1. HYDRAULIC DAMPERS

1.1. DESCRIPTION

1.1.1 Mode of operation
The pressure fluctuations occurring in hydraulic systems can be cyclical 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 subsequent 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 the system is increased.

1.2. APPLICATION

1.2.1 Pulsation damping
TYPE SB...P / SBO...P

Mode of operation
The pulsation damper has two fluid connections and can therefore be fitted directly inline.

The flow is directed straight at the bladder or diaphragm by diverting it in the fluid valve. This causes direct contact of the fluid with the bladder or diaphragm which, in an almost inertialless 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 1.4.1.

Installation
As close as possible to the pulsation source. Mounting position preferably vertical (gas valve pointing upwards).
1.2.2 Suction flow stabiliser
Type SB...S

General
The HYDAC suction flow stabiliser
- improves the NPSH value of the system;
- prevents 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 prevented. 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 in steel or stainless steel.

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).

1.2.3 Shock absorber
Type SB...A

General
The HYDAC shock absorber
- reduces pressure shocks;
- protects pipelines and valves from being destroyed.

Applications
The accumulators are particularly suitable for use in pipelines with quick-acting valves or flaps and whilst pumps are being switched on and off. They are also suitable for energy storage in low pressure applications.

Mode of operation
Sudden changes in pipeline 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 normal values. The shock absorber prevents this by converting potential into kinetic energy and vice versa. This prevents pressure shocks and protects pipelines, 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 including perforated disc which prevents the flexible bladder from extruding from the vessel, and the flange;
- the bladder in various compounds as shown under point 1.4.1 with built-in gas valve, which is used for charging pressure \( p_0 \) and for possible monitoring activities.

Special model
Shock absorbers can also be in the form of diaphragm or piston accumulators. Available on request.

Installation
As close as possible to the source of the erratic condition. Mounting position vertical (gas valve pointing upwards).
1.3 SIZING
1.3.1 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 variations in cross-section which represent reflection points for vibrations, and also to keep pressure drops to a reasonable level, the connection cross-section of the damper must be the same as the pipeline.

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

By giving the residual pulsation or the gas volume, the damper size can be calculated with the aid of the HYDAC software ASP (Accumulator Simulation Program). The results can then be printed out or the data files can be stored in ASP format.

The ASP-program is available free of charge via our website www.hydac.com or via e-mail to speichertechnik@hydac.com.

Designations:
\[
\begin{align*}
\Delta V &= \text{fluctuating fluid volume [L]} \\
q &= \text{piston stroke volume [L]} \\
q &= \frac{\pi \cdot d_k^2 \cdot h_k}{4} \\
d_k &= \text{piston diameter [dm]} \\
h_k &= \text{piston stroke [dm]} \\
\delta &= \text{coefficient of cyclic variation of the pump} \\
z &= \text{no. of compressions / effective cylinders per revolution} \\
x &= \text{residual pulsation [± %]} \\
\kappa &= \text{isentropic exponent} \\
\Phi &= \text{pressure ratio of pre-charge pressure to operating pressure [0.6 ... 0.9]} \\
\Phi &= \frac{p_m}{p_m} \\
\Delta p &= \text{height of pressure fluctuations} \\
\Delta p &= p_2 - p_1 \text{[bar]}
\end{align*}
\]

Formulae:
\[
V_0 = \frac{\Delta V}{\Phi^{\frac{1-x}{100}}} - \frac{\Phi^{\frac{1+x}{100}}}{\Phi}
\]

\[
\Delta V = \delta \cdot q
\]

\[
x(±%) = \frac{|p_2 - p_m|}{p_m} \cdot 100
\]

\[
= \frac{|p_2 - p_m|}{p_m} \cdot 100
\]
Isentropic exponent $\kappa$ dependent on pressure and temperature:

<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>$\delta$-value</th>
<th>$\delta$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-80</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>-60</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>-40</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>-20</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>20</td>
<td>0.60</td>
<td>0.25</td>
</tr>
<tr>
<td>40</td>
<td>0.25</td>
<td>0.20</td>
</tr>
<tr>
<td>60</td>
<td>0.13</td>
<td>0.07</td>
</tr>
<tr>
<td>80</td>
<td>0.12</td>
<td>0.05</td>
</tr>
<tr>
<td>100</td>
<td>0.05</td>
<td>0.02</td>
</tr>
<tr>
<td>120</td>
<td>0.13</td>
<td>0.07</td>
</tr>
<tr>
<td>140</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>160</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>180</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Calculation example

**Parameters:**
- Single-acting 3-piston pump
- Piston diameter: 70 mm
- Piston stroke: 100 mm
- Rpm: 370 min⁻¹
- Flow rate: 244 l/min
- Operating temperature: 20 °C
- Operating pressure:
  - Pressure side: 200 bar
  - Suction side: 4 bar

**Required:**
- a) Suction flow stabiliser for a residual pulsation of ±2.5%
- b) Pulsation damper for a residual pulsation of ±0.5%

**Solution:**

a) Determining the required suction flow stabiliser

\[
V_0 = \frac{\Delta V}{\left(\frac{\Phi}{x}\right)^{\frac{1}{\kappa}} - \left(\frac{\Phi}{1+\frac{x}{100}}\right)^{\frac{1}{\kappa}}}
\]

\[
V_0 = 0.13 \cdot \frac{\pi \cdot 0.7^2 \cdot 0.05}{4 \cdot 100} \left(\frac{1}{1-\frac{2.5}{100}}\right)^{\frac{1}{14}} - \left(\frac{0.6}{1+\frac{2.5}{100}}\right)^{\frac{1}{14}}
\]

\[
V_0 = 2.0 \text{ l}
\]

**Selected:** SB16S-25

b) Determining the required pulsation damper

\[
V_0 = \frac{\Delta V}{\left(\frac{\Phi}{x}\right)^{\frac{1}{\kappa}} - \left(\frac{\Phi}{1+\frac{x}{100}}\right)^{\frac{1}{\kappa}}}
\]

\[
V_0 = 0.13 \cdot \frac{\pi \cdot 0.7^2 \cdot 0.05}{4 \cdot 100} \left(\frac{1}{1-\frac{2.5}{100}}\right)^{\frac{1}{14}} - \left(\frac{0.7}{1+\frac{0.5}{100}}\right)^{\frac{1}{14}}
\]

\[
V_0 = 11.9 \text{ l}
\]

**Selected:** SB330P-13
1.3.2 Shock absorber
Pressure shock produced when a valve is closed without a hydraulic accumulator

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.

\[
V_0 = \frac{m \cdot v^2 \cdot 0.4}{2 \cdot p_s \cdot \left[ \frac{p_2}{p_1} \right]^{\frac{1}{2}} - 1} \cdot 10^2
\]

- \(m\) (kg) = weight of fluid in the pipeline
- \(v\) (m/s) = speed of fluid
- \(p_1\) (bar) = zero feed height of the pump
- \(p_2\) (bar) = permitted operating pressure
- \(p_0\) (bar) = pre-charge pressure

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

Simplified pressure shock calculation for the closing of a valve

**Estimate of Joukowsky’s max. occurring pressure shock**

\[
\Delta p (N/m^2) = \rho \cdot a \cdot \Delta v
\]

- \(\rho\) (kg/m³) = fluid density
- \(\Delta v\) = change of the fluid speed
- \(v, v_1\) = speed of the fluid before and after the change in its condition
- \(a\) (m/s) = velocity of the pressure wave propagation

\[
a (m/s) = \sqrt{\frac{1}{\rho \cdot \left[ \frac{1}{E \cdot e} \right]}}
\]

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

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

\[
t (s) = \frac{2 \cdot L}{a}
\]

- \(L\) (m) = length of the pipeline
- \(T\) (s) = effective operating time (closing) of the valve

If \(T < t\) then:

\[
p_{\text{max}} = p_1 + \Delta p
\]

If \(T > t\) then:

\[
p_{\text{max}} = p_1 + \rho \cdot a \cdot \Delta v \cdot \frac{t}{T}
\]
Calculation example

Rapid closing of a shut-off valve in a refuelling line.

Parameters:
Length of the pipe line L: 2000 m
NW of pipeline D: 250 mm
Wall thickness of pipeline e: 6.3 mm
Material of pipeline: Steel
Flow rate Q: 432 m³/h = 0.12 m³/s
Density of medium ρ: 980 kg/m³
Zero feed height of pump p₁: 6 bar
Min. operating pressure pmin: 4 bar
Effective closing time of the valve T: 1.5 sec.
(approx. 20% of the total closing time)
Operating temperature: 20 °C
Compression modulus of the fluid K: 1.62 × 10⁹ N/m²
Elasticity modulus (steel) E: 2.04 × 10¹¹ N/m²

Required:
Size of the required shock absorber, when the max. pressure (p₂) must not exceed 10 bar.

Solution:

Determination of reflection time:

\[
a = \frac{1}{\sqrt{\frac{\rho \cdot \left(\frac{1}{R} + \frac{D}{E \cdot e}\right)}{1}}}
\]

\[
a = \frac{980 \cdot \left(1 + \frac{1}{2}}{ \frac{162 \cdot 10^9 + 2.04 \cdot 10^{11} \cdot 6.3}}{250}
\]

\[
a = 1120 \text{ m/s}
\]

\[
t = \frac{2 \cdot L}{a} = \frac{2 \cdot 2000}{1120} = 3.575 \text{ s}
\]

* since T < t the max. pressure surge occurs and the formula as shown in Point 1.3.2 must be used.

\[
v = \frac{Q}{A} = \frac{0.12}{0.25 \pi \cdot \frac{D^2}{4}} = 2.45 \text{ m/s}
\]

\[
\Delta p = p \cdot a \cdot \Delta v
\]

\[
\Delta p = 980 \cdot 1120 \cdot (2.45-0) \cdot 10^{-5}
\]

\[
\Delta p = 26.89 \text{ bar}
\]

\[
p_{max} = p_{1} + \Delta p
\]

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

Determining the required gas volume:

\[
\rho_{0} \leq 0.9 \cdot p_{min}
\]

\[
\rho_{0} \leq 0.9 \cdot 5 = 4.5 \text{ bar}
\]

\[
V_0 = \frac{m \cdot v^2 \cdot 0.4}{2 \cdot p_{1} \cdot \left[\frac{p_{2}}{p_{1}} - 1\right] \cdot 10^2}
\]

\[
V_0 = \frac{2 \cdot 7 \cdot \left[\frac{1}{7} \pi \right]^2 - 1}{2.04 \cdot 10^{11} \cdot 6.3}
\]

\[
V_0 = 1641 \text{ l}
\]

Selected:

4 off shock absorbers SB35AH-450.
1.4. TECHNICAL DATA

1.4.1 MODEL CODE (also order example)
Pulsation damper, suction flow stabiliser, shock absorber

Series
SB... = with bladder
SBO... = with diaphragm

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

Nominal volume [l]

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

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

Material code
Standard model = 112 for mineral oils depending on operating medium

Fluid connection
1 = carbon steel
2 = high tensile steel
3 = stainless steel
4 = chemically nickel-plated (internal coating)
6 = low temperature steel

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

Accumulator bladder/diaphragm
2 = NBR20 (acrylonitrile butadiene)
3 = ECO (ethylene oxide epichlorohydrin)
4 = IIR (butyl)
5 = NBR21 (low temperature NBR)
6 = FKM (fluoro rubber)
7 = other (e.g. PTFE, EPDM)

Certification code
U = PED 97/23/EC

Permitted 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)
SBO250P-0.075E1 and for SBO210P-0.16E1:
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) Please give full details when ordering
1.4.2 General

Operating pressure
See tables (may differ from nominal pressure for foreign test certificates).

Nominal volumes
See tables

Effective gas volume
See tables, based on nominal dimensions. This differs slightly from the nominal volume and must be used when calculating the usable volume.

On the diaphragm accumulator, the effective gas volume corresponds to the nominal volume.

Usable volume
Volume of fluid which is available between the operating pressures $p_2$ and $p_1$.

Fluids
Mineral oils, hydraulic oils, non-flam fluids, water, emulsions, fuels.
Other fluids on request.

Gas charge
When supplied, the accumulator is only pre-charged for storage purposes. Higher pre-charge pressures are possible by arrangement.

Hydraulic accumulators must only be charged with nitrogen.
Never use other gases.

Risk of explosion!

Permitted operating temperature
-10 °C ... +80 °C
263 K ... 353 K
for material code 112.
Others on request.

Permitted pressure ratio
Ratio of maximum operating pressure $p_2$ to gas pre-charge pressure $p_0$.
See Catalogue section:
- Accumulators
  No. 3.000

General safety instructions
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 the fluid have been released.

Please read the operating manual!
- Bladder Accumulators
  No. 3.201.CE
- Diaphragm Accumulators
  No. 3.100.CE
- Piston Accumulators
  No. 3.301.CE
### 1.4.3. Pulsation damper

#### Dimensions SB

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>11</td>
<td>365</td>
<td>80</td>
<td>118</td>
<td>57</td>
<td>G 1 1/4</td>
<td>SB330P</td>
</tr>
<tr>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
<td>13</td>
<td>384</td>
<td>70</td>
<td>121</td>
<td>53</td>
<td>G 1 1/4</td>
<td>SB550P</td>
</tr>
<tr>
<td>2.5</td>
<td></td>
<td></td>
<td></td>
<td>36</td>
<td>346</td>
<td>–</td>
<td>160</td>
<td>55</td>
<td>G 1 1/4</td>
<td>SB800P</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>94</td>
<td>414</td>
<td>–</td>
<td>215</td>
<td>49</td>
<td>G 1 1/4</td>
<td>SB1000P</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>18</td>
<td>455</td>
<td>80</td>
<td>171</td>
<td>57</td>
<td>G 1 1/4</td>
<td>SB330P</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td>26</td>
<td>491</td>
<td>100</td>
<td>150</td>
<td>53</td>
<td>G 1 1/4</td>
<td>SB550P</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td>20</td>
<td>589</td>
<td>70</td>
<td>121</td>
<td>57</td>
<td>G 1 1/4</td>
<td>SB330P</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td>18</td>
<td>559</td>
<td>80</td>
<td>171</td>
<td>53</td>
<td>G 1 1/4</td>
<td>SB330PH</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td>28</td>
<td>593</td>
<td>100</td>
<td>171</td>
<td>57</td>
<td>G 1 1/2</td>
<td>SB330P</td>
</tr>
<tr>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td>40</td>
<td>620</td>
<td>–</td>
<td>229</td>
<td>57</td>
<td>G 1 1/2</td>
<td>SB330PH</td>
</tr>
<tr>
<td>32</td>
<td></td>
<td></td>
<td></td>
<td>50</td>
<td>652</td>
<td>130x140</td>
<td>150</td>
<td>100</td>
<td>SAE®-6000 PSI</td>
<td>SB330PH</td>
</tr>
</tbody>
</table>

* Certification to PED 97/23/EC

1) M58x4, high pressure connection DN 16, others on request

2) Standard connection code = A1, others on request
### Dimensions SBO

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.075</td>
<td>250</td>
<td>0.9</td>
<td>131</td>
<td>64</td>
<td>hex. 41</td>
<td>13</td>
<td>1/4</td>
<td>G 1/4</td>
<td>SBO250P...E1</td>
</tr>
<tr>
<td>0.16</td>
<td>180</td>
<td>1.0</td>
<td>143</td>
<td>74</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.32</td>
<td>160</td>
<td>2.6</td>
<td>175</td>
<td>93</td>
<td></td>
<td>80</td>
<td>25</td>
<td>1/2</td>
<td>SBO210P...E1</td>
</tr>
<tr>
<td>0.5</td>
<td>3.0</td>
<td>192</td>
<td></td>
<td>105</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>5.6</td>
<td>222</td>
<td></td>
<td>115</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SBO330P...E1</td>
</tr>
<tr>
<td>0.75</td>
<td>140</td>
<td>5.1</td>
<td>217</td>
<td>121</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SBO210P...E1</td>
</tr>
<tr>
<td>1.0</td>
<td>200</td>
<td>6.0</td>
<td>231</td>
<td>136</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SBO200P...E1</td>
</tr>
<tr>
<td>1.4</td>
<td>140</td>
<td>6.2</td>
<td>244</td>
<td>145</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SBO140P...E1</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>7.7</td>
<td>250</td>
<td>150</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SBO210P...E1</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>8.2</td>
<td>255</td>
<td>153</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SBO250P...E1</td>
</tr>
<tr>
<td>2.0</td>
<td>100</td>
<td>6.3</td>
<td>261</td>
<td>160</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SBO100P...E1</td>
</tr>
<tr>
<td></td>
<td>210</td>
<td>8.9</td>
<td>267</td>
<td>167</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SBO210P...E1</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>13.5</td>
<td>377</td>
<td>170</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SBO250P...E1</td>
</tr>
<tr>
<td>3.5</td>
<td>50</td>
<td>7.9</td>
<td>368</td>
<td>158</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SBO50P...E1</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>13.5</td>
<td>377</td>
<td>170</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SBO250P...E1</td>
</tr>
<tr>
<td>4.0</td>
<td>50</td>
<td>7.9</td>
<td>368</td>
<td>158</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SBO50P...E1</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>13.5</td>
<td>377</td>
<td>170</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SBO250P...E1</td>
</tr>
<tr>
<td>0.25</td>
<td>500</td>
<td>4.5 (5.2)</td>
<td>162 (180)</td>
<td>115</td>
<td>80</td>
<td>25</td>
<td>G 1/2</td>
<td>SBO500P...A6</td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>330</td>
<td>8.9 (8.4)</td>
<td>202 (215)</td>
<td>140 (142)</td>
<td>95</td>
<td></td>
<td></td>
<td></td>
<td>SBO450P...A6</td>
</tr>
<tr>
<td>1.3</td>
<td>400</td>
<td>13.8</td>
<td>267</td>
<td>199</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SBO400P...A6</td>
</tr>
<tr>
<td>2.0</td>
<td>250</td>
<td>15.6 (15)</td>
<td>285 (274)</td>
<td>201 (199)</td>
<td>105</td>
<td>30</td>
<td>G 1</td>
<td>SBO250P...A6</td>
<td></td>
</tr>
<tr>
<td>2.8</td>
<td>400</td>
<td>24.6</td>
<td>308</td>
<td>252</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SBO400P...A6</td>
</tr>
<tr>
<td>4.0</td>
<td>400</td>
<td>36.6</td>
<td>325</td>
<td>287</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SBO400P...A6</td>
</tr>
</tbody>
</table>

* certification to PED 97/23/EC

¹ Standard connection code = A1, others on request

() brackets indicate different dimensions for stainless steel version

SBO210P...E1
SBO200P...E1
SBO140P...E1
SBO210P...A6
SBO250P...A6
SBO50P...E1
Pulsation dampers for aggressive media

**SBO...P-...A6/347...(PTFE)**

Pulsation damper in stainless steel with PTFE coated diaphragm and PTFE or FFKM seals. Also available without connection block.

Certification:
PED 97/23/EC

Permitted operating temperature:
-15 °C ... +80 °C

Permitted pressure ratio $p_2 : p_0 = 2 : 1$

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>10</td>
<td>11</td>
<td>140</td>
<td>60</td>
<td>210</td>
<td>105</td>
<td>30 G 1</td>
<td>ISO 228</td>
<td></td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>27</td>
<td>197</td>
<td></td>
<td>230</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>40</td>
<td>12</td>
<td>165</td>
<td></td>
<td>210</td>
<td></td>
<td></td>
<td>ISO 228</td>
<td></td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>26</td>
<td>200</td>
<td></td>
<td>230</td>
<td></td>
<td></td>
<td>ISO 228</td>
<td></td>
</tr>
</tbody>
</table>

) Standard connection code = AI, others on request

**SBO...P-...A4/777... (PVDF/PTFE)**

Pulsation damper in PVDF with PTFE-coated diaphragm.

Permitted operating temperature:
-15 °C ... +65 °C

Permitted pressure ratio $p_2 : p_0 = 2 : 1$

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>10</td>
<td>5.7</td>
<td>128</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>6.5</td>
<td>130</td>
<td>18</td>
</tr>
<tr>
<td>0.5</td>
<td>10</td>
<td>6.0</td>
<td>168</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>6.8</td>
<td>170</td>
<td>19</td>
</tr>
</tbody>
</table>
Spare parts
SB...P

<table>
<thead>
<tr>
<th>Description</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder complete*</td>
<td>3</td>
</tr>
<tr>
<td>Bladder</td>
<td>2</td>
</tr>
<tr>
<td>Gas valve insert</td>
<td>3</td>
</tr>
<tr>
<td>Retaining nut</td>
<td>4</td>
</tr>
<tr>
<td>Cap nut</td>
<td>5</td>
</tr>
<tr>
<td>Valve protection cap</td>
<td>6</td>
</tr>
<tr>
<td>O-ring</td>
<td>7</td>
</tr>
<tr>
<td>Anti-extrusion ring*</td>
<td>14</td>
</tr>
<tr>
<td>Seal kit*</td>
<td></td>
</tr>
<tr>
<td>O-ring</td>
<td>7</td>
</tr>
<tr>
<td>Washer</td>
<td>15</td>
</tr>
<tr>
<td>O-ring</td>
<td>16</td>
</tr>
<tr>
<td>Support ring</td>
<td>23</td>
</tr>
<tr>
<td>O-ring</td>
<td>27</td>
</tr>
<tr>
<td>O-ring</td>
<td>47</td>
</tr>
<tr>
<td>O-ring</td>
<td>48</td>
</tr>
</tbody>
</table>

* recommended spares

**O-ring dimensions (mm)**

<table>
<thead>
<tr>
<th>Series</th>
<th>Nom. volume</th>
<th>Item 7</th>
<th>Item 16</th>
<th>Item 27</th>
<th>Item 47</th>
<th>Item 48</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB330P</td>
<td>1-6 l</td>
<td>7.5x2</td>
<td>55x3.5</td>
<td>42.2x3</td>
<td>46x3</td>
<td>24.2x3</td>
</tr>
<tr>
<td>SB550P</td>
<td>1-5 l</td>
<td>7.5x2</td>
<td>50.17x5.33</td>
<td>37.82x1.78</td>
<td>40.94x2.62</td>
<td>23.52x1.78</td>
</tr>
<tr>
<td>SB330P/PH</td>
<td>10-32 l/4+6 l</td>
<td>7.5x2</td>
<td>80x5</td>
<td>57.2x3</td>
<td>67.2x3</td>
<td>37.2x3</td>
</tr>
<tr>
<td>SB330PH</td>
<td>10-32 l</td>
<td>7.5x2</td>
<td>100x5</td>
<td>64.5x3</td>
<td>84.5x3</td>
<td>44.2x3</td>
</tr>
</tbody>
</table>

1) For code 663 and 665 different dimensions

**SB800P**

<table>
<thead>
<tr>
<th>Description</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder</td>
<td>2</td>
</tr>
<tr>
<td>Charging screw</td>
<td>6</td>
</tr>
<tr>
<td>Seal ring U 9.3x13.3x1</td>
<td>7</td>
</tr>
<tr>
<td>Support ring</td>
<td>8</td>
</tr>
</tbody>
</table>

**SB1000P**

<table>
<thead>
<tr>
<th>Description</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder</td>
<td>2</td>
</tr>
<tr>
<td>Charging screw</td>
<td>6</td>
</tr>
<tr>
<td>Seal ring</td>
<td>7</td>
</tr>
</tbody>
</table>
Description | Item
---|---
Charging screw | 1
Seal ring | 2
Seal ring | 3

Please read operating manual!
Available on request!
1.4.4 Suction flow stabiliser

SB16S

Dimensions

| SB 16 S - permitted working pressure 16 [bar]; certified to PED 97/23/EC |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| [l]             | [l]             | [l]                | [kg]   |        |        |          |        |              |
| 12              | 12              | 1                  | 40     | 580    | 425    | 219      | 220    | 65            |
| 25              | 25              | 2.5                | 60     | 1025   |        |          |        |              |
| 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

Spare parts

<table>
<thead>
<tr>
<th>Description</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder</td>
<td>2</td>
</tr>
<tr>
<td>Gas valve insert</td>
<td>3</td>
</tr>
<tr>
<td>O-ring</td>
<td>11</td>
</tr>
<tr>
<td>Insertion ring, 2x</td>
<td>18</td>
</tr>
<tr>
<td>Lock nut</td>
<td>21</td>
</tr>
<tr>
<td>Retaining ring</td>
<td>22</td>
</tr>
<tr>
<td>Cap nut</td>
<td>25</td>
</tr>
<tr>
<td>O-ring</td>
<td>27</td>
</tr>
<tr>
<td>Seal ring</td>
<td>28</td>
</tr>
<tr>
<td>Lock nut</td>
<td>29</td>
</tr>
</tbody>
</table>
### 1.4.5 Shock absorber

**SB16/35A(H)**

#### Dimensions

**SB16/35 A - permitted operating pressure 16/35 [bar] (PED 97/23/EC)**

<table>
<thead>
<tr>
<th>Nominal volume</th>
<th>Effective gas volume</th>
<th>Weight [kg]</th>
<th>A (approx.) [mm]</th>
<th>B (approx.) [mm]</th>
<th>C (approx.) [mm]</th>
<th>DN 1) DIN 2633</th>
</tr>
</thead>
<tbody>
<tr>
<td>[l]</td>
<td>[l]</td>
<td>SB16A</td>
<td>SB35A</td>
<td>SB16A</td>
<td>SB35A</td>
<td>SB16A</td>
</tr>
<tr>
<td>100</td>
<td>99</td>
<td>84</td>
<td>144</td>
<td>870</td>
<td>880</td>
<td>390</td>
</tr>
<tr>
<td>150</td>
<td>143</td>
<td>101</td>
<td>161</td>
<td>1070</td>
<td>1080</td>
<td>490</td>
</tr>
<tr>
<td>200</td>
<td>187</td>
<td>122</td>
<td>223</td>
<td>1310</td>
<td>1320</td>
<td>685</td>
</tr>
<tr>
<td>300</td>
<td>278</td>
<td>155</td>
<td>288</td>
<td>1710</td>
<td>1720</td>
<td>975</td>
</tr>
<tr>
<td>375</td>
<td>392</td>
<td>191</td>
<td>326</td>
<td>2230</td>
<td>2240</td>
<td>1250</td>
</tr>
<tr>
<td>450</td>
<td>480</td>
<td>237</td>
<td>386</td>
<td>2625</td>
<td>2635</td>
<td>1465</td>
</tr>
</tbody>
</table>

**SB16/35 AH - Permitted operating pressure 16/35 [bar] (PED 97/23/EC)**

<table>
<thead>
<tr>
<th>Nominal volume</th>
<th>Effective gas volume</th>
<th>Weight [kg]</th>
<th>A (approx.) [mm]</th>
<th>B (approx.) [mm]</th>
<th>C (approx.) [mm]</th>
<th>DN 1) DIN 2633</th>
</tr>
</thead>
<tbody>
<tr>
<td>[l]</td>
<td>[l]</td>
<td>SB16AH</td>
<td>SB35AH</td>
<td>SB16AH</td>
<td>SB35AH</td>
<td>SB16AH</td>
</tr>
<tr>
<td>100</td>
<td>99</td>
<td>93</td>
<td>153</td>
<td>957</td>
<td>965</td>
<td>457</td>
</tr>
<tr>
<td>150</td>
<td>143</td>
<td>110</td>
<td>170</td>
<td>1157</td>
<td>1165</td>
<td>557</td>
</tr>
<tr>
<td>200</td>
<td>187</td>
<td>131</td>
<td>230</td>
<td>1417</td>
<td>1425</td>
<td>842</td>
</tr>
<tr>
<td>300</td>
<td>278</td>
<td>164</td>
<td>297</td>
<td>1865</td>
<td>1873</td>
<td>1092</td>
</tr>
<tr>
<td>375</td>
<td>392</td>
<td>200</td>
<td>335</td>
<td>2307</td>
<td>2315</td>
<td>1342</td>
</tr>
<tr>
<td>450</td>
<td>480</td>
<td>246</td>
<td>395</td>
<td>2702</td>
<td>2710</td>
<td>1542</td>
</tr>
</tbody>
</table>

1) other nominal widths on request

### Spare parts

#### Description | Item
---|---
Bladder | 2
Lock nut | 3
O-ring | 11
Seal ring | 13
Vent screw | 18
O-ring | 19
Retaining ring | 21
O-ring | 25
2. **SILENCER**

2.1. **APPLICATION**

2.1.1 **Silencer for fluid noise damping**

Type SD...

---

**General**

All displacement pumps such as axial and radial piston pumps, vane, gear or screw pumps produce volume and pressure fluctuations which are exhibited 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 reflecting the oscillations within the SILENCER the majority of the oscillations are damped across a wide frequency spectrum.

**Construction**

The HYDAC 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 SILENCER can be used for mineral oils, phosphate ester and water glycol. A stainless steel model is available for other fluids.

**Special model**

SILENCERS can also be in the form of diaphragm or piston accumulators. Available on request.

**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 must be taken into account.

Please read the operating manual!

No. 3.701.CE

---

2.2. **SIZING**

2.2.1 **Silencer**

The sizing calculation of the HYDAC 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 $D$ from 20 dB upwards.

$$D = 20 \cdot \log \frac{\Delta p_0}{\Delta p_m}$$

$\Delta p_0$ = height of pressure fluctuations without silencer

$\Delta p_m$ = height of pressure fluctuations with silencer

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

1) the size of the silencer body
2) the fundamental frequency $f$ of the pump.

$$f = \frac{i \cdot n}{60} \text{ in Hz}$$

$i$ = number of displacement elements

$n$ = rpm in min$^{-1}$

2.2.2 **Calculation example**

**Parameters:**

Axial piston pump with 9 pistons
Rpm 1500 min$^{-1}$
Connection G1
Corresponds to $D = 19$ mm
Flow rate 300 l/min
Operating fluid: mineral oil
Max. operating pressure 210 bar

**Solution:**

1) Fundamental frequency $f$

$$f = \frac{i \cdot n}{60} \text{ in Hz}$$

$= \frac{9 \cdot 1500}{60}$

$= 225$ Hz

2) From the "Damping curve" graph, the following SILENCER type can be selected:

SD330-S10/012U-330AE/AE

transmission damping $\approx 31$ dB

pressure drop $\approx 2$ bar.
2.2.3 Damping curve

![Damping curve graph]

2.2.4 Pressure drop

SD330-1.3...

![Pressure drop graph 1.3]

SD330-S10...
SD330-4.2...

![Pressure drop graph S10 and 4.2]
flow rate Q [l/min]

pressure drop [bar]

SD330-L10...

HFC

HFD

mineral oil (HLP)

SD330-S15...

HFC

HFD

mineral oil (HLP)
2.3. TECHNICAL DATA

2.3.1 Model code
( also order example)

Series

Size

Material code

Valve body (not applicable)

Shell
1 = carbon steel
2 = carbon steel with coating*

Seal material
2 = NBR (acrylonitrile butadiene)
6 = FPM (fluoro rubber)

Certification code
U = PED 97/23/EC

Permitted operating pressure in bar

Inlet connector / Outlet connector
see table 2.3.3

* only on request

2.3.2 Dimensions

SD330

Dimensions

<table>
<thead>
<tr>
<th>Size</th>
<th>Nom. volume [l]</th>
<th>L [mm]</th>
<th>L1 [mm]</th>
<th>Ø D [mm]</th>
<th>J ISO 228</th>
<th>Weight [kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3</td>
<td>1.3</td>
<td>250</td>
<td>–</td>
<td>114</td>
<td>G 1</td>
<td>6.5</td>
</tr>
<tr>
<td>S 10</td>
<td>1.8</td>
<td>355</td>
<td>155</td>
<td></td>
<td>G 1 1/4</td>
<td>5.5</td>
</tr>
<tr>
<td>L 10*</td>
<td>5.5</td>
<td>815</td>
<td>615</td>
<td></td>
<td>G 1 1/2</td>
<td>14.0</td>
</tr>
<tr>
<td>4.2</td>
<td>4.2</td>
<td>346</td>
<td>–</td>
<td>168</td>
<td>G 2</td>
<td>12.5</td>
</tr>
<tr>
<td>S 15</td>
<td>4.7</td>
<td>420</td>
<td>155</td>
<td></td>
<td></td>
<td>11.4</td>
</tr>
</tbody>
</table>
### 2.3.3 Silencer connections

#### a) Threaded connection to ISO 228

**Fluid connection A**

<table>
<thead>
<tr>
<th>Size</th>
<th>AC</th>
<th>AD</th>
<th>AE</th>
<th>AF</th>
<th>AG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G 1/2 - ISO 228</td>
<td>G 3/4 - ISO 228</td>
<td>G 1 - ISO 228</td>
<td>G 1 1/4 - ISO 228</td>
<td>G 1 1/2 - ISO 228</td>
</tr>
<tr>
<td></td>
<td>$D_i = 13$ mm</td>
<td>$D_i = 16$ mm</td>
<td>$D_i = 19$ mm</td>
<td>$D_i = 25$ mm</td>
<td>$D_i = 32$ mm</td>
</tr>
<tr>
<td></td>
<td>$L_E$ [mm]</td>
<td>$L_A$ [mm]</td>
<td>$L_E$ [mm]</td>
<td>$L_A$ [mm]</td>
<td>$L_E$ [mm]</td>
</tr>
<tr>
<td>S 10</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>L 10</td>
<td>–</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>26</td>
</tr>
</tbody>
</table>

#### b) Flange connection SAE J518 (Code 62 - 6000 psi)

**Fluid connection F**

<table>
<thead>
<tr>
<th>Size</th>
<th>FG</th>
<th>FH</th>
<th>FI</th>
<th>FK</th>
<th>FL</th>
<th>FM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SAE 1/2&quot;</td>
<td>SAE 3/4&quot;</td>
<td>SAE 1&quot;</td>
<td>SAE 1 1/4&quot;</td>
<td>SAE 1 1/2&quot;</td>
<td>SAE 2&quot;</td>
</tr>
<tr>
<td></td>
<td>$D_i = 13$ mm</td>
<td>$D_i = 19$ mm</td>
<td>$D_i = 25$ mm</td>
<td>$D_i = 32$ mm</td>
<td>$D_i = 38$ mm</td>
<td>$D_i = 50$ mm</td>
</tr>
<tr>
<td></td>
<td>$L_E$ [mm]</td>
<td>$L_A$ [mm]</td>
<td>$L_E$ [mm]</td>
<td>$L_A$ [mm]</td>
<td>$L_E$ [mm]</td>
<td>$L_A$ [mm]</td>
</tr>
<tr>
<td>S 10</td>
<td>53</td>
<td>31</td>
<td>59</td>
<td>36</td>
<td>65</td>
<td>36</td>
</tr>
<tr>
<td>L 10</td>
<td>–</td>
<td>105</td>
<td>120</td>
<td>76</td>
<td>28</td>
<td>76</td>
</tr>
</tbody>
</table>

* on request
– not available

### 3. NOTE

The information in this brochure relates to the operating conditions and applications described. For applications and operating conditions not described, please contact the relevant technical department. All technical details are subject to change without notice.