
Suction flow stabiliser
Shock absorber
Silencer – fluid silencer

Hydraulic Diaphragm Accumulators

Nominal volume: 0.075 - 4 litres
Pressure range: 50 - 750 bar

9. ACCESSORIES



Safety and Shut-off Block

With mechanical, electrical or pneumatic pressure relief and connection for test gauge.

Charging and Testing Unit

With charging hose and gauge, protective case is optional, pressure release valve or gas pressure valve available on request.

Mobile and Portable Nitrogen Charging Unit

HYDAC nitrogen charging units facilitate fast and cost-effective filling or topping up of the required gas pre-charge pressure in bladder, diaphragm and piston accumulators.
They guarantee optimum use of commercially available nitrogen bottles up to a residual pressure of 20 bar and a maximum accumulator pressure of 350 bar.

10. ACCUMULATOR SET

Supports for Hydraulic Accumulators

Hydac supports are used to mount all types of hydraulic accumulator, safely and simply, irrespective of mounting position. Clamps, consoles and complete accumulator sets are available.

PLEASE NOTE

All details in this brochure are subject to technical modifications.