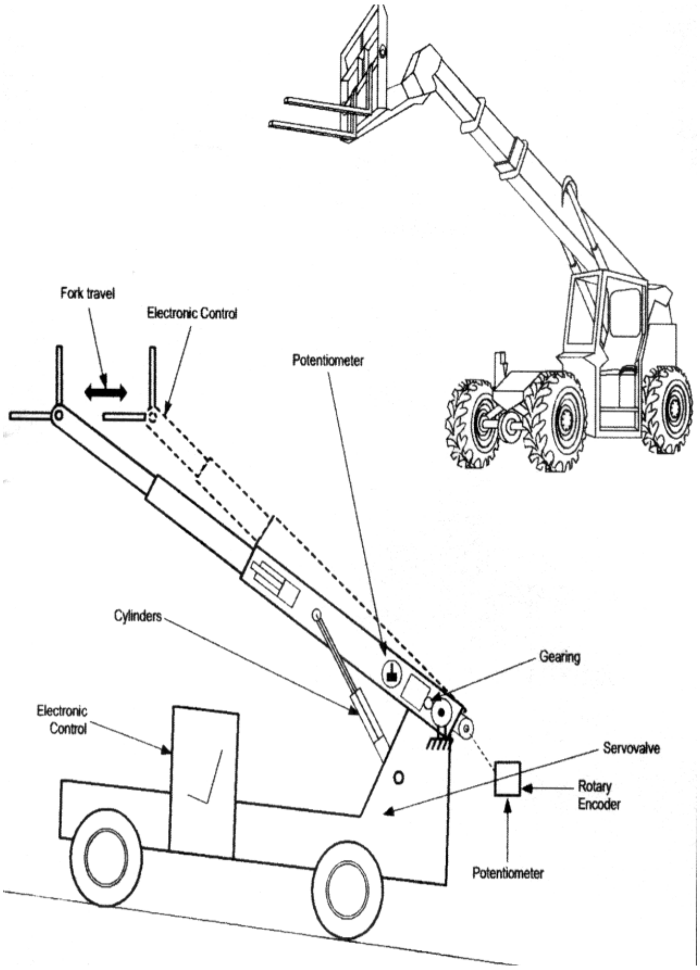
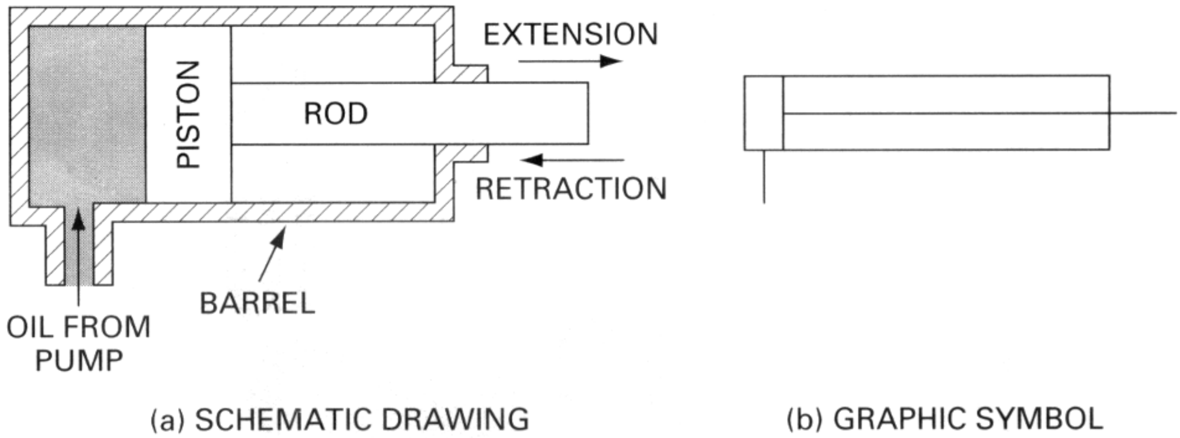
Hydraulic Cylinders

1- INTRODUCTION

Pumps perform the Function of Adding Energy to the Fluid of a Hydraulic System for Transmission to Some Output Location.
Hydraulic Cylinders and Hydraulic Motors do just the Opposite.
They Extract Energy from the Fluid and Convert it to Mechanical Energy to Perform Useful Work.
Hydraulic Cylinders (called Linear Actuators*)* Extend and Retract A Piston Rod to provide a Push or Pull Force to drive The External Load along a Straight-line Path.
Hydraulic Motors (called Rotary Actuators*)* Rotate a Shaft Provide a Torque to drive the Load along a Rotary Path.



2- HYDRAULIC CYLINDER



Single-Acting Hydraulic Cylinder

The Simplest Type of Hydraulic Cylinder is the Single-Acting Design. It consists of a Piston inside a Cylindrical Housing called a Barrel. Attached to One End of the Piston is a Rod, which Extends outside One End of the Cylinder (Rod End).
At the Other End (Blank End) is a Port for the Entrance and Exit of Oil. A Single-Acting Cylinder can exert a Force in Only the Extending Direction as Fluid from the Pump enters the Blank End of the Cylinder.

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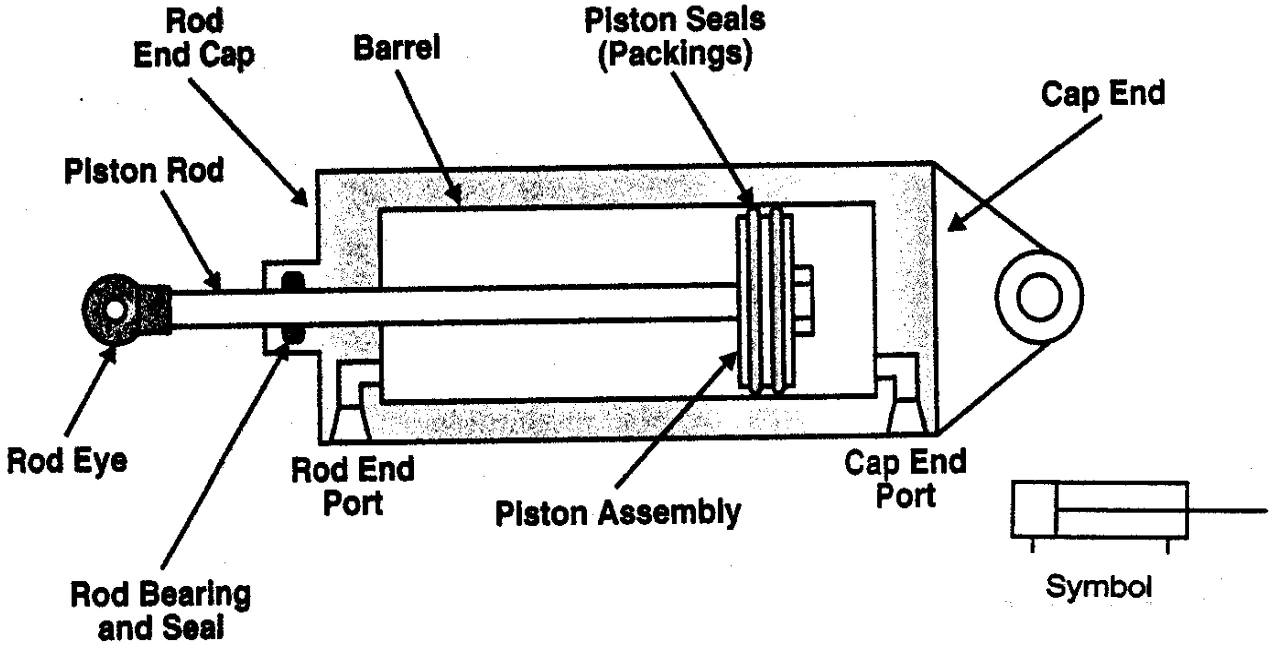
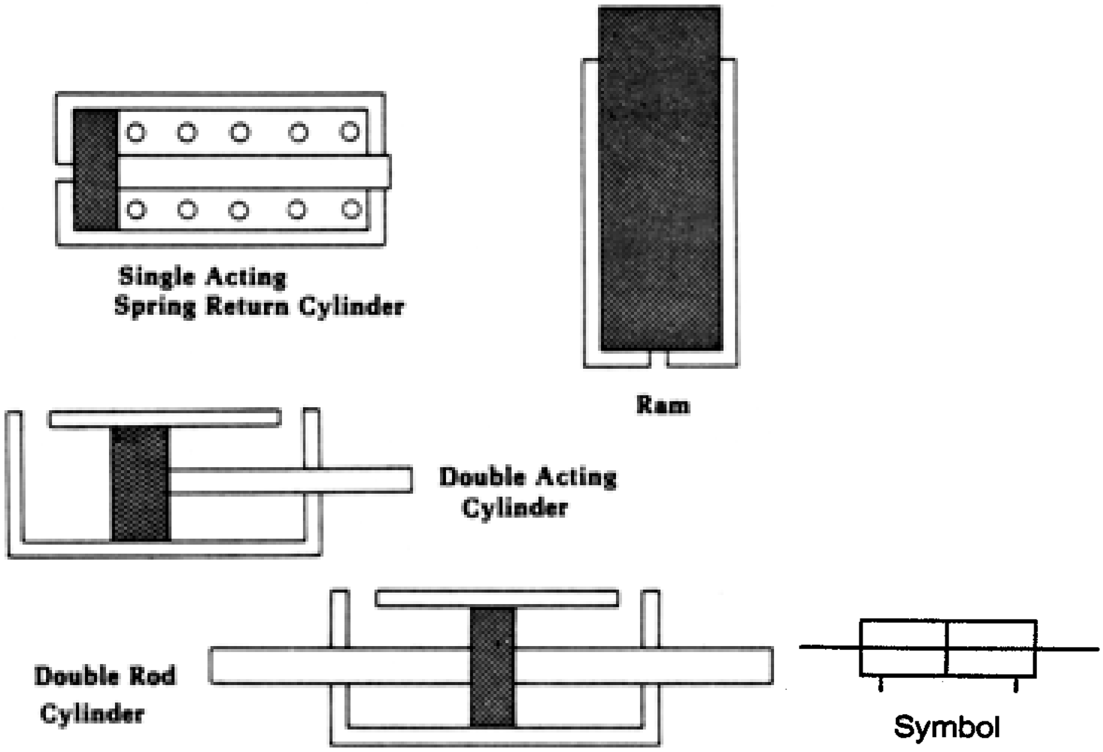
Single-Acting Cylinders do Not Retract Hydraulically. Retraction is accomplished by Using Gravity or by The Inclusion of a Compression Spring in the Rod End.



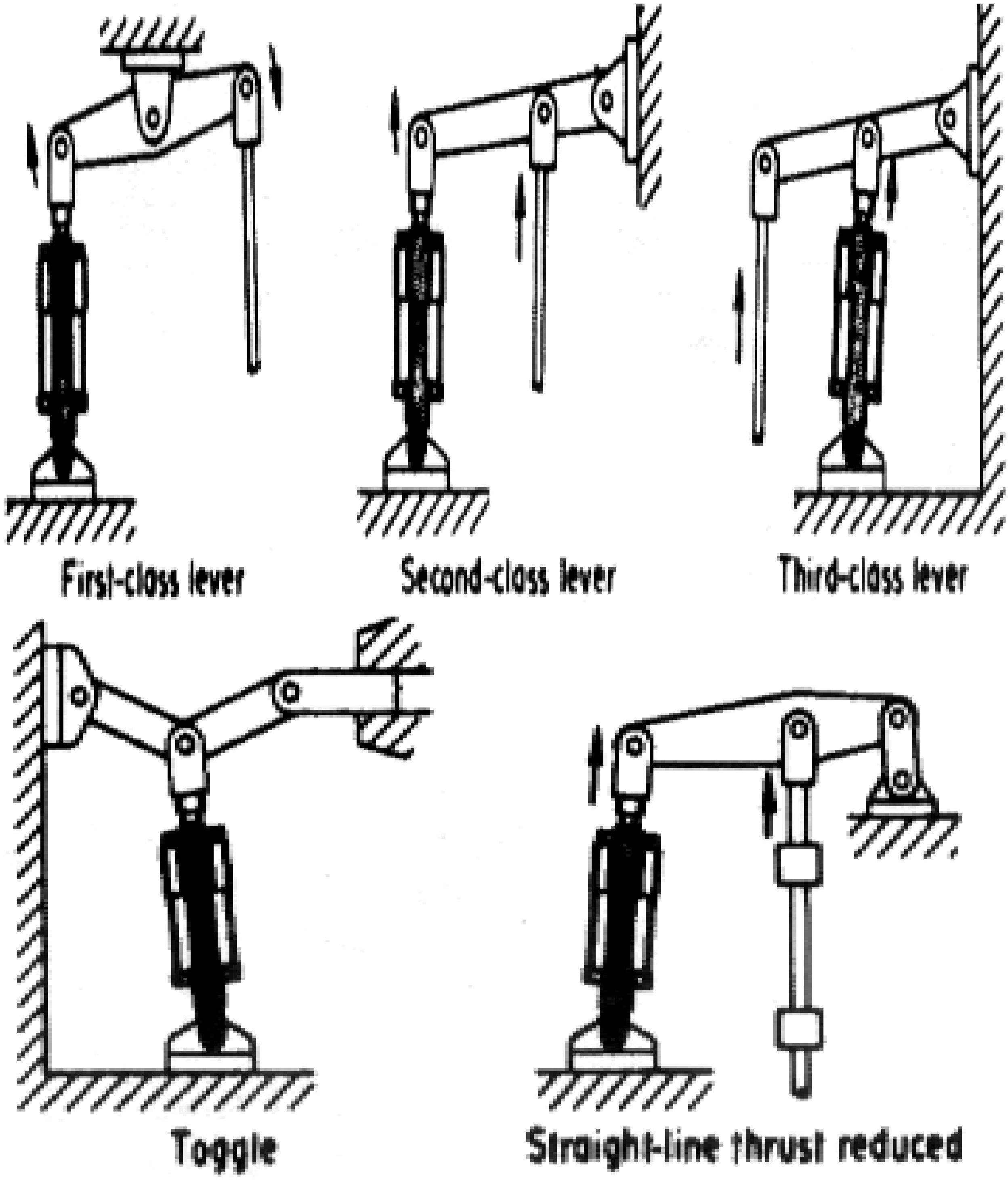
Double-Acting Hydraulic Cylinder

Such a cylinder can be Extended and Retracted Hydraulically. Output Force can be applied in Two Directions (Extension and Retraction).



3- MECHANICAL LINKAGES

These Linkages can transform a Linear Motion into either an Oscillating or Rotary Motion. Linkages can also be employed to Increase or Decrease the Effective Leverage and Stroke of a Cylinder. Much Effort has been made by Manufacturers of Hydraulic Cylinders to Reduce or Eliminate the Side Loading of cylinders created as a result of Misalignment. It is Almost Impossible to achieve Perfect Alignment even though the Alignment of a Hydraulic Cylinder has a Direct Bearing on its life.



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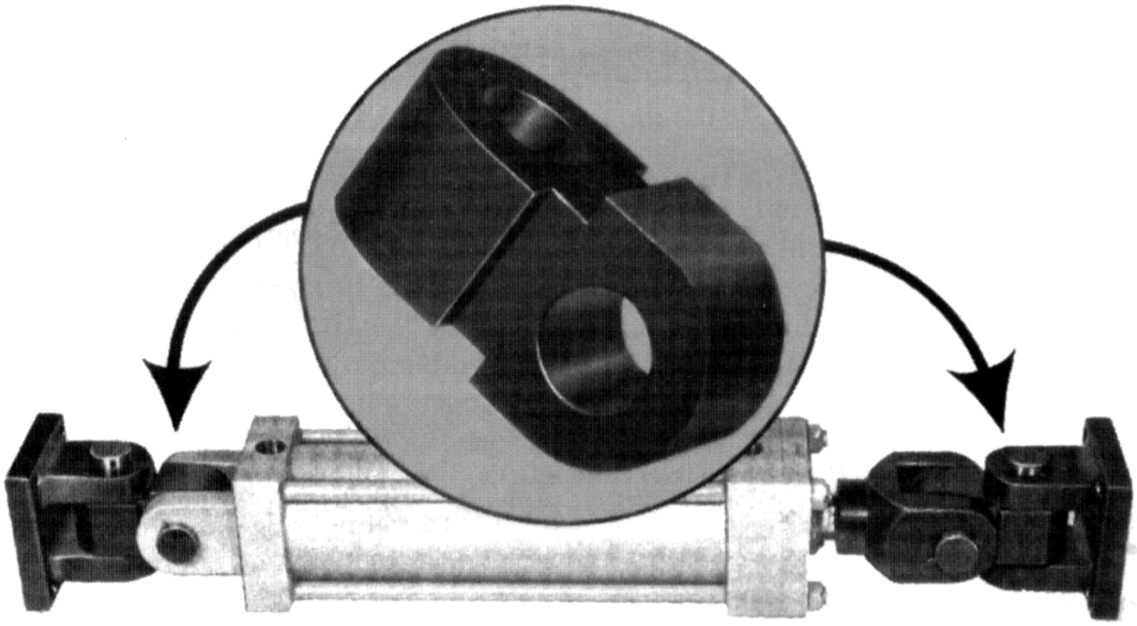
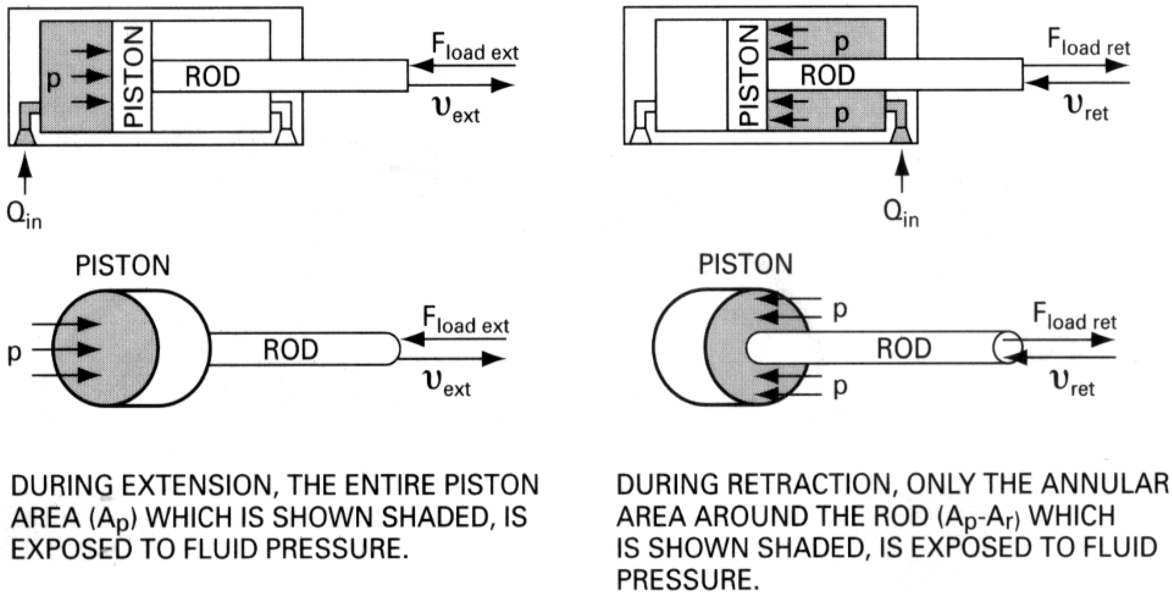
A Universal Alignment Mounting accessory designed to Reduce Misalignment Problems.



By Using one of these Accessory Components and a Mating Clevis at Each End of the Cylinder (see Figure), the following Benefits are obtained:

1. Free Range of Mounting Positions
2. Reduced Cylinder Binding and Side Loading
3. Allowance for Universal Swivel
4. Reduced Bearing and Tube wear
5. Elimination of Piston Blow-By caused by Misalignment

4- CYLINDER FORCE VELOCITY and POWER



(a) EXTENSION STROKE (b) RETRACTION STROKE

Output Force, (F) and Piston Velocity (V) of Double-Acting Cylinders are not the Same for Extension and Retraction Strokes. During the Extension Stroke, Fluid enters the Blank End of the cylinder through the Entire Circular Area of the Piston (Ap). During the Retraction

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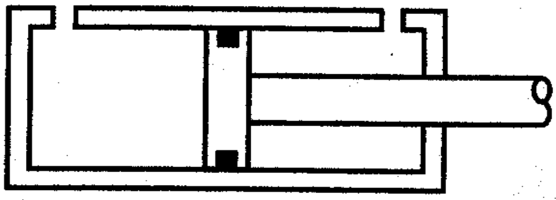
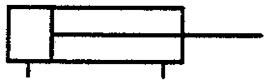
Stroke, Fluid enters the Rod End through The Smaller Annular Area between the Rod and Cylinder Bore (Ap - Ar) where Ap equals the Piston Area and Ar equals the Rod Area. This Difference in Flow-Path Cross-Sectional Area accounts for The Difference in Piston Velocities Since Ap > (Ap - Ar), **The Retraction Velocity > The Extension Velocity** for the Same Input Flow-Rate.
Similarly, during the Extension Stroke, Fluid Pressure bears on Entire Circular Area of the Piston during the Retraction Stroke, Fluid Pressure bears Only on The Smaller Annular Area between the Rod and Cylinder Bore. This Difference in Area accounts for the Difference in Output Forces. Since Ap > (Ap - Ar), **The Extension Force > The Retraction Force** for the Same Operating Pressure.





Symbol

a. Single-Ended Cylinder (double-acting)

Next Equations allow for the Calculation of The Output Force and Velocity for the Extension and Retraction Strokes of 100% Efficient Double-Acting Cylinders.

Extension Stroke

$$F_{ext}(\mathrm{N}) = p\,(\mathrm{Pa}) \times A_p(\mathrm{m}^2)$$

$$v_{ext}(\mathrm{m/s}) = \frac{Q_{in}(\mathrm{m}^3/\mathrm{s})}{A_p(\mathrm{m}^2)}$$

Retraction Stroke

$$F_{ret}(\mathrm{N}) = p\,(\mathrm{Pa}) \times (A_p - A_r)\mathrm{m}^2$$

$$v_{ret}(\mathrm{m/s}) = \frac{Q_{in}(\mathrm{m}^3/\mathrm{s})}{(A_p - A_r)\mathrm{m}^2}$$

Power developed by a Hydraulic Cylinder=Force X Velocity during a given Stroke.
Using this Relationship and Eqs., we arrive at the same result:

Power = PX Q_{in}.

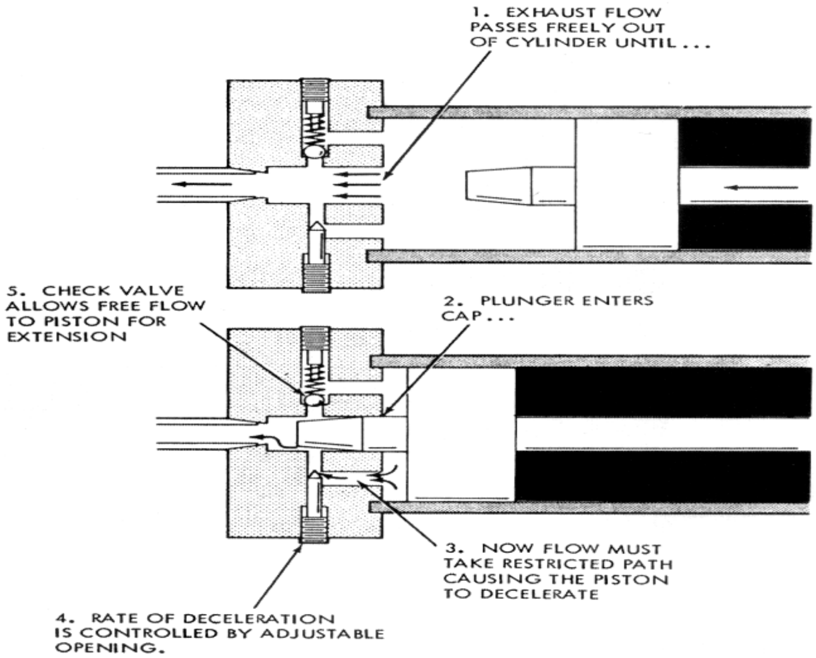
Power developed =Pressure X Cylinder Input Volume Flow-Rate for Both the Extension and Retraction Strokes.
The Horsepower developed by a Hydraulic Cylinder for either the Extension or Retraction Stroke can be found

$$\text{Power (HP)} = \frac{v_p\,(\mathrm{ft/s}) \times F\,(\mathrm{lb})}{550} = \frac{Q_{in}\,(\mathrm{gpm}) \times p(\mathrm{psi})}{1714}$$

Using Metric Units, for either the Extension or Retraction Stroke

$$\text{Power (kW)} = v_p\,(\mathrm{m/s}) \times F\,(\mathrm{kN}) = Q_{in}\,(\mathrm{m}^3/\mathrm{s}) \times p(\mathrm{kPa})$$

5- HYDRAULIC CYLINDER CUSHIONS



Double-Acting Cylinders sometimes contain Cylinder Cushions at the Ends of the Cylinder to Slow the Piston Down near the Ends of the Stroke. This Prevents Excessive Impact When the Piston is stopped by the End Caps. Deceleration Starts the Tapered Plunger Enters the Opening in the Cap. This Restricts the Exhaust Flow from the Barrel to the Port. During the Last Small Portion of the Stroke, the Oil Must exhaust through an Adjustable Opening.

The Cushion Design also incorporates a **Check Valve** to Allow Free Flow to the Piston during Direction Reversal. The Maximum Pressure developed by Cushions at the Ends of a Cylinder Must be Considered since Excessive Pressure Buildup would Rupture the Cylinder