Milwaukee Cylinder offers additional products to help complete your system needs. **Pressure Boosters** are ideal for limited operation applications requiring intermittent high pressure when you only have low-pressure air. **Air Oil Tanks** supplement a booster system by providing a source of low pressure oil, while also providing an outlet for entrapped air. **Accumulators** can improve overall system efficiency.
**HOW A BOOSTER WORKS**

A booster, or pressure intensifier, is a device that amplifies available line pressure in order to perform work requiring much higher pressure. It operates a hydraulic cylinder without the need for a hydraulic power unit. A booster is basically a cylinder and is similar in internal design, except that the rod end of the piston does not extend outside. The rod becomes a ram for hydraulic fluid. A booster is equivalent to a transformer, or pulley system, in that it changes the ratio of pressure input to pressure output but does not amplify power. Low pressure air, as found in most plants or shops, is connected to the large cylinder. Pressures are typically 80 to 100 PSI. This low pressure is converted by the booster to a much higher hydraulic pressure on the output side. This discharge has an amplified pressure potential equal to the product of the supply pressure and the booster ratio. Total power is not changed, as the low pressure input air must operate against a large area piston in order to produce high pressure from a much smaller surface area.

Standard boosters are available in ratios running from approximately 2:1 up to 36:1. In the selection of a particular booster (for details, see page 143), not only does the ratio have to be taken into account, but also the output volume has to be matched to the cylinder which the booster will drive.

**What does the working cylinder see?**

In our example above, we have an output of 1600 PSI hydraulic pressure. When this 1600 PSI is fed to a cylinder, the total area of the piston in the cylinder is now under a pressure of 1600 PSI! Therefore, instead of an air cylinder which would have to work under 100 PSI air pressure, we can now have a cylinder working under 1600 PSI hydraulic pressure. True, this cylinder will only perform work at this pressure through a volume of fluid in the cylinder that is equal to the same volume displacement in the booster, but for many operations, this volume displacement at such increased pressures is completely satisfactory.

**Operating power**

In the example above, shop air is used as the power source, as this is the most common way boosters are used. It is, however, quite possible to use oil as the operating power source, particularly for extremely high pressure applications. For example, if you need to develop 40,000 PSI and had a choice of 80 PSI air or 3,000 PSI oil, the air booster ratio would be 500:1 and the oil only about 13:1. It’s obvious that using an oil to oil booster system would be far less expensive. Standard boosters are air to oil only.

**When should boosters be used?**

Typical applications for boosters are shown on page 128. Without going into a list of such applications, let’s see when you are better off using a booster rather than a complete hydraulic system. Keep in mind that boosters will never replace the pump-cylinder method of work ability...nor are they intended to do so. Therefore, as a general statement, you use a booster when intermittent high pressure is required in a limited operation, and all you have is low pressure air. In all of the published applications, there is really no exception to this general rule. The reason for this is that boosters and cylinder combinations are not intended for rapid cycling with high pressures: i.e., their total power is limited.

Now that we’ve eliminated the negative, let’s take the positive approach. You need to clamp a fixture into position for a work application. You have 100 psi shop air. An air cylinder operating under 100 psi will simply not hold the fixture in position in the intended application. Here’s an ideal spot for a booster and hydraulic cylinder. As a plus, remember that the hydraulic cylinder can be controlled in its clamping action better than an air cylinder. By using a Dual Pressure Booster (Model BA), the clamping cylinder will travel rapidly toward the fixture, under light pressure, and then will, at the end of its travel, exert high pressure just as it clamps.

**Cost Ratio.** Another reason for using boosters is the cost ratio of a booster system vs. pump system. You have a machine which requires a linear actuator pressure of 5,000 PSI. If you were to design in a complete 5,000 PSI hydraulic system into this one machine, it could cost you many times a booster system! Again, remember that we are talking about one machine requiring intermittent high pressure.

**Long Holding Times.** Another case is where you want to exert a high pressure for a long time, such as maintaining pressures on printing rolls. A booster-cylinder system will maintain a continuous pressure with very little power input. In a pump-cylinder system, the pump must be kept in continual operation. (In order to achieve such holding pressure, there must be a relief valve inserted in the system.)

**Extreme High Pressures.** Pressures over 10,000 PSI can be obtained with special boosters while virtually impossible with ordinary rotary pumps. When you require an inexpensive way of achieving high pressure, even up to 50,000 PSI, the booster is the answer.
BOOSTER FEATURES

1. **Booster Barrel**
   The barrel is of steel tubing, honed to a fine finish and hard chrome plated. This provides superior sealing power, minimum friction and maximum seal life.

2. **Rod**
   Made of high strength steel, induction hardened. It is grounded and polished to a low micro finish, and then chrome plated to resist scoring and corrosion, for maximum life.

3. **Rod Seals**
   Rod seals are of Milwaukee Cylinder’s high quality, stacked vee construction. They are specifically designed for high pressure hydraulic use, and their performance record has proven their long lasting, low leakage capability.

4. **Nozzles**
   Steel nozzles are externally removable for replacing seals without disturbing booster assembly or tie-rod torque. Four self-locking nuts require only a standard shop wrench for removal.

5. **End Caps**
   Heavy duty end caps are machined from solid, durable steel. All mountings are rigidly attached by either threading or welding. All mountings are expertly machined to provide accurate alignment on matched beds or mounting surfaces.

6. **Tie Rods and Nuts**
   Tie rods are constructed from medium carbon steel, with a yield strength of 125,000 PSI. Threads are accurately machined for rigid engagement of the nuts. Nuts are high strength, self-locking type.

7. **Piston**
   Precision machined from high strength iron alloy. The piston is pilot fitted and threaded to the rod. “U” cup seals are supported by back-up washers.

8. **End Cap Seals**
   The barrel is sealed to the end caps with a high temperature, compression type gasket that seals over the entire face of the tube end.

9. **Ports**
   Large, unrestricted ports conforming to NFPA standards are provided. They can be rotated to any 90° position in relation to each other and the booster mounting. Dry seal, national pipe threads are standard with SAE straight thread ports, oversized ports and metric ports available upon request.
DUAL PRESSURE BOOSTERS

In Milwaukee Cylinder’s Model BA Booster, the high pressure output is applied only after the ram has entered the secondary, or high pressure seal. This allows a low pressure approach stroke and a high pressure work stroke where the working ram travels only a short distance under high pressure, as when a part needs to be clamped in position for another operation. Model BA boosters are self bleeding and an external valve in the inlet is not required.

RAPID TRAVERSE, AUTOMATIC SEQUENCING WITH BA BOOSTER

Below the circuit shows the use of a double-acting cylinder with rapid traverse at low pressure and sequencing to high pressure when the load is picked up. When the air valve is shifted, the left air-oil tank forces oil through the booster and extends the cylinder. When the load is picked up, the timer valve ports air to the booster for a high pressure output to the cylinder. On the return stroke, the right air-oil tank retracts the cylinder.
Dual Pressure Boosters – Model BA

**MODEL BA 11 - No Tie Rod Extension**

**MODEL BA 10 - Tie Rod Extended Both Ends**

**MODEL BA 12 - Tie Rod Extended Rod End**

**MODEL BA 13 - Tie Rod Extended Blind End**

**MODEL BA 42 - Side Lug Mounting**

**MODEL BA 41 - Tapped Holes in Caps Flush Mounting**

**TABLE BA**

<table>
<thead>
<tr>
<th>Bore Ø</th>
<th>E</th>
<th>K</th>
<th>AA</th>
<th>BB</th>
<th>DD</th>
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**Pressure Limitation Rated Output:** 3000 psi

**Pressure Limitation Rated Input:** 250 psi

Over 3000 psi, contact factory.

OTHER MOUNTING STYLES AVAILABLE UPON REQUEST

ADD 2” TO REQUIRED STROKE FOR BA BOOSTERS

www.milwaukeecylinder.com
How a Single Pressure Booster Works

1. Low pressure air is applied to the large surface piston during the entire work stroke. The input pressure of BD Boosters is rated at 250 PSI air.

2. The rod of the BD booster is constantly under high pressure throughout the entire work stroke. It has but a single seal assembly.

3. Oil flows out, and back in, the same port on the high pressure end of the BD booster. Make up oil is provided through an external check valve or needle valve.

SINGLE PRESSURE BOOSTERS

Milwaukee Cylinder’s Model BD Boosters are used where high pressure output is required during the entire work stroke of the cylinder. This design is used for all output pressures and exclusively with special boosters where pressures are above the normal 3,000 PSI. Its single rod seal assembly constantly surrounds the rod. Because of its simpler design, model BD is not self bleeding and more care must be taken in bleeding out air when installing.

BD BOOSTER WITH SINGLE-ACTING CLAMPING CYLINDER

The circuit shows a BD booster powering a short stroke, spring return cylinder. A simple valve on the input line to the booster can be either manually or automatically operated. Input to the booster is kept on as long as the clamping action of the cylinder is required. Once removed, the internal spring in the cylinder returns the cylinder piston which, in turn, returns the oil to the booster port.
**TABLE BD**

<table>
<thead>
<tr>
<th>Bore Ø</th>
<th>E</th>
<th>K</th>
<th>AA</th>
<th>BB</th>
<th>DD</th>
<th>EE</th>
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</tbody>
</table>

Other mounting styles available upon request.

**Model BD, Pressure Boosters**

- **Model BD 11 - No Tie Rod Extension**
- **Model BD 10 - Tie Rod Extended Both Ends**
- **Model BD 12 - Tie Rod Extended Rod End**
- **Model BD 13 - Tie Rod Extended Blind End**

**Pressure Limitation Rated Output:**
- 3000 psi

**Pressure Limitation Rated Input:**
- 250 psi

Over 3000 psi, contact factory.

**Dimensional Data**

- **Model BD 42 - Side Lug Mounting**
- **Model BD 41 - Tapped Holes in Caps Flush Mounting**
Booster Applications

**APPLICATIONS FOR BOOSTERS**

**High Pressure From Shop Air**
One of the principle applications for boosters is in the conversion of low pressure shop air to high pressure hydraulic operation for a specific function where a hydraulic cylinder is required. Many operations require the smooth power inherent in a hydraulic cylinder, yet do not require the expenditure for a complete hydraulic installation. The small, yet powerful movement of a booster driven hydraulic cylinder can be used to hold a piece for riveting, as a spot welding clamp, for punching, piercing, forming, crimping, bending, stamping, shearing, marking, etc. The complete installation of booster, air-oil tank and cylinder can be mounted directly on the equipment itself.

**Testing**
Testing of manufactured parts for physical strength, leaks or burst rating can easily be accomplished with a booster-cylinder combination or a booster alone. A hydraulic cylinder will give a precise, high pressure force for mechanical testing, and a booster can be linked up directly, to a die casting, for instance, to test for leaks.

**Fluid Transfer**
Fluids that are difficult or impossible to transfer with a conventional pump can be fed through a valve-booster combination. Depending on the type of fluid, boosters can be produced with special metals, such as stainless steel.

**Liquid Injection**
High pressure injection of liquids are readily handled with a booster. Such liquids, injected into high pressure gas lines or containers, might include lubricants, antifreeze or odorants.

**Holding Pressures**
Long holding pressures required in vulcanizing, laminating, bonding or curing can be readily maintained without drawing power or generating heat, except for making up any leakage loss. A booster can maintain accurate pressure levels under such static conditions for an indefinite time.

**Save Space and Weight**
In many applications, booster driven cylinders can replace an extremely large, low pressure air cylinder with a small, efficient, high pressure hydraulic cylinder. Coupled with reduced circuitry, the overall weight of a machine can be reduced, as well as the total space required.

**Lower Cost**
A booster system is less expensive than an overall hydraulic system with its pump-motor requirements. They also require only a fraction of the air of a direct cylinder installation. Hydraulic requirements are also much smaller to operate a given function.

**Smother Power**
Compared to air, boosters provide work cylinders with the smooth, efficient power of a hydraulic installation. When such power is required, and installations are limited to smaller volumes, boosters are ideal.

**Points of Consideration**
1. Plant air distribution system must be capable of maintaining the required pressure to the booster.
2. Regulators should be the relieving type. A leaky poppet could result in a dangerous pressure rise.
3. Directional control valves and air conditioners should have ports at least as large as the booster.
4. Always bleed air from the hydraulic circuit when installing booster systems. Type BA boosters are self bleeding.

A Milwaukee Cylinder designed special booster featuring a 10" bore, 60" stroke and a 51/2" rod. This booster, mounted on the side of a steel “I” beam, converts a 3,000 psi oil input to an 8,000 PSI output of an ethylene-glycol solution with a total high pressure displacement of 1,400 cubic inches. The booster also had to be designed to operate over a temperature range from -65° to +100° F.

**High Pressures**
Extremely high pressure, up to 50,000 psi, have been achieved with special boosters. Such high pressures would be impossible with an ordinary hydraulic rotary pump.
1. Based on load requirements, select a cylinder bore size that will provide an adequate safety margin.

Example: Load: 4500 lbs. From the cylinder selector chart, choose a cylinder bore size that will provide an adequate safety factor. Therefore, add a minimum of 25% to the calculated volume as a safety factor.

2. Knowing the stroke required for the cylinder, calculate the volume of oil required for full extension under load pressure. This is the piston area times the cylinder stroke. It is important to note that the required volume should not be underestimated. Therefore, add a minimum of 25% to the calculated volume as a safety factor.

From the cylinder chart, area is 4.909 in². (You require a 2" stroke.)

Volume = 4.91 x 2 x 1.25 = 12.25 in³

3. Divide the hydraulic system pressure by the available shop air pressure to determine booster ratio.

Booster Ratio = 1000/80 = 12.5

4. From the booster ratio chart, select the required booster bore and rod sizes that will safely handle the booster ratio.

A booster ratio of 13.22 adequately covers the 12.5 ratio requirement.

This gives the booster with a bore of 5" and a rod with a diameter of 1¾". Reading down on the chart, the volume per in. of stroke is 1.49.

5. To determine the booster stroke, divide the calculated high pressure oil volume (from Vol Output) by the vol/in of stroke. Add 2" for a BA booster.

Stoke = 12.28/1.49 + 2 = 10.24"

From the above, you specify a cylinder with a bore of 2½" and a stroke of 2½". You specify a booster with a 5" bore, a 1¼" rod and a 10¼" stroke. From this information, you can determine specific mounting dimensions for BA boosters on page 139. (Other bore and rod combinations will also do the job.)
**BOOSTER BORE & ROD DIAMETERS**

The following chart quickly provides booster bore and rod diameters for basic discharge pressures when the input pressure is 100 PSI. Example: if required pressure to cylinder is 1500 PSI, read down column and select any rod and bore diameter desired, such as a 3" rod and a 12" bore. The left column shows that a displacement of 7.07 in³ per inch of stroke will result. Other combinations can, of course, be chosen at a glance for the most economical booster or for a booster that fits the installation requirements.

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</table>

**MILWAUKEE CYLINDER AIR OIL TANKS**

Air-Oil Tanks serve several purposes in a booster system:
- They are used as a source of oil to compensate for any loss in the hydraulic system
- They can provide hydraulic pressure to return the cylinder to its starting position
- They provide an outlet for entrapped air in the hydraulic system.

The Air-Oil Tank literally contains air on top of oil. The air is under line pressure from the same source as the air used to operate the booster. A sight-gauge is mounted on the side of Milwaukee Cylinder Air-Oil Tanks so that the level of oil in reserve can be readily observed. When required, hydraulic fluid may be added through a port in the top of the tank after shutting off air pressure.

**Features:** Milwaukee Cylinder Air-Oil Tanks are manufactured with the same care and high quality materials as are all Milwaukee Cylinder’s Boosters and Cylinders. Maximum pressure for these tanks is 250 psi. They are suitable for all hydraulic fluids up to 200°F (93°C). Milwaukee Cylinder Air-Oil Tanks incorporate the following high quality features:
- High strength, solid steel end caps with large fill and drain plugs for fast circuit filling
- Steel tubing sealed to each end cap with compression type gaskets
- Replaceable sight gauge enclosed in aluminum shield for maximum gauge protection
- A unique baffle system, inside both end caps, assures rapid intake and discharge with a minimum of churning, foaming and aeration.

**Booster & Air-Oil Combination**

By specifying a combination of a booster and air-oil tank, savings are obtained in space, cost and installation time. Tanks are mounted directly on the booster, using a common end plate and tie-rods. Due to the fact that air-oil tanks must always be used vertically, this combination is limited to a vertically mounted installation. When ordering this combination, specify BAT or BDT depending upon whether a BA or BD booster is used. Tanks are selected with the same size bore as the booster. When determining length, subtract one “J” length from the overall combined length of the individual booster and tank lengths.
SELECTING A TANK SIZE

If the tank is used as a source of pressure to return the cylinder, its size must be in excess of the total cylinder displacement, otherwise, oil will be injected into the air line. Tanks should also be large enough to replenish any hydraulic losses without the necessity of adding fluid too frequently. In the chart below, always select a tank volume equal to or slightly greater than the cylinder volume. After the cylinder volume is determined, it can be located on the chart. Note that a selection may be made with varying tank diameters and lengths. (If a booster-tank combination is required, select the tank diameter to match the booster diameter.)

**AIR OIL TANK SELECTION CHART**

<table>
<thead>
<tr>
<th>Tank Bore Ø (in)</th>
<th>3¼</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>8</th>
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**AIR OIL TANK DIMENSIONAL CHART**

**Design Guide**

- Hyd-Pneu Devices
- Cyl Accessories
- Manipulators
- Power Units/Valves
- Design Guide
**Nitrogen Oil Accumulators**

**Dimensional Data**

Nitrogen-over-oil Accumulators are designed for use over a wide range of industrial applications. Built to the same high quality standards maintained on *Milwaukee Cylinder* Air and Hydraulic Cylinders, Series NA Accumulator can be applied to:

- Simplify hydraulic circuit design
- Lower the hydraulic circuit horsepower requirements
- Improve hydraulic system operation
- Provide exceptionally fast cycle operation when in operation

<table>
<thead>
<tr>
<th>Cylinder Code</th>
<th>Model No.</th>
<th>Size</th>
<th>Oil Capacity in³/min</th>
<th>Gas Capacity in³/min</th>
<th>Length A</th>
<th>Ø B</th>
<th>Ø C</th>
<th>Thread Hole Depth D</th>
<th>Thread E</th>
<th>Port *F NPT</th>
<th>Seal Kit Code</th>
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<td>NA2 - 05</td>
<td>½ Pint</td>
<td>14.5</td>
<td>16.2</td>
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<td>2%</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>¾</td>
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<td>22</td>
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<td>–</td>
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<td>3508-1080</td>
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<td>5½</td>
<td>1</td>
<td>¾ - 16</td>
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</tr>
</tbody>
</table>

* Available with SAE straight thread; O-Ring port at no additional cost.
NA SERIES PISTON-TYPE ACCUMULATORS

DESIGN FEATURES

Milwaukee Cylinder’s Series NA Piston-Type Accumulators are of a sturdy, compact, cylindrical design, built to provide dependable performance at long service life. Series NA features:

1. Honed steel barrel, welded to the hydraulic steel end cap.
2. Solid steel gas end cap, screwed in place for easy removal and seated with O-ring and back-up washer.
3. Lightweight, low inertia aluminum piston, reducing bounce, over travel, and shock when in operation.
4. Non-metallic wear rings provide piston to wall contact. Non-scoring, low frictional drag, these scarf cut rings also stop shock waves from reaching primary seal. The wear rings also provide a wiper type action, thus protecting the primary seal.
5. Proven O-ring balanced seal design with double back-up anti-extrusion rings.
6. Protected gas fill valve. This valve also incorporates a release valve for quick exhausting of the pre charge gas.

APPLICATION

Milwaukee Cylinder’s Series NA Piston-Type Accumulators have a wide range of applications such as:

- Cushioning peak loads
- Shock absorption
- Compensating for circuit leakage
- Maintaining constant loading on holding circuits
- Performing extremely fast cylinder cycles
- Reducing pump size and circuit horsepower
- A safety device—in case of pump failure—Hydraulic power is available to activate brakes or other locking devices.

Determination of the usable volume of oil obtained from a specific size Accumulator, under specific operating conditions, can be computed by using the formula $P_1V_1 = P_2V_2$ (Isothermal) where:

- $P_1$ = absolute precharge pressure (Gauge + 14.7) psia
- $V_1$ = Initial gas volume cubic inch
- $P_2$ = Final pressure psia
- $V_2$ = Final gas volume cubic inch

Compute $V_2$ volume for both maximum and minimum operating pressure, ($P_2$). Subtracting the $V_2$ volume from the Accumulator total gas volume will result in the Accumulator oil volumes at both operating pressure limits. The difference between the two resulting oil volumes, is the usable volume of Accumulator oil.

PART LIST

When ordering parts specify Model No., Part No., Description, Serial No. and Quantity.

```
<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
<th>Qty.</th>
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<td>Accumulator Shell</td>
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<td>Piston</td>
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<td>3</td>
<td>Wear Ring</td>
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<td>O-Ring (Piston)</td>
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<td>5</td>
<td>Backup Washer</td>
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<td>6</td>
<td>O-Ring (End Cap)</td>
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<td>7</td>
<td>Backup Washer</td>
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<td>End Cap</td>
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<td>Bracket</td>
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<td>Cap Screws</td>
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</tbody>
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EXAMPLE FOR NA 4-4

Gas Capacity: 128 cubic inches
Operating Pressure Range: 1500 to 2200 psi
Pre-charge Pressure: 800 psi

- At 2200 psi
  - $P_1V_1 = P_2V_2$
  - $814.7 \times 128 = 2214.7 \times V_2$
  - $V_2 = 47.2$ cu.in. gas
  - $V_1 - V_2 = 81.2$ cu.in. oil

- At 1500 psi
  - $814.7 \times 128 = 1514.7 \times V_2$
  - $V_2 = 68.5$ cu.in. gas
  - $V_1 - V_2 = 59.5$ cu.in. oil

Usable Oil Volume

$81.2 - 59.5 = 21.7$ cu.in. (Based on Isothermal performance)

SPECIAL UNITS

Milwaukee Cylinder can supply you an Accumulator to do your job.

Accumulators for:

1. Fire-resistant fluids
2. Water operation
3. High pressure
4. High and low temperature operation
5. Special flange mounts for direct connection to check valves or manifold mounts.

These are some of the special applications which are available. Contact your local Milwaukee Cylinder representative or the factory direct with your requirements.