## Accumulators Applications Guidelines

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**More Information**

HYDAC Accumulators have played a key role in providing innovative solutions resulting in lowering operational costs and increasing hydraulic system performance in mobile, industrial and process applications.

This application guidebook will serve as an overview and allow focus on helping solve customers’ problems.
ACCUMULATORS APPLICATIONS GUIDELINES

Overview

HYDAC accumulators – a name synonymous with advanced technology, design, manufacturing and application engineering for more than 50 years. HYDAC USA is the only major domestic manufacturer of all three types of accumulators—bladders, diaphragms and pistons and has over 1,000 distributors worldwide with more than 50 wholly owned branches.

Accumulators are an essential element in modern hydraulics. Hydro-pneumatic accumulators use compressed gas to apply force to hydraulic fluid using different construction elements to separate the gas side from the fluid side. Bladders use a flexible closed membrane, diaphragms use a flexible open membrane and pistons use a moveable piston with a sealing system.

Bladder Accumulators

SB Series

Diaphragm Accumulators

SBO Series

Piston Accumulators

SK Series

Basic Accumulator Terms

\[ P_0 = \text{gas precharge pressure} \]
\[ V_0 = \text{effective gas volume of the accumulator} \] (this is an internal net volume)
\[ T_0 = \text{temperature at precharging} \]
\[ P_1 = \text{min. working pressure} \]
\[ V_1 = \text{gas volume at } P_1 \]
\[ P_2 = \text{max. working pressure} \]
\[ V_2 = \text{gas volume at } P_2 \]

\[ P_0@T_0 = \text{gas precharge pressure at precharge ambient temperature} \]
\[ P_0@T_1 = \text{gas precharge pressure at minimum ambient temperature} \]
\[ P_0@T_2 = \text{gas precharge pressure at maximum ambient temperature} \]
Guidelines

Many applications can use any of the three types of accumulators, but it’s important to determine the best solution for the application. **Accumulators are typically selected based on system pressure, system temperature, volume need, flow rate, pressure ratio, installation space/position and chemical compatibility.** It’s important to note any weight, dimensional, cost and lead time restrictions impact the choice, as well.

Quick Reference Comparison of Standard Accumulators

<table>
<thead>
<tr>
<th>Type</th>
<th>Design</th>
<th>Nominal Volume</th>
<th>MAWP (psi)</th>
<th>Pressure Ratio</th>
<th>Flow Rate</th>
<th>Mounting Position</th>
<th>Weight</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder</td>
<td>• best general purpose</td>
<td>1 qt. to 15 gal</td>
<td>3000, 5000 (up to 10,000)</td>
<td>4:1</td>
<td>up to 480 gpm</td>
<td>prefer vertical</td>
<td>middle</td>
<td>middle</td>
</tr>
<tr>
<td></td>
<td>• wide range of standard sizes</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>• good for shock applications (good response characteristics)</td>
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</tr>
<tr>
<td>Diaphragm</td>
<td>• small volume &amp; flow</td>
<td>5 in³ to 1 gal</td>
<td>3000, 5000 (up to 10,000)</td>
<td>8:1</td>
<td>typically up to 60 gpm</td>
<td>any</td>
<td>lowest</td>
<td>lowest</td>
</tr>
<tr>
<td></td>
<td>• low weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• compact design</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>• good for shock applications (good response characteristics)</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Piston</td>
<td>• best for large stored volumes</td>
<td>1 qt. to 100 gal</td>
<td>3000, 5000 (up to 10,000)</td>
<td>∞:1</td>
<td>up to 2000 gpm</td>
<td>prefer vertical</td>
<td>highest</td>
<td>middle</td>
</tr>
<tr>
<td></td>
<td>• best for high flow rates</td>
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<td></td>
<td>• not recommended for shock applications</td>
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<td></td>
<td>• best for use with backup nitrogen bottles</td>
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</table>

Characteristics of HYDAC Accumulators

**Bladder Accumulators**
- High discharge velocities
- No pressure differential between fluid side and gas side
- Compact and low maintenance
- High charge and discharge frequencies

**Diaphragm Accumulators**
- Function-optimized and weight-optimized design
- Unlimited choice of installation positions
- Low maintenance and long service life

**Piston Accumulators**
- Minimal pressure differential between fluid side and gas side
- Large effective volume
- Variable installation position
- Monitoring of the piston position possible using a variety of systems
- Particularly suitable for back-up configurations
- Extreme flow rates
- No sudden discharge of gas when seals are worn

**IMPORTANT!**
Ask questions to discover the best solution!
Accumulator Functions
Using accumulators improves the performance of the whole system. They can be used for the below functions:

Energy Storage
- Load compensation
- Heave compensation
- Boom suspension power/ stabilization
- Downforce control
- Auto start/stop
- Valve actuation
- Volume compensation
- Leak compensation
- Back-up/emergency braking
- Auxiliary/emergency power deployment
- Energy storage for launching
- Energy storage for presses
- Energy storage for test systems
- Energy storage for flight control
- Supplemental drive power
- Supplemental pump flow
- Boost rate of acceleration
- Peak shaving of power demand
- Track tensioning

Shock Absorption
- Load stabilization
- Bucket stabilization
- Heave compensation
- Ride control
- Pressure/shock control
- Shock absorption
- Downforce control
- Shock absorption on valve opening
- Track tensioning

Pulsation
Dampening
- Load stabilization
- Bucket stabilization
- Heave compensation
- Boom suspension power/ stabilization
- Ride control
- Vibration dampening
- Pulsation dampening
- Noise reduction

Benefits Of These Functions
Energy Storage
- Increased energy/fuel efficiency (fuel/energy savings)
- System downsizing - design improvement
- System downsizing - less weight
- System downsizing - less floor space required
- Reduced cost to manufacture
- Increased machine acceleration (quicker to speed)
- Reduced engine size (lower energy, weight, cost, space)
- Improved lifting energy efficiency (load compensation)
- Increased payload per lift
- Availability of emergency / stand-by power
- Lubrication control and seal oil supply
- Improved steering / ease of handling
- Reduced machine cycle time
- Emission reduction
- Increased safety
- Increased machine productivity
- Steady downforce improves attachment performance

Shock Absorption
- Increased machine life (less wear from vibration)
- Pressure shock control due to foreign objects
- Increased driver comfort; reduced fatigue (less vibration)
- Reduced machine cycle time
- Increased safety
- Increased machine productivity
- Steady downforce improves attachment performance
- Compensate for thermal expansion/contraction (shock)

Pulsation
Dampening
- Noise reduction
- Even force on shape being pressed
- Increased machine life (less wear from vibration)
- Suction flow stabilization
- Increased driver comfort; reduced fatigue (less vibration)
- Reduced machine cycle time
- Increased safety
- Increased machine productivity

Precharge Recommendations
For energy storage:
\[ P_0 = 0.9 \times P_1 \]
\[ P_1 = \text{minimum working pressure} \]

For shock absorption:
\[ P_0 = (0.6 \text{ to } 0.9) \times P_m \]
\[ P_m = \text{median working pressure} \]

For pulsation dampening:
\[ P_0 = (0.6 \text{ to } 0.8) \times P_m \]
\[ P_m = \text{median working pressure} \]

Temperature Effect
Due to the Ideal Gas Laws, the precharge pressure of an accumulator is affected by the ambient temperature of the accumulator’s operating environment. Given the constant volume of an accumulator shell when the temperature rises, the gas pressure will increase and conversely as the temperature goes lower, the gas pressure decreases. This temperature effect on precharge gas pressure will affect operation of the accumulator in a hydraulic fluid system. Therefore it is critical to consider the precharge pressure at \( T_x \), maximum ambient temperature, and \( T_0 \), the minimum ambient temperature, when sizing an accumulator to ensure that the accumulator is sized large enough to operate properly over the entire operating ambient temperature range. The formula below describes the ambient temperature and precharge pressure relationship to any temperature.

Fahrenheit
\[ P_0 @ T_0 = P_0 @ T_x \times \left( \frac{T_0 + 460}{T_x + 460} \right) \]
\[ T_x = \text{actual ambient operating temperature in °F} \]
\[ T_0 = \text{precharge ambient temperature} \]
\[ P_0 @ T_x = \text{gas precharge pressure at precharge ambient temperature} \]
\[ P_0 @ T_0 = \text{gas precharge pressure at maximum ambient operating temperature, where} \]
\[ T_0 \leq T_x \leq T_s \]

Celsius
\[ P_0 @ T_0 = P_0 @ T_x \times \left( \frac{T_0 + 273}{T_x + 273} \right) \]
\[ T_x = \text{precharge temperature in °C} \]
\[ T_0 = \text{maximum operating temperature in °C} \]
\[ T_s = \text{precharge ambient temperature} \]
\[ P_0 @ T_x = \text{gas precharge pressure at precharge ambient temperature} \]
\[ P_0 @ T_0 = \text{gas precharge pressure at maximum ambient operating temperature, where} \]
\[ T_0 \leq T_x \leq T_s \]

For more information go to www.HYDAC-NA.com > Products > Accumulators (button) or contact Accumulator Product Management or Customer Service at 610-266-0100.
Discovery Questions for Mobile Accumulator Applications

In the following mobile application examples, denoted is a typical accumulator choice. However it is important to thoroughly review the application before deciding on the type and size of accumulator. For mobile applications, necessary questions examples are below:

What is the operating environment of the system (corrosive, etc.)?

What is the installation space and mounting position criteria?

What temperature range will the accumulator experience (min/max)?
MOBILE APPLICATIONS

Agricultural

- Front loader dampening
- Implement down pressure
- Tractor suspension systems
- Pressure spike protection from stone strikes
- Boom suspension on field sprayers

Automotive

- Pump noise dampening
- Leakage compensation in transmission
- Brake systems and suspension

Construction

- Braking system
- Chassis dampening
- Load dampening
- Track tensioning
- Noise dampening

Cranes

- Boom dampening
- Steering systems
- Load compensation
MOBILE APPLICATIONS

Forestry
- Shock absorption
- Load stabilization
- Ride control

Material Handling
- Shock absorption
- Ride control

Military
- Energy storage for door/lift emergency power
- Ride control

Mining
- Steering systems
- Emergency braking
MOBILE APPLICATIONS

**Municipal**
- Noise dampening
- Energy storage in regenerative circuits (stop and go)

**Rail**
- Braking system
- Noise dampening

**Utility Vehicles**
- Boom suspension in lifts
- Bucket stabilization
Discovery Questions for Industrial Accumulator Applications

In the following industrial application examples, denoted is a typical accumulator choice. However it is important to thoroughly review the application before deciding on the type and size of accumulator. For industrial applications, necessary questions examples are below:

What flow rate is required?

What is the pressure range (min/max)?

What type of maintenance criteria is important to the system design (location of installation, do items get repaired or replaced, etc)?
INDUSTRIAL APPLICATIONS

**Aerospace**

- Energy storage for hydraulic brake system and hydraulic flight controls

**Balers, Compactors, Shredders, Crushers, Grinders**

- Pressure shock control for larger / foreign objects

**Die Casting Machines**

- Energy storage during the injection process
- Volume compensation

**Iron & Steel Metal Forming**

- Energy storage in rolling mills
- Pressure shock control in blast furnace hydraulics
INDUSTRIAL APPLICATIONS

**Machine Tools (CNC)**

- Support for the hydraulics for tool change
- Energy storage for machining

**Paper & Pulp**

- Energy storage for emergency functions in friction bearing hydraulics
- Energy storage in high/low pressure power units

**Plastic Machinery & Molding**

- Energy storage during the injection molding or blow molding process
- Pulsation dampening on the hydraulic drive

**Power Plants**

- Emergency supply for turbine control system
- Pulsation dampening on pumps
- Lubrication control and seal oil supply
- Water treatment

Commonly used accumulator for this application.
INDUSTRIAL APPLICATIONS

**Press**
- Pulsation dampening for uniform force driving the shaping process

**Shipping / Marine**
- Energy storage for pump support
- Pulsation dampening on large ship diesel engines
- Emergency energy for lifeboat deployment

**Simulators & Entertainment**
- Energy storage on crash test systems
- Pulsation dampening on servo hydraulic axes

**Wind Turbines**
- Pressure shock control in pitch control system
- Energy storage for braking units
Discovery Questions for Process Technology Accumulator Applications

In the following process technology application examples, denoted is a typical accumulator choice. However it is important to thoroughly review the application before deciding on the type and size of accumulator. For process technology applications, necessary questions examples are below:

- What chemical compatibility is needed?
- What is the system pressure range (min/max)?
- What is the system temperature range (min/max)?
PROCESS TECHNOLOGY APPLICATIONS

**Chemical Industry**
Commonly used accumulator for this application.

- Energy storage and pulsation dampening on dosing pumps
- Suction flow stabilization on the suction side of pumps

**Loading Stations & Refineries**
Commonly used accumulator for this application.

- Shock absorption for valves closing during unloading stage
- Pulsation dampening on pipelines

**Oil & Gas / Offshore**
Commonly used accumulator for this application.

- Shock absorption for valves closing
- Energy storage for deep sea rams
- Emergency energy for safety systems such as Blow Out Preventers (BOP)
- Energy storage in wellhead control systems
Discovery Questionnaire
Forms for the Three Primary Accumulator Functions

These forms are to be used to discover additional information to help diagnose, design and deliver to the customers specific needs.
# Sizing Accumulators

## Energy Storage Form

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<table>
<thead>
<tr>
<th>Company</th>
<th>E-mail</th>
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</table>

<table>
<thead>
<tr>
<th>Address</th>
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<table>
<thead>
<tr>
<th>Phone</th>
<th>State</th>
<th>Zip</th>
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<thead>
<tr>
<th>Phone</th>
<th>Fax</th>
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<tbody>
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</tr>
</tbody>
</table>

### Operation of Pump

- Continuous Operation
- Emergency Operation

Maximum Operating Pressure \( P_2 \) \( \text{PSI} \)
Minimum Operating Pressure \( P_1 \) \( \text{PSI} \)
Precharge Pressure at 68°F (20°C) \( P_0 \) \( \text{PSI} \)
Temperature Range of Environment \( T \) °F
Temperature Range of Fluid or System \( T_F \) °F
Pump Flow Rate \( Q_P \) GPM
Total Cycle Time of System \( T_E \) Sec.
Number of Actuators (cylinders, etc.) \( NV \)

### Actuator Time Schedule and Flow

- \( Q_{Vi} \) = Required Actuator Flow (GPM)
- \( E_i \) = Actuator Start Time
- \( A_i \) = Actuator Shut Down Time

\( i = 1 \) for first actuator, \( i = 2 \) for second actuator, etc. up to \( NV \)

- \( QV1 = \) \( E1 = \) \( A1 = \)
- \( QV2 = \) \( E2 = \) \( A2 = \)
- \( QV3 = \) \( E3 = \) \( A3 = \)
- \( QV4 = \) \( E4 = \) \( A4 = \)
- \( QV5 = \) \( E5 = \) \( A5 = \)

### Fluid

### Required Mounting Orientation

### Country of Final Installation

(for country codes please see inside back page)

### Required Quantity

<table>
<thead>
<tr>
<th>Annual Usage</th>
<th>Target Price</th>
<th>Competitor</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

### Additional Remarks
Shock Applications Form

Please attach any special requirements or drawings to the fax or e-mail.

What is the source of the shock? (i.e. valve closing, pump start, or other - please describe)

At the instance the shock occurs what is the...
Flow rate: __________ GPM
Normal Operating Pressure: __________ PSI ; Maximum Spike Pressure: __________ PSI
The system's maximum allowable design pressure: __________ PSI
Information is required on all piping from the shock source to the anticipated location of the shock absorber (accumulator).
Please continue to answer the following:
Total Number of pipes: __________ (up to 10 pipes)

Starting at the shock source, please answer the following:

<table>
<thead>
<tr>
<th>Pipe</th>
<th>Inner Diameter (inches)</th>
<th>Length (feet)</th>
<th>Pipe</th>
<th>Inner Diameter (inches)</th>
<th>Length (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>6</td>
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<td>2</td>
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<td>5</td>
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<td>10</td>
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</tr>
</tbody>
</table>

If the vertical height from the shock source to the anticipated location of the shock absorber is greater than 10 feet please state this distance.
Vertical Height: __________ feet

Fluid

Required Mounting Orientation

Country of Final Installation (for country codes please see inside back page)

Required Quantity
Annual Usage __________ Target Price __________ Competitor __________ Quantity __________

Additional Remarks
# Pulsation Dampening Form

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Company</th>
<th>E-mail</th>
<th>Address</th>
<th>Phone</th>
<th>State</th>
<th>Zip</th>
<th>Phone</th>
<th>Fax</th>
</tr>
</thead>
</table>

**Please attach any special requirements or drawings to the fax or e-mail.**

**What type of pump is causing the pulsation?**
Please name or describe (e.g., piston pump, gear pump, etc.)

**What is the...**

- **Flow rate:** _______ GPM
- **Pump:** _______ RPM
- **Pump Piston Diameter:** _______ (inches)
- **Pump Piston Stroke:** _______ (inches)
- **Number of Rotating Elements:** _______ (3 piston, 13 tooth gear, etc.)
- **Operating Pressure:** _______ psi
- **The system’s maximum allowable pressure:** _______ psi

**Line Size where pulsation dampener will be fitted into:** ____________________________

*(The I.D. of the line is what is really required)*

**Note:** A pulsation dampener should be always be installed as close to the pulsation source as possible to optimize its performance. A pulsation dampener should never be placed greater than 10 ft away from the pulsation source.

**Fluid**

**Required Mounting Orientation**

**Country of Final Installation** *(for country codes please see inside back page)*

**Required Quantity**

<table>
<thead>
<tr>
<th>Annual Usage</th>
<th>Target Price</th>
<th>Competitor</th>
<th>Quantity</th>
</tr>
</thead>
</table>

**Additional Remarks**
**Certifications**

Accumulators and gas bottles are pressure vessels. Each country has its own safety regulations and certifications that govern pressure vessels. The most common certifications are ASME, PED, AS1210 and CRN. HYDAC is able to provide certification for any country and will comply with specific industry standard (ABS, DNV, etc) at time of order.

**ASME Certification (HYDAC country code S)**
If pressure is greater than 15psi and the ID is greater than 6 in. then the shell will have appropriate stamping.

**PED: Pressure Equipment Directive (HYDAC country code U)**
If pressure in bar times the volume in liters is greater than 1,000 then the assembly must carry a “CE” mark. If pressure in bar times the volume in liters is less than 1,000 then the assembly is built in accordance with PED but cannot carry a “CE” mark.

**Complete Country Code Listing** (European Union Member States listed in bold.)

<table>
<thead>
<tr>
<th>Country</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>S3</td>
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1) approval required in the individual territories
2) approval required in the individual provinces
3) alternative certificates possible

**Safety Requirements Overview**

Hydro-pneumatic accumulators are pressure equipments subjected to legal pressure regulations. For the operation and the testing of accumulator equipped hydraulics, all local regulations have to be observed to avoid any risks and to guarantee the safety for the whole lifetime of the units.

Therefore “safety devices in accordance with the PED 97/23/EC ANNEX 1:2.11” are available.

HYDAC offers various types of standard “safety devices”, which should be used on the gas and fluid sides to protect against pressures in excess of design parameters.

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**WARNING!**

**FAILURE OR IMPROPER SELECTION OR IMPROPER USE OF THE PRODUCTS AND/OR SYSTEMS DESCRIBED HEREIN OR RELATED ITEMS CAN CAUSE DEATH, PERSONAL INJURY AND PROPERTY DAMAGE.**

This document and other information from HYDAC, its subsidiaries and authorized distributors provide product and/or system options for further investigation by users having technical expertise. It is important that you analyze all aspects of your application and review the information concerning the product or system in the current product catalog. Due to the variety of operating conditions and applications for these products or systems, the user, through its own analysis and testing, is solely responsible for making the final selection of the products and systems and assuring that all performance, safety and warning requirements of the application are met.

HYDAC does not assume the risk of and shall not be liable for failure due to fire. HYDAC offers fire safety devices and recommends their use.

The products described herein, including without limitation, product features, specifications, designs, availability and pricing, are subject to change by HYDAC Corporation and its subsidiaries at any time without notice.

All accumulators should be visually inspected (signs of leakage etc.), tested for functionality and have a complete seal change out within 10 years of service.
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HYDAC literature is available for ordering. Email us at HYD.catalog@hydac-na.com using the appropriate Part Number (PN) and name. Other brochures, manuals and technical documents are also available when ordering from our website.

Various market and product brochures are also available for ordering.

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PN02081318

Accumulators Catalog
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Brochure PN2205620

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Catalog - PN02085359

Filter Systems Catalog
PN02075860

Accessories Catalog
PN02080105

Mobile Valves Brochure
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Compact Hydraulics
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Catalog (online only)

Process Technology*
Catalog (online only)

*These catalogs are digital file versions only.