HYDAC INTERNATIONAL

Hydraulic Dampers

1. DESCRIPTION

1.1. GENERAL

The pressure fluctations occurring in hydraulic systems can be periodical or one-off problems due to:

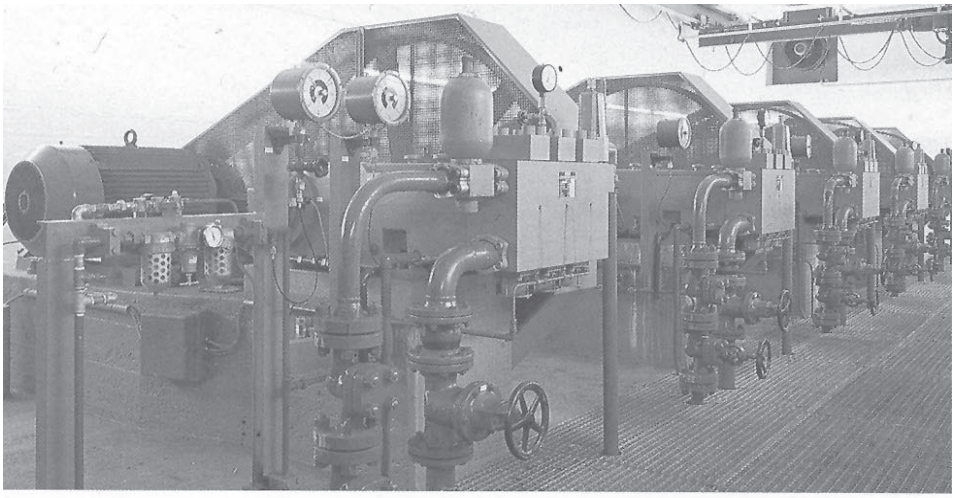
– flow rate fluctuations from displacement pumps
– actuation of shut-off and control valves with short opening and closing times
– switching pumps on and off
– sudden linking of spaces with different pressure levels

HYDAC hydraulic dampers are particularly suitable for damping such pressure fluctuations.

Selecting the most suitable hydraulic damper for each system ensures that

– vibrations caused by pipes, valves, couplings etc. are minimised and resulting pipe and valve damage is prevented
– measuring instruments are protected and their performance is no longer impaired
– the noise level in hydraulic systems is reduced
– the performance of machine tools is improved
– interconnection of several pumps in one line is possible
– a pump rpm and feed pressure increase is possible
– the maintenance and servicing costs can be reduced
– the service life of a system is increased

1.2. APPLICATION EXAMPLES



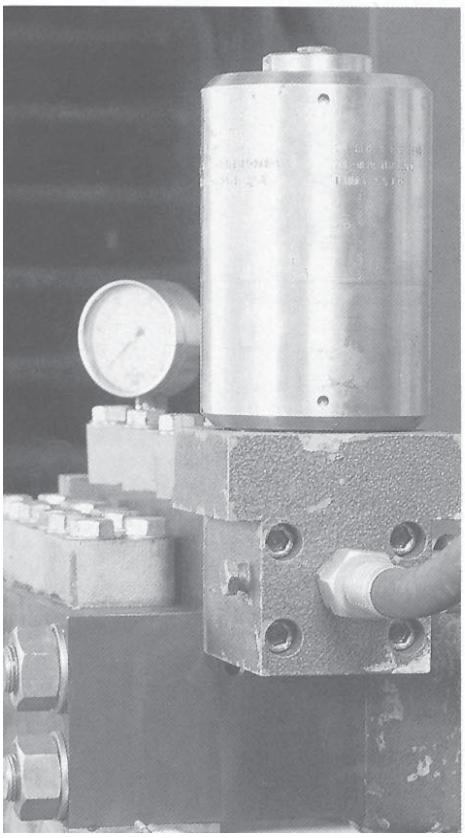


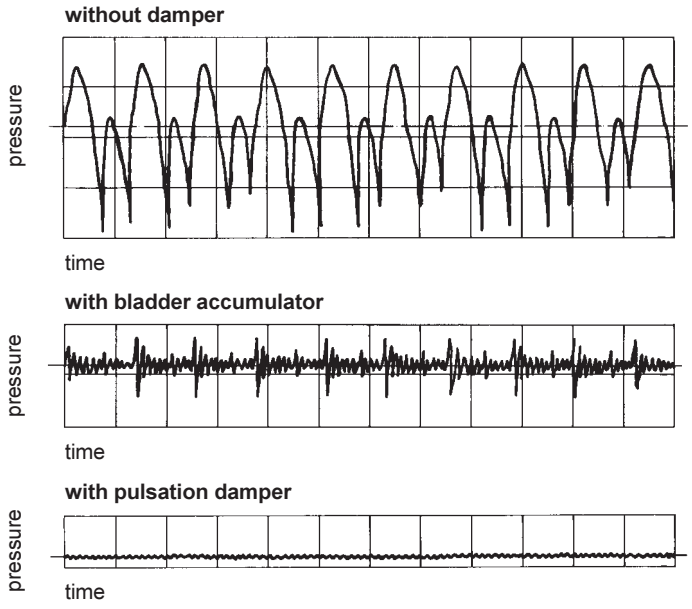
figure 1
HYDAC pulsation damper for reducing the pressure pulsations of 3 piston pumps, used in the pressure water supply station of a pickling plant.

figure 2
Refuelling plants for ships are usually miles from the pump stations. The kinetic energy of the fluid caused by a rapid shut-off is absorbed by the HYDAC shock absorber, avoiding an excessive pressure build-up and eliminating pressure surges.

figure 3
HYDAC high pressure pulsation damper for reducing the pressure pulsations of an 800 bar pump, used to clean a paint plant with water under high pressure.

2. TYPES OF CONSTRUCTION

2.1. PULSATION DAMPER TYPE SB ... P



GENERAL

The HYDAC pulsation damper

– prevents pipe breaks caused by material fatigue, pipe oscillations and irregular flow rates;
– protects valves, control devices and other instruments;
– improves noise level damping.

APPLICATIONS

The pulsation damper is particularly suited for: hydraulic systems, displacement pumps of all types, sensitive measurement and control instruments and manifolds in process circuits in the chemical industry.

MODE OF OPERATION

The pulsation damper has two fluid connections and can therefore be fitted directly inline.
The volume flow is directed straight at the bladder or diaphragm by diverting it in the fluid valve. This causes direct contact of the volume flow with the bladder or diaphragm which, in an almost inertialess operation, balances the flow rate fluctuations via the gas volume. It particularly compensates for higher frequency pressure oscillations. The pre-charge pressure is adjusted to individual operating conditions.

CONSTRUCTION

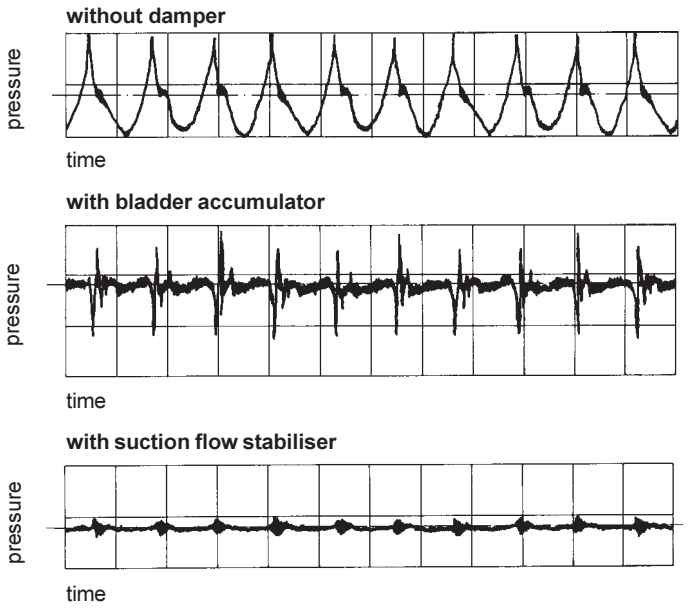
The HYDAC pulsation damper consists of:

– the welded or forged pressure vessel in carbon steel; for chemically aggressive fluids with internal coating or in stainless steel;
– the special fluid valve with inline connection, which guides the flow into the vessel (threaded or flange connection);
– the bladder or diaphragm in various compounds as shown under point 4.1.

INSTALLATION

As close as possible to the pulsation source. Mounting position preferably vertical (gas valve pointing upwards).

2.2. HYDAC SUCTION FLOW STABILISER TYPE SB ... S



GENERAL

The HYDAC suction flow stabiliser

– improves the NPSH value of the system;
– avoids cavitation of the pump;
– prevents pipe oscillations.

APPLICATIONS

Main application areas are piston and diaphragm pumps in public utility plants, reactor construction and the chemical industry.

MODE OF OPERATION

Trouble-free pump operation is only possible if no cavitation occurs in the pump suction and pipe oscillations are avoided. A relatively high fluid volume in the suction flow stabiliser in relation to the displacement volume of the pump reduces the acceleration effects of the fluid column in the suction line. Also, an air separation is achieved due to the extremely low flow rate in the suction flow stabiliser and the deflection on a baffle. By adjusting the charging pressure of the bladder to the operating conditions, the best possible pulsation damping is achieved.

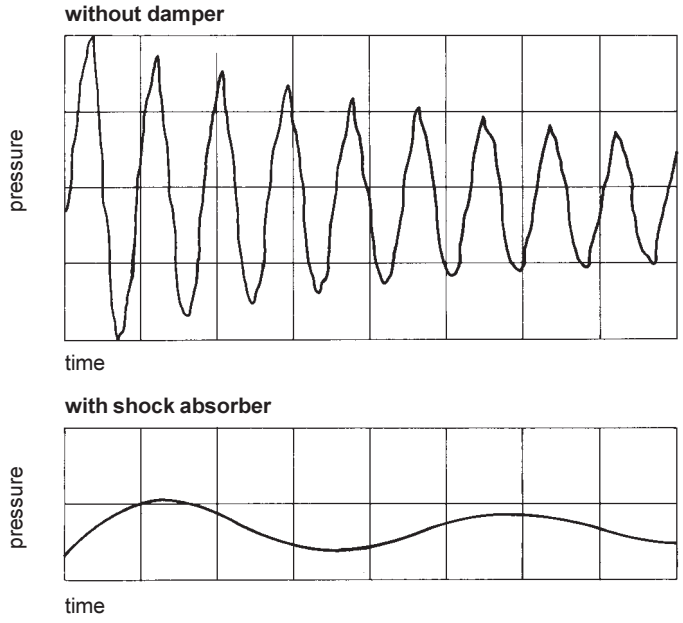
CONSTRUCTION

The HYDAC suction flow stabiliser consists of a welded vessel; inlet and outlet are on opposite sides and are separated by a baffle. The upper part houses the encapsulated bladder. In addition, there is a vent screw in the cover plate and a drainage facility on the bottom.

INSTALLATION

As close as possible to the suction inlet of the pump. Mounting position vertical (gas valve pointing upwards).

2.3. HYDAC SHOCK ABSORBER TYPE SB ... A



GENERAL

The HYDAC shock absorber

– reduces pressure surges;
– protects pipe lines and valves from destruction.

APPLICATIONS

The accumulators are particularly suited for use in pipe lines with quick-acting valves or flaps and during switching on and switching off of pumps.
They are also suitable for energy storage in low pressure applications.

MODE OF OPERATION

Sudden changes in the stationary conditions in pipe lines with a fluid flow, such as those caused by pump failure or the closing or opening of valves, can cause pressures which are many times higher than the stationary values.
The shock absorber prevents this by converting potential into kinetic energy and vice versa.
This prevents pressure surges and protects pipe lines, valves, control instruments and other devices from destruction.

CONSTRUCTION

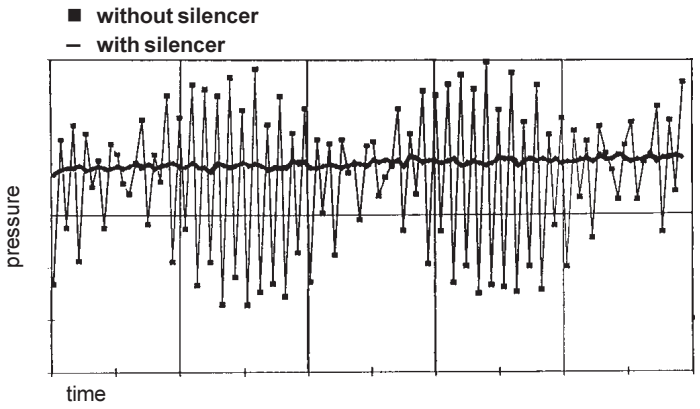
The HYDAC shock absorber consists of:

– the welded pressure vessel in carbon steel with or without corrosion protection or in stainless steel;
– the connection with perforated disc which prevents the flexible bladder from extruding from the vessel, and the flange;
– the bladder in various compounds as shown under point 4.1. with built-in gas valve, which is used for charging pressure p_0 and for possible monitoring activities.

INSTALLATION

As close as possible to the source of the non-stationary condition. Mounting position vertical (gas valve pointing upwards).

2.4. HYDAC SILENCER FLUID SILENCER TYPE SD ...



GENERAL

All displacement pumps such as axial and radial piston pumps, vane, gear or screw pumps produce volume and pressure fluctuations which show up as vibrations and noises. Noises are not only produced and transmitted by the pump but they are also the result of mechanical vibrations and vibrations caused by the fluid pulsations, which are amplified when transmitted to larger areas. Insulation, the use of flexible hoses and silencer covers can only provide partial solutions to the problem as they do not prevent transmission to other areas.

APPLICATIONS

Vehicles, machine tools, plastics machinery, aeroplanes, ships, hydraulic power stations and other systems with a large "surface" are all applications where the noise level can be reduced.

MODE OF OPERATION

The HYDAC FLUID SILENCER is based on the principle of an expansion chamber with interference line. By reflection of the oscillations within the silencer the majority of the oscillations is damped across a wide frequency spectrum.

CONSTRUCTION

The HYDAC FLUID SILENCER consists of a welded or forged external housing, an internal tube and two pipe connections on opposite sides. The silencer has no moving parts and no gas charge and is therefore absolutely maintenance free. The HYDAC FLUID SILENCER can be used for mineral oils, phosphate ester and water glycol. A stainless steel model is available for other fluids.

INSTALLATION

It is recommended that one connection side is joined via a flexible hose in order to reduce the transmission of mechanical vibrations. The mounting position of the damper is optional, whereby the flow direction has to be taken into account.

2.5. RECOMMENDATIONS

2.5.1 General

On no account must any welding, soldering or mechanical work be carried out on the accumulator shell. After the hydraulic line has been connected it must be completely vented. Work on systems with hydraulic dampers (repairs, connecting pressure gauges etc) must only be carried out once the pressure and fluid have been released.

Please observe operating instructions!

2.5.2 Extract from the approval specifications Federal Republic of Germany

As pressure vessels, hydraulic dampers are subject to the (German) Pressure Vessel Regulations (DruckbehV). The design, manufacture and testing is in accordance with AD notices. Installation, equipment and operation are controlled by the "Technical Regulations - Pressure Vessels (TRB)". The pressure vessels of hydraulic dampers 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 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 2.5.4.

The following tests are prescribed for each group:

Group	Tests before commissioning at manufacturer´s	at user´s	Recurrent testing
II p > 25 bar and p × l ≤ 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 × l > 200 and p × l ≤ 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 × l > 1000	As for group III	As for group III	Internal test: every 10 years for non-corrosive fluids, otherwise every 5 years. Every 10 years, tests to be carried out by authorities.

2.5.3 Other countries

Hydraulic dampers which are installed in other countries are supplied with the test certificates required in that country. The user country must be stated when ordering. The German certificate is not generally accepted in all countries.

HYDAC pressure vessels can be supplied with virtually any test certificate.

The permissible operating 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
CIS	A6
China	A9
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	A1
Netherlands	C
New Zealand	T
Norway	A1
Poland	A4
Portugal	A1
Rep. of Ireland	A1
Romania	K
Slovakia	A8
Spain	A2
South Africa	A1
Sweden	R
Switzerland	G
USA	S
others on request	

2.5.4 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 ≤ 1 l, a maximum permissible pressure PS ≤ 1000 bar and a pressure capacity PS x V ≤ 50 bar x l do not receive a CE mark. Operational safety and repeat testing are controlled as before by national laws.

3. SIZING

3.1. GENERAL

Definition of variables

The compression and expansion processes are governed by the laws of polytropic change in state of ideal gases

$p \times V^n = \text{constant}$

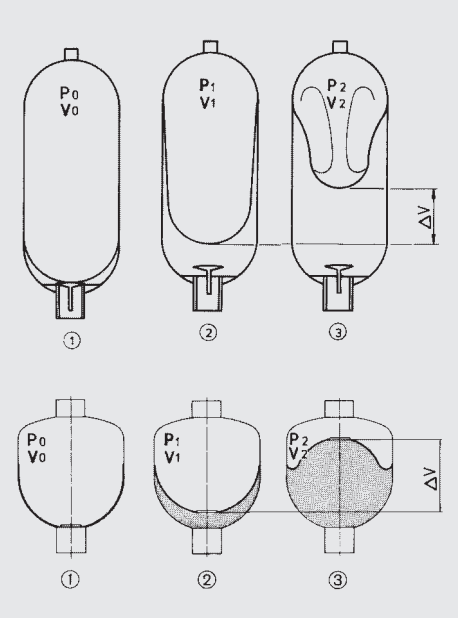
where time is taken into account by the polytropic power "n" (ratio of specific heats c_p/c_v).

$p_0 \times V_0^n = p_1 \times V_1^n = p_2 \times V_2^n$

Slow expansion or compression processes occur almost **isothermally,** the polytropic power can be set at n = 1.
For **rapid** processes the **adiabatic** change in state n = 1.4 (for nitrogen as a diatomic gas) applies.

With the aid of the following formulae the required gas volume V_0 can be calculated for various applications. In the formulae pressures always have to be used as absolute values.

p_0 = gas pre-charge pressure
p_1 = minimum working pressure
p_2 = maximum 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_{max} = max. working temperature



① The bladder (diaphragm) is pre-charged with nitrogen. The fluid valve is closed and stops the bladder (diaphragm) extruding from the shell.

② When the minimum working pressure is reached, there should be a small amount of fluid between bladder (diaphragm) and check valve (approx. 10 % of the nominal accumulator volume) so that the bladder (diaphragm) does not hit the valve every time it expands, as this could cause damage.

③ Accumulator at maximum working pressure. The volume change between the minimum and maximum working pressure corresponds to the effective fluid volume:

$\Delta V = V_1 - V_2$

Selection of gas pre-charge pressures

The selection of and adherence to the gas pre-charge pressure has a considerable influence on the performance of the damper and the life expectancy of the bladder/ diaphragm.

Recommended values

Depending on the individual application, the following gas pre-charge pressure is set at maximum working temperature:

– for pulsation damping:

$p_{0,\,t_{max}}$ = 0.6 ÷ 0.8 x p_m
(p_m = pump pressure)

Examples:

$p_{0,\,t_{max}}$ = 0.6 x p_m for 1 piston pump
= 0.7 x p_m for 3 or more piston pumps
= 0.8 x p_1 for working pressure range

– for suction flow stabilisation:

$p_{0,\,t_{max}}$ = 0.6 ÷ 0.7 x p_m

– for shock absorption:

$p_{0,\,t_{max}}$ = 0.9 x p_m
(p_m = working pressure)

Critical values

– Hydraulic dampers with bladder

$p_{0,\,t_{max}} \leq 0.9 \times p_1$
with a permissible pressure ratio of

$p_2/p_0 \leq 4 : 1$

– For shock absorber:

p_{0max} = 10 bar

– Hydraulic damper with diaphragm

$p_{0,t_{max}} \leq 0.9 \times p_1$
with a permissible pressure ratio of

$p_2/p_0 \leq 8 : 1$ (welded construction) or

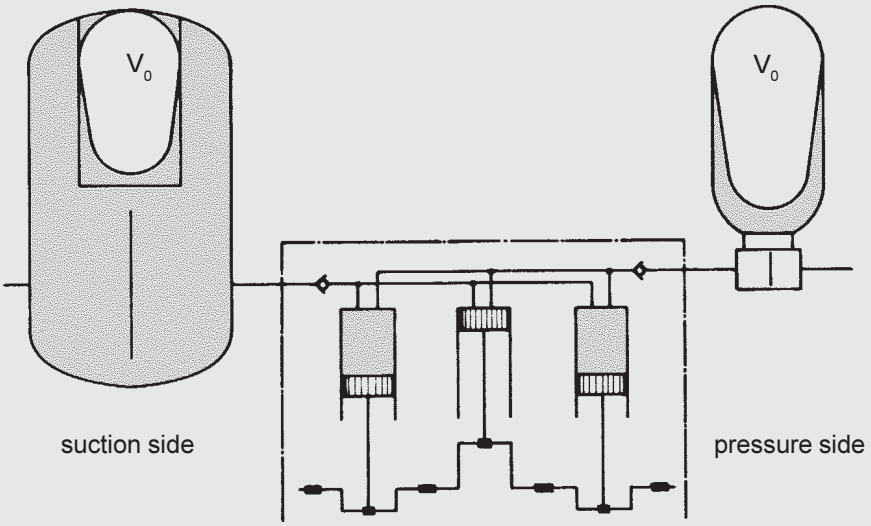
$p_2/p_0 \leq 10 : 1$ (threaded construction)

Temperature effect

In order that the recommended gas pre-charge pressures are being maintained even at relatively high working temperatures, p_0 for charging and testing cold accumulators should be selected as follows:

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

3.2. PULSATION DAMPER AND SUCTION FLOW STABILISER



On the suction and pressure side of piston pumps almost identical conditions regarding non uniformity of the flow rate occur. Therefore the same formulae for determining the effective gas volume are used for calculating the damper size. That in the end two totally different damper types are used is due to the different acceleration and pressure ratios on the two sides.

Not only is the gas volume V_0 a decisive factor but also the connection size of the pump has to be taken into account when selecting the pulsation damper. In order to avoid additional cross section changes which represent reflection points for vibrations, and also to keep pressure drops to a reasonable level, the connection cross section of the damper has to be the same as the pipe line.

The gas volume V_0 of the damper is determined with the aid of the formula for adiabatic changes of state.

A simulation of the pressure performance can be carried out by means of a computer programme for real pipe line conditions.

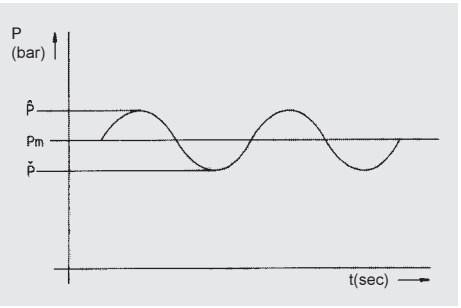
Formulae:

$$V_0\ (l) = \frac{\Delta V}{0.695 \times \left[1 - \left(\frac{100}{100+x}\right)^{0.714}\right]}$$

$$X\ (\pm\%) = \frac{100}{\left(1 - \frac{\Delta V}{0.695 \times V_0}\right)^{1.4}} - 100$$

$$\Delta V\ (l) = \delta \times q$$

$$X\ (\pm\%) = \frac{\hat{p} - p_m}{p_m} \times 100 = \frac{\check{p} - p_m}{p_m} \times 100$$



V_0 = required gas volume
ΔV = fluctuating fluid volume
q (l) = stroke volume per cylinder
$\check{p} - p_m$ = $\hat{p} - p_m$ = amplitude of pressure fluctuations
X = residual pulsation
$\hat{p}$ = max. working pressure
$\check{p}$ = min. working pressure
p_m = pump flow rate or pressure in the suction line

Types of pump	z	δ
Gear pump	7-14	0.1 - 0.3
Piston pump	1-11	0.01 - 0.6
e.g.	1	0.6
	2	0.25
	4	0.12
	3	0.13
	5	0.05
	6	0.13
	7	0.02
	9	0.01

δ = Coefficient of cyclic variation of the pump

z = No. of compressions / effective cylinders per revolution

δ factors for other types, i.e. gear, axial and radial piston pumps on request.

Calculation example:

Parameters:

Single acting 3-plunger pump

piston diameter	60 mm
piston stroke	80 mm
rpm	370 min^{-1}
flow rate	244 l/min.
operating temp.	20 °C
operating pressure	
(pressure side)	250 bar
(suction side)	4 bar

Required:

Suction flow stabiliser for a residual pulsation of ± 2.5 %

Pulsation damper for a residual pulsation of ± 0.5 %

Solution:

a) Determination of required suction flow stabiliser

$$V_0 = \frac{\Delta V}{0.695 \times \left[1 - \left(\frac{100}{100+x}\right)^{0.714}\right]}$$

$$V_0 = \frac{0.13 \times \frac{0.6^2 \times \pi}{4} \times 0.8}{0.695 \times \left[1 - \left(\frac{100}{100+2.5}\right)^{0.714}\right]}$$

$V_0 = 2.42$ l

Selected: SB 16 S-25
(see table point 4.3.)

b) Determination of required pulsation damper

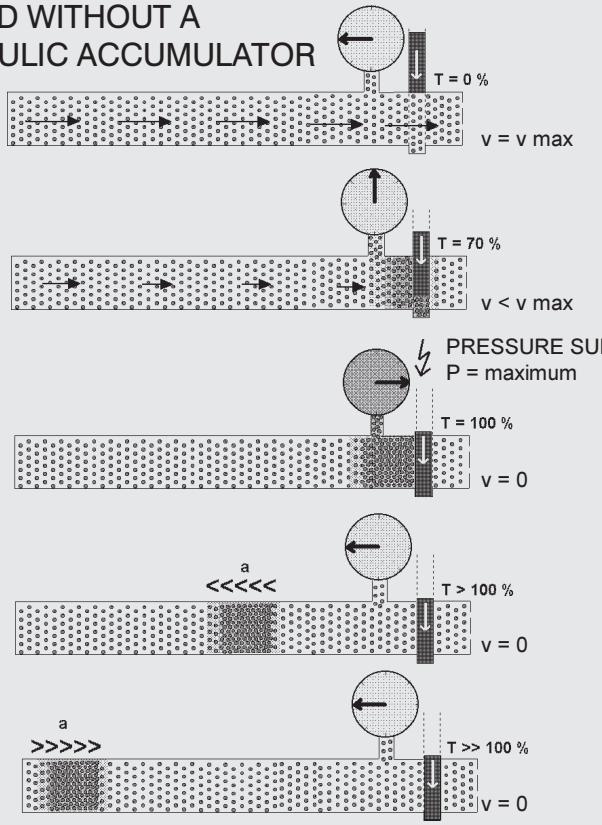
$$V_0 = \frac{\Delta V}{0.695 \times \left[1 - \left(\frac{100}{100+x}\right)^{0.714}\right]}$$

$$V_0 = \frac{0.13 \times \frac{0.6^2 \times \pi}{4} \times 0.8}{0.695 \times \left[1 - \left(\frac{100}{100+0.5}\right)^{0.714}\right]}$$

$V_0 = 11.9$ l

Selected: SB 330 P-20

3.3. PRESSURE SURGE PRODUCED WHEN A VALVE IS CLOSED WITHOUT A HYDRAULIC ACCUMULATOR



Simplified pressure surge calculation for the closing of a valve.

Estimate of Joukowsky's max. occurring pressure surge

Δp (N/m²) = ρ x a x Δv
Δv = v - v_1
ρ (kg/m³) = fluid density
Δv = changes of the fluid speed
v (m/sec) = speed of the fluid before the change in the stationary condition
v_1 (m/sec) = speed of the fluid after the change in the stationary condition
a (m/sec) = velocity of the pressure wave propagation

$$a\ (m/sec) = \frac{1}{\sqrt{\rho \times \left(\frac{1}{K} + \frac{D}{E \times e}\right)}}$$

K (N/m²) = compression modulus of the fluid
E (N/m²) = modulus of elasticity of the pipe line
D (mm) = internal diameter of pipe line
e (mm) = wall thickness of pipe line

The pressure wave runs to the other end of the pipe line and will reach the valve again after time t (reflection time), whereby:

$$t\ (sec) = \frac{2 \times L}{a}$$

L (m) = length of the pipe line
T (sec) = effective operating time (closing) of the valve

If T < t:
$p_{max} = p_1 + \Delta p$
If T > t:

$$p_{max} = p_1 + \rho \text{ x a x } \Delta v \text{ x } \frac{t}{T}$$

Determination of required damper size

The accumulator must absorb the kinetic energy of the fluid by converting it into potential energy within the pre-determined pressure range. The change of state of the gas is adiabatic in this case.

$$V_0\ (l) = \frac{m \times v^2 \times 0.4}{2 \times p_1 \times \left[\left(\frac{p_2}{p_1}\right)^{0.286} - 1\right] \times 10^2} \times \left(\frac{p_1}{p_0}\right)^{0.714}$$

m (kg) = weight of fluid in the pipe line
v (m/sec) = speed of fluid
p_1 (bar) = zero feed height of pump
p_2 (bar) = permissible working pressure
p_0 (bar) = pre-charge pressure

A special calculation programme to analyse the pressure curve is available for sizing during pump failure or start-up and for manifolds.

Calculation example

Quick closing of a shut-off valve in a re-fuelling line.

Parameters:

Length of pipe line L:
2000 m

NW of pipe line D:
250 mm

Wall thickness of pipe line e:
6.3 mm

Material of pipe line:
steel

Flow rate Q:
432 m³/hr = 0.12 m³/sec

Density of medium ρ:
980 kg/m³

Zero feed height of pump p_1:
6 bar

Min. operating pressure p_{min}:
4 bar

Effective closing time of valve T:
1.5 sec
(approx. 20 % of the total closing time)

Operating temperature:
20 °C

Compression modulus of the fluid K:
1.62×10^9 N/m²

Elasticity modulus (steel) E:
2.04×10^{11} N/m²

Required:

Size of required shock absorber, when the max. pressure (p_2) must not exceed 10 bar.

Solution:

Determination of reflection time:

$$a = \frac{1}{\sqrt{\rho \times \left(\frac{1}{K} + \frac{D}{E \times e}\right)}}$$

$$a = \frac{1}{\sqrt{980 \times \left(\frac{1}{1.62 \times 10^{9}} + \frac{250}{2.04 \times 10^{11} \times 6.3}\right)}}$$

$$a = 1120 \text{ m/s}$$

$$t = \frac{2 \times L}{a} = \frac{2 \times 2000}{1120} = 3.575 \text{ s} *$$

* since T < t the max. pressure surge occurs and the formula as shown under 3.3. must be used

$$v = \frac{Q}{A}$$

$$v = \frac{0.12}{0.25^2 \times \pi / 4} = 2.45 \text{ m/s}$$

$$\Delta p = \rho \times a \times \Delta v$$

$$\Delta p = 980 \times 1120 \times (2.45\text{-}0) \times 10^{-5}$$

$$= 26.89 \text{ bar}$$

$$p_{max} = p_1 + \Delta p$$

$$p_{max} = 6 + 26.89 = 32.89 \text{ bar}$$

Determination of the required gas volume:

$$p_0 \leq 0.9 \times p_{min}$$

$$p_0 \leq 0.9 \times 5 = 4.5 \text{ bar}$$

$$V_0 = \frac{m \times v^2 \times 0.4}{2 \times p_1 \times \left[\left(\frac{p_2}{p_1}\right)^{0.286} - 1\right] \times 10^2} \times \left(\frac{p_1}{p_0}\right)^{0.714}$$

where $m = v \times \rho = \frac{\pi}{4} \times D^2 \times L \times \rho$

and $v = Q / A = \frac{4 \times Q}{\pi \times D^2}$

this results in

$$V_0 = \frac{980 \times \frac{0.25^2 \times \pi}{4} \times 2000 \times 2.45^2 \times 0.4}{2 \times 7 \times \left[\left(\frac{11}{7}\right)^{0.286} - 1\right] \times 10^2} \times \left(\frac{7}{4.5}\right)^{0.714}$$

$$V_0 = 1641 \text{ l}$$

Selected:

4 off shock absorbers SB 35 A - 450.

A simulation of the pressure performance for existing pipe line systems can be carried out with the aid of a computer programme.

3.4. SILENCER

The sizing calculation of the HYDAC FLUID SILENCER is designed to result in a small unit with the best possible damping. The starting point for the selection table is to determine the level of transmission damping from 20 dB upwards.

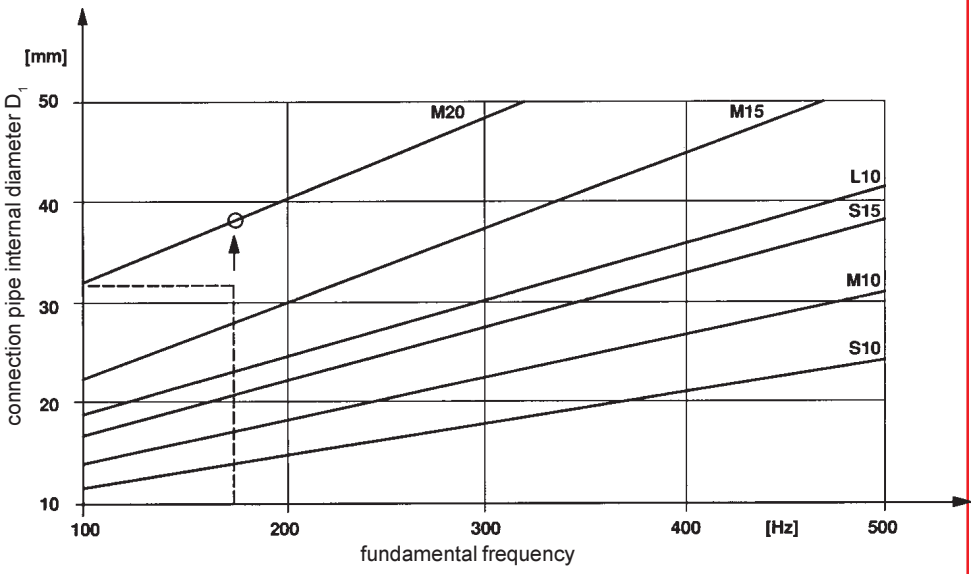
For the selection of the damper the following has to be taken into account:

1) the connection diameter di.

   The connection diameter di affects the damping effect and determines the silencer size.

2) the fundamental frequency f of the pump

   The fundamental frequency can be calculated as follows:
   f = i x n / 60 in Hz
   i = number of displacement elements
   n = minimum rpm in min^{-1}



Calculation example:

Parameters:

Axial piston pump with 7 pistons
rpm 1500 min^{-1}
connection SAE 1 ¼ - 6000 psi
corresponds to di = 32 mm
flow rate 300 l/min
max operating pressure 210 bar

Solution:

1) Fundamental frequency f
   f = i x n / 60 in Hz
   = 7 x 1500/60
   = 175 Hz

2) From the selection table the following model can be selected for connection, fundamental frequency and maximum operating pressure:
   SD 330 M 20 / 012 A-330 FK/FK

4. TECHNICAL SPECIFICATIONS

4.1. MODEL CODE

PULSATION DAMPER, SUCTION FLOW STABILISER, SHOCK ABSORBER
(also order example)

SB 330 P – 10 A 1 / 112 A – 330 AI

Series
SB = with bladder
SBO = with diaphragm

Type
A = shock absorber
P = pulsation damper
PH = high flow pulsation damper
S = suction flow stabiliser

Nominal volume in l

Fluid connection
A = threaded connection
E = threaded connection for welded construction (diaphragm accumulators only)
F = flange
(full details required)

Type code
1 = standard model (not for threaded construction)
2 = back-up model[1)]
6 = standard model for threaded construction diaphragm accumulators of the type SBO…P-.A6

Material code[2)]
Standard model = 112 for mineral oils
depending on operating medium

Fluid connection
0 = plastic (internal coating)[1)]
1 = carbon steel
2 = stainless steel 1.4021
3 = stainless steel 1.4571
4 = chemically nickel-plated (internal coating)[1)]
6 = TT-steel (low temperature)

Accumulator shell
0 = plastic (internal coating)[1)]
1 = carbon steel
2 = chemically nickel-plated (internal coating)[1)]
4 = stainless steel 1.4571[1)]
6 = TT-steel (low temperature)

Accumulator bladder[3)]
2 = NBR (acrylonitrile butadiene)
3 = ECO (ethylene oxide epichlorohydrin)
4 = IIR (butyl)
5 = TT-NBR (low temperature)
6 = FPM (fluoro rubber)
7 = other

User country[2)]
A = Germany
for other countries see table on page 6

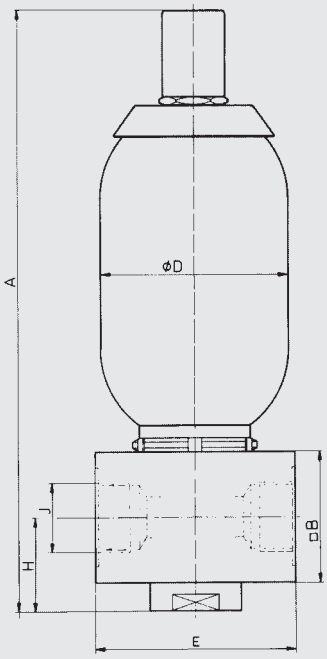
Permissible operating pressure (bar)

Connection thread to
AI = ISO 228 (BSP), standard connection
BI = DIN 13 to ISO 965/1 (metric)
CI = ANSI B1.1 (UNF thread, sealing to SAE standard)
DI = ANSI B1.20 (NPT thread)
for SBO 250 P - 0.075 E1 and for SBO 210 P - 0.16 E1:
AK = ISO 228 (BSP), standard connection

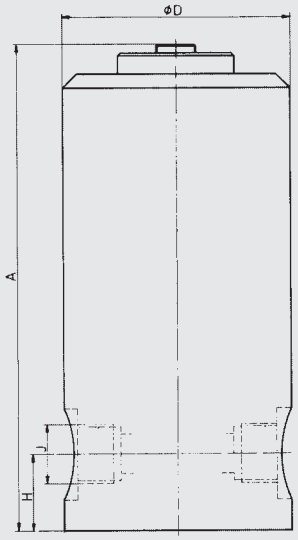
[1)] Not available for all models
[2)] Not all combinations are possible
[3)] When ordering spare bladders, please state smallest bladder connection port size at gas charging end

4.2. PULSATION DAMPER

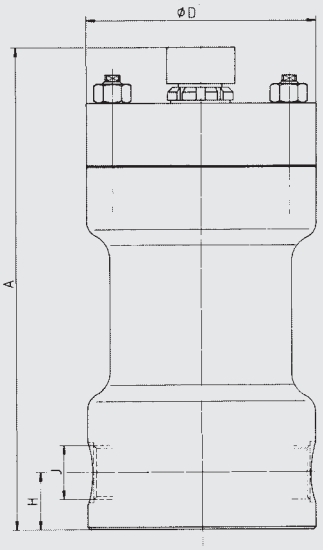
Series SB 330/550 P (PH)-…



SB 800 P-…



SB 1000 P-…

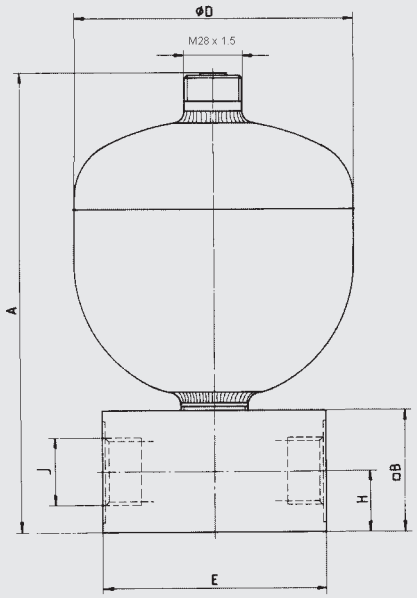


4.2.1 **Dimensions**

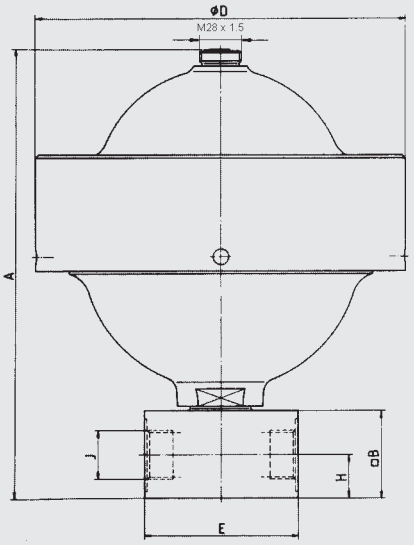
Nominal volume litres	Max. operating pressure (TRB/ AD regulations)	Effective gas vol. litres	Weight kg	A mm	□ B mm	Ø D mm	E mm	H mm	J [2] thread ISO 228	Series
1	330	1.0	11	365	80	118	120	57	G 1¼	SB330P
	550		13	384	70	121		53		SB550P
1.5	800	1.3	36	346	–	160	–	55		SB800P
	1000		94	414	–	215	–	49	[1]	SB1000P
2.5	330	2.4	16	570	80	118	120	57	G 1¼	SB330P
	550	2.5	20	589	70	121		53		SB550P
4	330	3.7	18	455	80	171		57		SB330P
			26	491	100			85	G 1½	SB330PH
10		9.3	40	620		222				SB330P
			50	652	130x140		150	100	SAE2"-6000 PSI	SB330PH
13	330	12.0	48	712	100	229		85	G 1½	SB330P
20		18.4	70	920						SB330P
			80	952	130x140			100	SAE2"-6000 PSI	SB330PH
24	330	23.6	82	986	100	229		85	G 1½	SB330P
32		33.9	100	1445						SB330P
			110	1475	130x140			100	SAE2"-6000 PSI	SB330PH

[1] M 56 x 4, high pressure connection DN 16; others on request
[2] Standard connection code = AI; others on request

Series SBO…P…E



SBO…P…A6

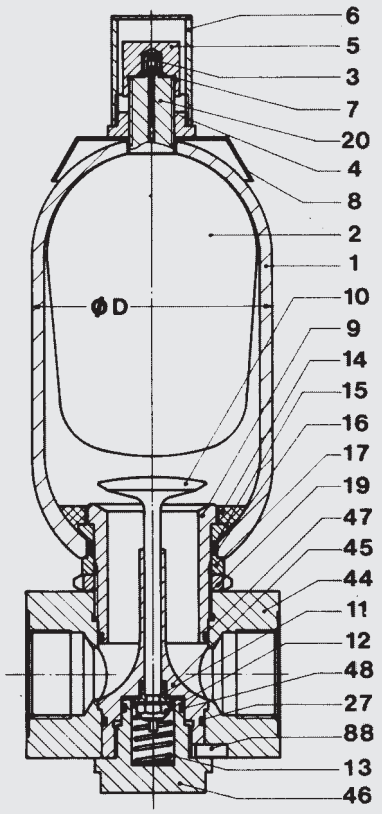


4.2.1 **Dimensions**

Nominal volume litres	Max. operating pressure * carbon steel	Max. operating pressure * stainless steel	Weight kg	A mm	□ B mm	Ø D mm	E mm	H mm	J [2] thread ISO 228	Series	
0.075	250	–	0.9	131	–	64	hex. 41	13	G ¼	SBO250P-...E1	welded construction
0.16	210	180	1.0	143	–	74				SBO210P-...E1	
0.32		160	2.6	175	50	93	80	25	G ½		
0.5		–	2.9	188		104					
0.6	330	–	5.9	222	60	115	105	30	G 1	SBO330P-...E1	
0.75	210	140	4.8	217		121				SBO210P-...E1	
1.0	200	–	6.2	231		136				SBO200P-...E1	
1.4	140	–	6.5	244		145				SBO140P-...E1	
	210	–	8.0	250		150				SBO210P-...E1	
	250	–	8.5	255		255				SBO250P-...E1	
2.0	100	100	6.6	261		160				SBO100P-...E1	
	210	–	9.2	267		167				SBO210P-...E1	
3.5	50	–	13.8	377						SBO50P-...E1	
	210	–								SBO210P-...E1	
0.25	500	350	4.5 (5.2)	162 (180)	50	115	80	25	G ½	SBO500P-...A6	threaded construction
0.6	330	250	8.9 (8.4)	202 (215)	60	140 (142)	95		G 1	SBO450P-...A6	
1.3	400	–	13.8	267		199	105	30		SBO400P-...A6	
2.0	250	180	15.6 (15)	285 (274)		201 (199)				SBO250P-...A6	
2.8	400	–	24.6	308		252				SBO400P-...A6	
4.0		–	36.6	325		287					

( ) brackets indicate different dimensions for stainless steel version
[2] standard connection code = AI; others on request
* (TRB / AD regulations)

Series SB...P



4.2.2 Spare parts SB...P

Description	Item
Gas valve insert *	3
Bladder, complete * consisting of:	
Bladder	2
Gas valve insert	3
Retaining nut	4
Cap nut	5
Valve protection cap	6
O-ring	7
Anti-extrusion ring *	14
Seal kit * consisting of:	
O-ring	7
Washer	15
O-ring	16
Support ring	23
O-ring	27
O-ring	47
O-ring	48

* recommended spares

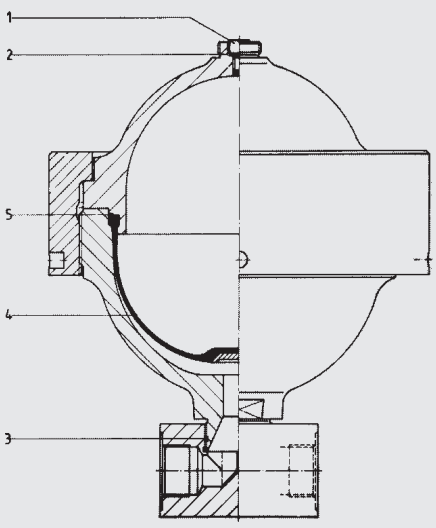
Description	Item
Connection, complete consisting of:	
Oil valve body	9
Valve plate	10
Damping sleeve	11
Safety nut	12
Spring	13
Anti-extrusion ring	14
Washer	15
O-ring	16
Spacer	17
Lock nut	19
Support ring (only for 330 bar)	23
O-ring	27
Connector	44
Guide piece	45
Cap	46
O-ring	47
O-ring	48
Locking key	88

O-ring dimensions (mm)

Nom. volume	Item 7	Item 16	Item 27	Item 47	Item 48
1 to 4 l	7.5 x 2	55 x 3.5 [2]	42.2 x 3 [2]	46 x 3 [2]	24.2 x 3 [2]
10 to 50 l and 40 l [1]	7.5 x 2	80 x 5 [2]	57.2 x 3 [2]	67.2 x 3 [2]	37.2 x 3 [2]
10 to 32 l [1]	7.5 x 2	100 x 5 [2]	64.5 x 3 [2]	89.5 x 3 [2]	44.2 x 3 [2]

[1] PH damper
[2] For code 663 and 665 different dimensions

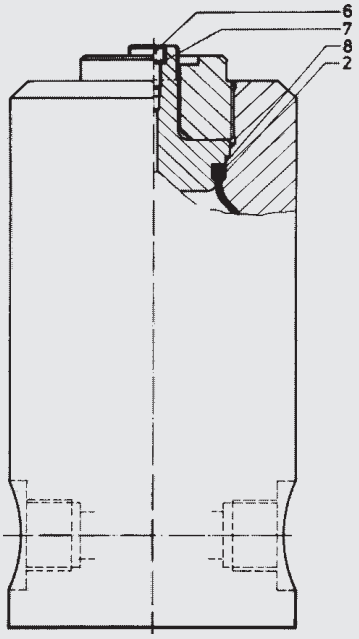
Series SBO...A6



Description	Item
Charging screw	1
Seal ring	2
Seal ring	3
Diaphragm [1]	4
Support and sealing section [1]	5

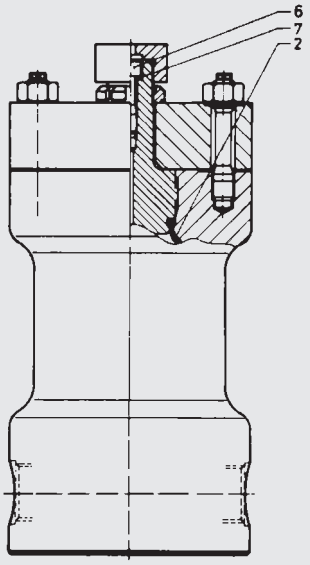
[1] only for threaded construction

SB 800 P



Description	Item
Bladder	2
Charging screw	6
Seal ring U 9.3 x 13.3 x 1	7
Support and sealing section	8

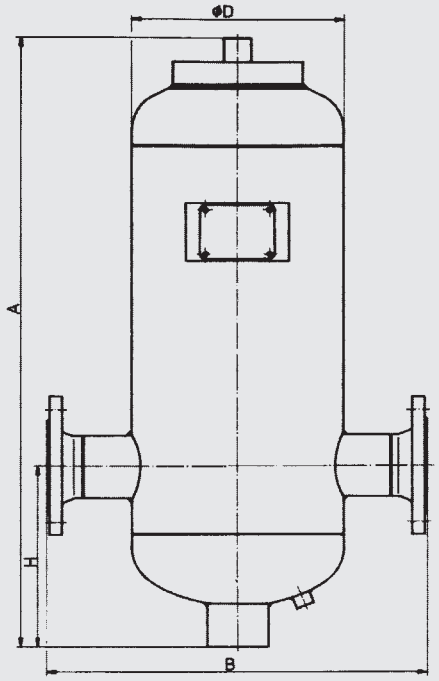
SB 1000 P



Description	Item
Bladder	2
Charging screw	6
Seal ring	7

4.3. SUCTION FLOW STABILISER

Series SB 16 S



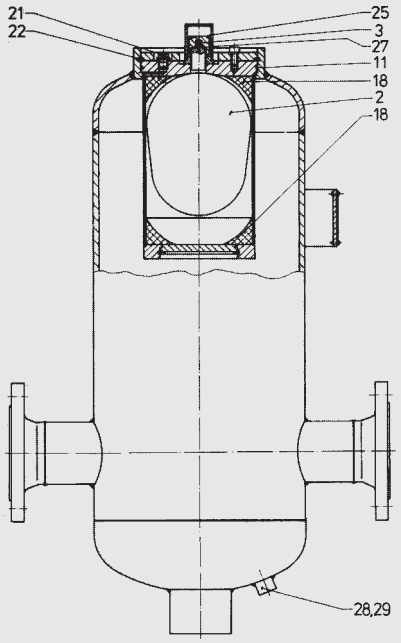
4.3.1 Dimensions

SB 16 S - permissible working pressure 16 bar (TRB/AD regulations)

Nom. volume litres	Fluid volume litres	Effective gas volume litres	Weight kg	A mm	B mm	Ø D mm	H mm	DN DIN 2633
12	12	1	40	580	425	219	220	65
25	25	2.5	60	1025	425	219	220	65
40	40	4	85	890	540	300	250	80
100	100	10	140	1150	650	406	350	100
400	400	35	380	2050	870	559	400	125

Further pressure ranges 25 bar, 40 bar; others on request
Other fluid volumes on request

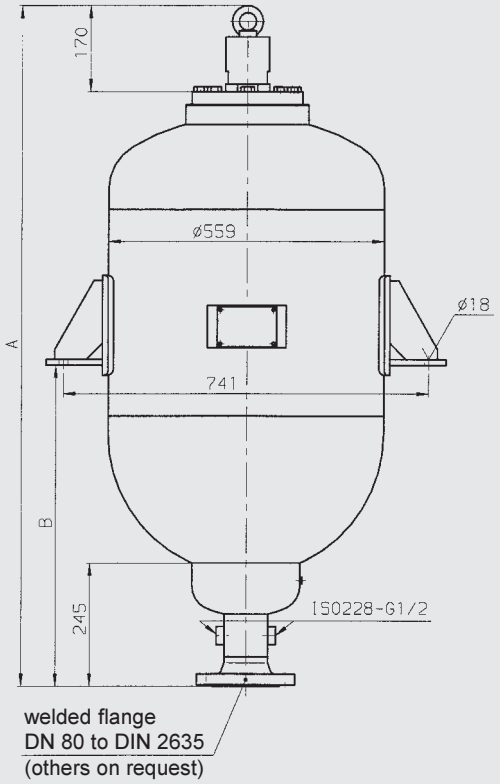
4.3.2 Spare parts



Description	Item
Bladder	2
Gas valve insert	3
O-ring	11
Insertion ring, 2 x	18
Lock nut	21
Retaining ring	22
Cap nut	25
O-ring	27
Seal ring	28
Lock nut	29

4.4. SHOCK ABSORBER

Series SB...A

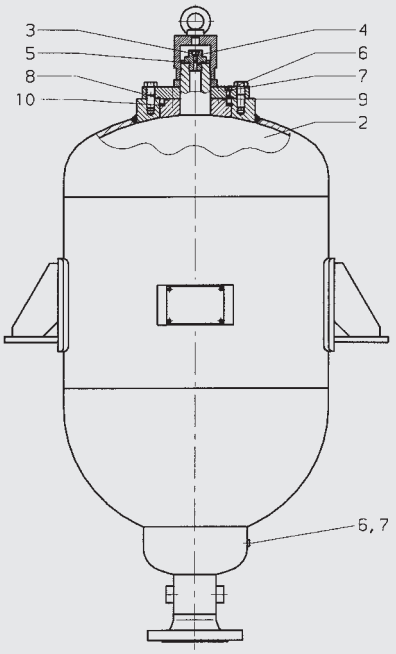


4.4.1 Dimensions

SB 35 A - permissible working pressure 35 bar (TRB / AD regulations)					
Nominal volume litres	Effective volume litres	Weight kg	A (approx.) mm	B (approx.) mm	DN [1] DIN 2635
100	104	144	1040	465	80
150	149	161	1240	565	
200	197	223	1500	850	
300	297	288	1950	1100	
375	370	326	2390	1350	
450	445	386	2785	1550	

[1] other nominal widths on request

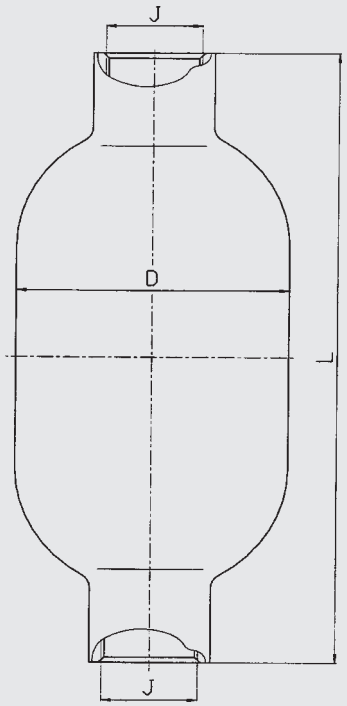
4.4.2 Spare parts



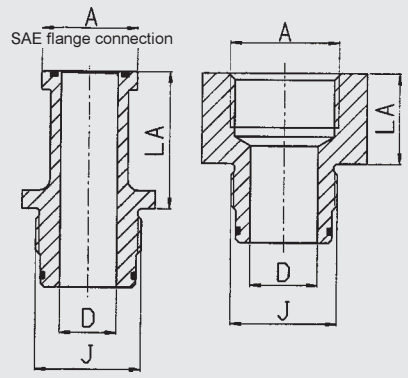
Description	Item
Bladder	2
Lock nut	3
Seal ring	4
O-ring	5
Vent screw	6
Seal ring	7
O-ring	8
O-ring	9
Retaining ring	10

4.5. SILENCER

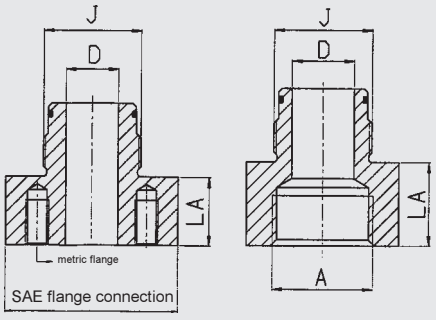
SD 330



1) Inlet



2) Outlet



4.5.1 Dimensions

Size	Length L mm	Diameter D mm	Weight kg	Connection J ISO 228
S 10	355	114	5.5	G 1 ¼"
M 10	575	114	9.6	G 1 ¼"
L 10	815	114	14	G 1 ¼"
S 15	420	168	11.4	G 2"
M 15	590	168	17.0	G 2"
M 20	605	222	60	G 2 ½"

4.5.2 Silencer model code

SD 330 – S15 / 012 A – 330 AE/AE

Silencer series

Size

Material code

Valve body (not applicable)

Vessel
1 = carbon steel
3 = carbon steel with coating*

Seals
2 = NBR (acrylonitrile butadiene)
6 = FPM (fluoro rubber)

User country
A = Germany
for other countries see table on page 6

Permissible operating pressure (bar)

Inlet connector/outlet connector
See table 4.5.3

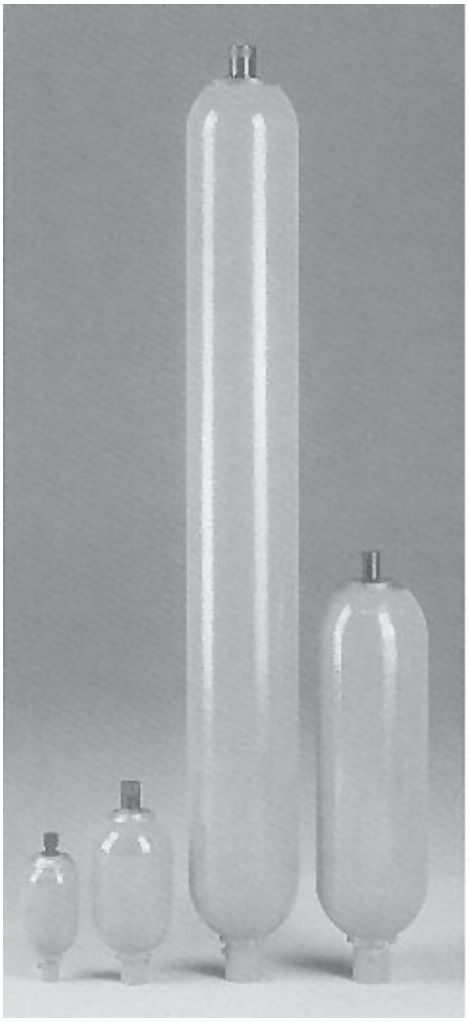
* only on request

4.5.3 Inlet connectors and outlet connectors with mounting part

			Connection J					
			G 1 ¼"		G 2"		G 2 ½"	
Fluid connection	A	D	Code	LA mm	Code	LA mm	Code	LA mm
BSP ISO 228	G ½"	13	AC	13/13	–	–	–	–
	G ¾"	16	AD	13/13	AD	16/16	–	–
	G 1"	19	AE	30/30	AE	16/16	AE	16/16
	G 1 ¼"	25	–	–	AF	16/16	AF	16/16
	G 1 ½"	32	–	–	AG	36/36	AG	16/16
Flange SAE 6000 psi	½"	13	FG	*	–	–	–	–
	¾"	19	FH	*	FH	105/36	–	–
	1"	25	FI	*	FI	120/36	FI	*
	1 ¼"	32	–	–	FK	76/28	FK	*
	1 ½"	38	–	–	FL	76/28	FL	150/52
	2"	50	–	–	–	–	FM	127/40

LA figure: inlet/outlet
* on request
- not available

5. ACCUMULATOR RANGE



Standard bladder accumulator

Model: SB...
Nominal volume: 0.5...50 l
Max. operating pressure: up to 550 bar

Low pressure accumulator

Model: SB 40...
Nominal volume: 2.5...200 l
Max. operating pressure: 40 bar

High-flow bladder accumulator

Model: SB...H...
Nominal volume: 10...50 l
Max. operating pressure: 35...330 bar
Max. flow rate: 30...140 l/sec

Bladder accumulator in composite construction

The combination of steel with external synthetic reinforcement reduces the weight of shells by half compared with conventional steel shells.

Bladder accumulator

Stainless steel
Model: SB...
Nominal volume: 2.5...450 l
Max. operating pressure: 35...1000 bar

Diaphragm accumulator

Welded construction
Model: SBO...-...E
Nominal volume: 0.075...3.5 l
Max. operating pressure: 50...330 bar

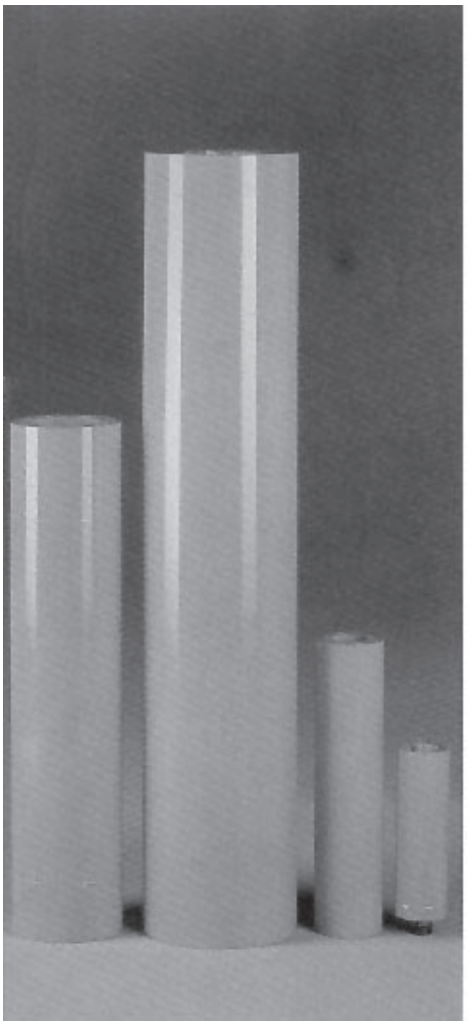
Diaphragm accumulator

Threaded construction
Model: SBO...-...A6
Nominal volume: 0.1...4 l
Max. operating pressure: 210...750 bar

Diaphragm accumulator

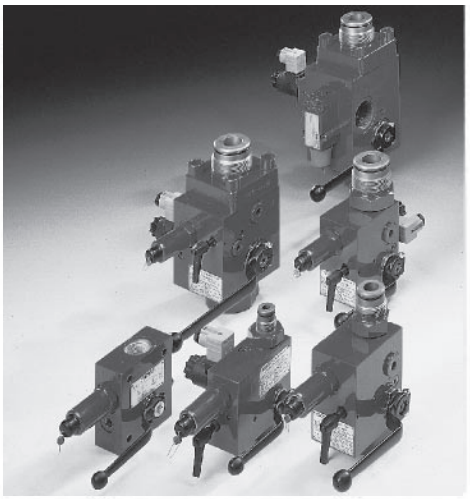
Stainless steel
Model: SBO...
Nominal volume: 0.16...2 l
Max. operating pressure: 100...600 bar

6. ACCUMULATOR ACCESSORIES



Piston accumulator

Model: SK...
Nominal volume: 0.2...1200 l
Max. operating pressure: 200...1000 bar



Safety and shut-off block

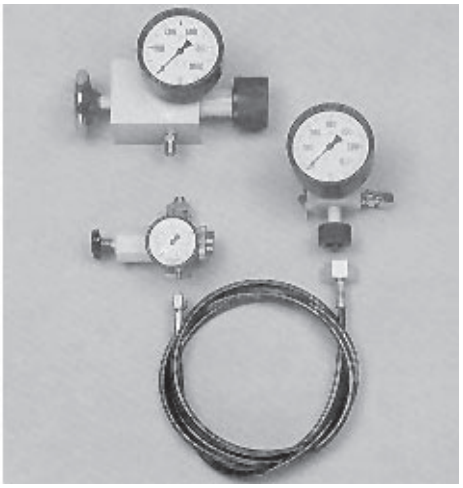
Model: SAF/DSV...M (E)...
Nominal size: 10, 20, 32
Max. operating pressure:
400 bar/350 bar (DSV)
Manually or solenoid operated pressure release valve.

Mounting elements

HyRac clamps and consoles for optimum mounting of hydraulic accumulators.

Accumulator set ACCUSET

Compact, ready-to-install unit, consisting of hydraulic accumulator, safety and shut-off block and accumulator set.



Charging and testing unit

For pre-charge pressures of up to 800 bar.

Charging and testing unit FPU-1

With charging hose, pressure gauge and gas pressure release valve for HYDAC accumulators and other makes of accumulator up to 350 bar pre-charge pressure.

Mobile and transportable nitrogen charging unit

For pre-charge pressures of up to 350 bar.

PLEASE NOTE

All details in this brochure are subject to technical modifications.