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Introduction

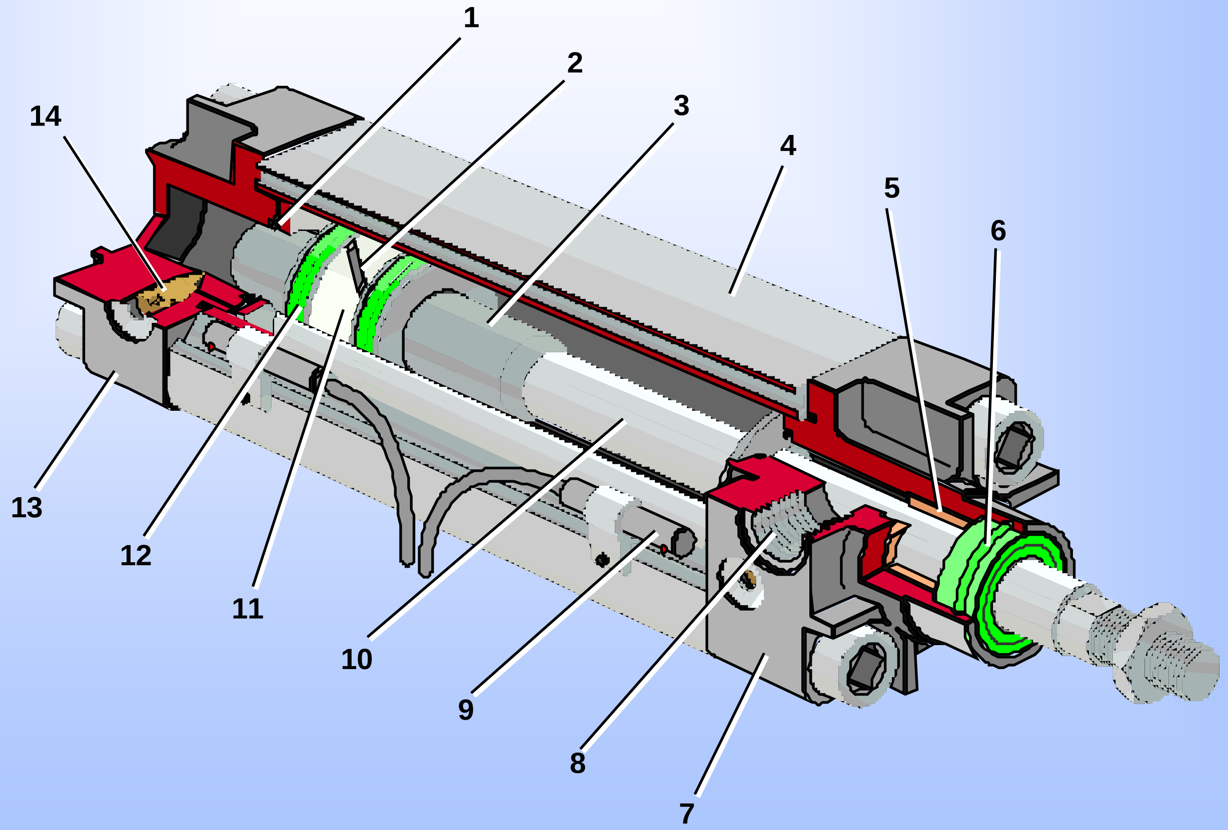
- Pneumatic actuators include linear cylinders and rotary actuators.
- They are devices providing power and motion to automated systems, machines and processes.
- A pneumatic cylinder is a simple, low cost, easy to install device that is ideal for producing powerful linear movement.
- Speed can be adjusted over a wide range.
- A cylinder can be stalled without damage.

Introduction

- Adverse conditions can be easily tolerated such as high humidity, dry and dusty environments and cleaning down with a hose.
- The bore of a cylinder determines the maximum force that it can exert.
- The stroke of a cylinder determines the maximum linear movement that it can produce.
- The maximum working pressure depends on the cylinder design. VDMA cylinders work up to 16 bar.
- Thrust is controllable through a pressure regulator.

Basic Construction

1 cushion seal
2 magnet
3 cushion sleeve
4 barrel
5 guide bush
6 rod and wiper seal
7 front end cover
8 front port
9 reed switch
10 piston rod
11 wear ring
12 piston seal
13 rear end cover
14 cushion screw



Fundamental designs

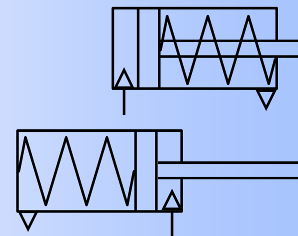
Fundamental designs

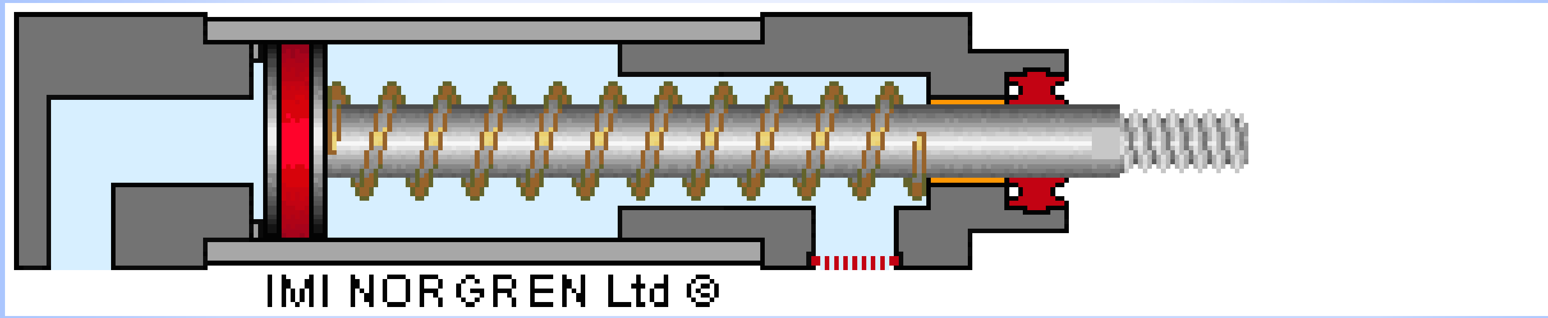
- Pneumatic actuators are made in a wide variety of sizes, styles and types including the following
- Single acting with and without spring return
- Double acting
  - Non cushioned and fixed cushioned
  - Adjustable cushioned
  - Magnetic
- Rodless
- Rotary
- Clamping
- Bellows

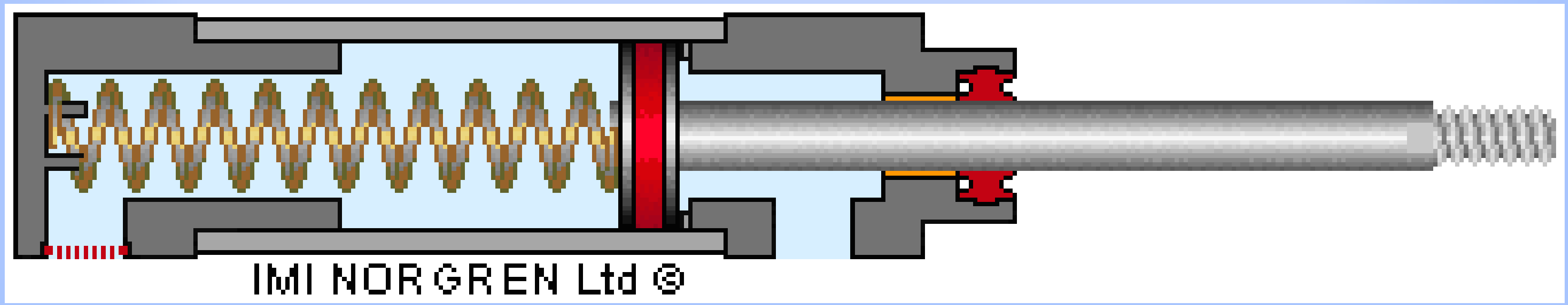
Single acting spring return

- Single acting cylinders have a power stroke in one direction only

- Normally in
- Normally out







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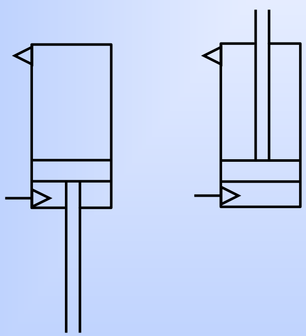
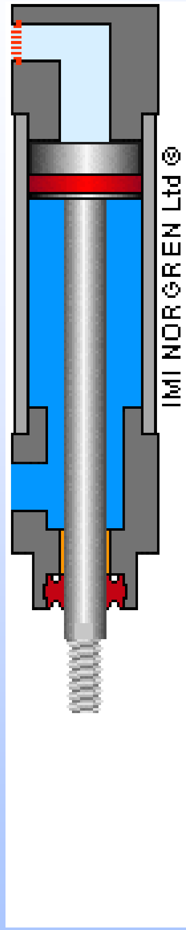
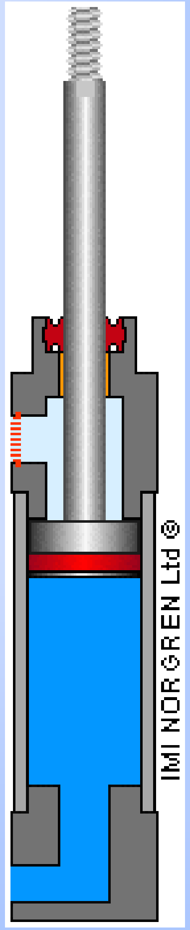
Single acting no spring

- **Gravity or other external force to return the rod**







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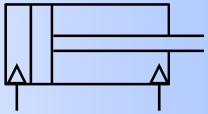
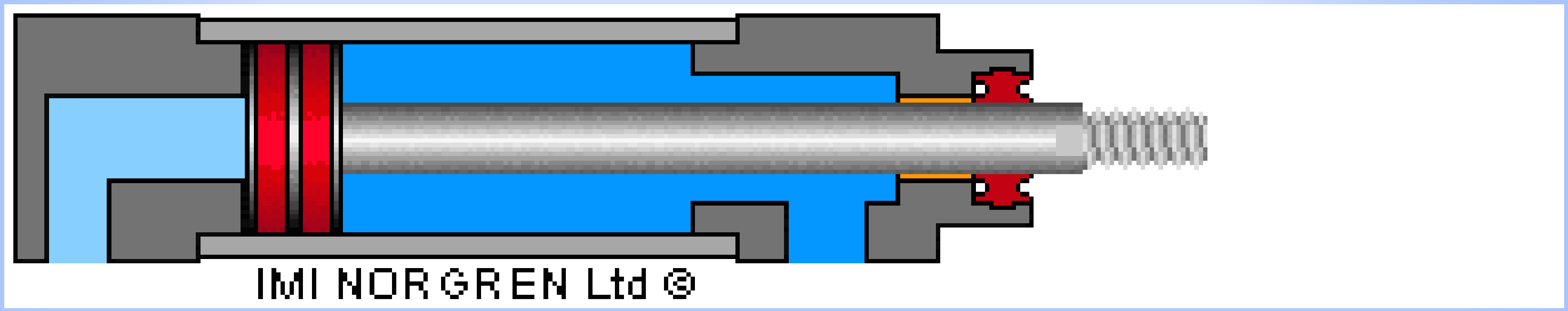
Double acting

- Double acting cylinders use compressed air to power both the outstroke and instroke.
- Superior speed control is possible
- There are
  - Non-cushioned types
  - Fixed cushioned types
  - Adjustable cushioned types

Double acting non-cushioned

- Non cushioned cylinders are suitable for full stroke working at slow speed.
- Higher speeds with external cushions





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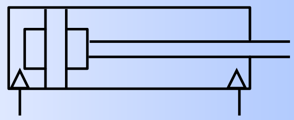
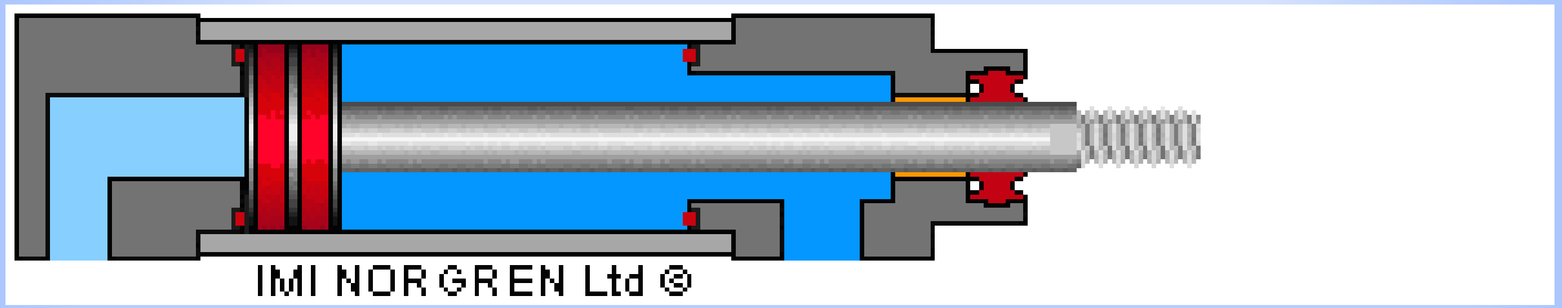
Double acting fixed cushions

- **Small bore light duty cylinders have fixed cushions**





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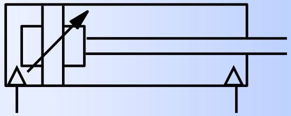
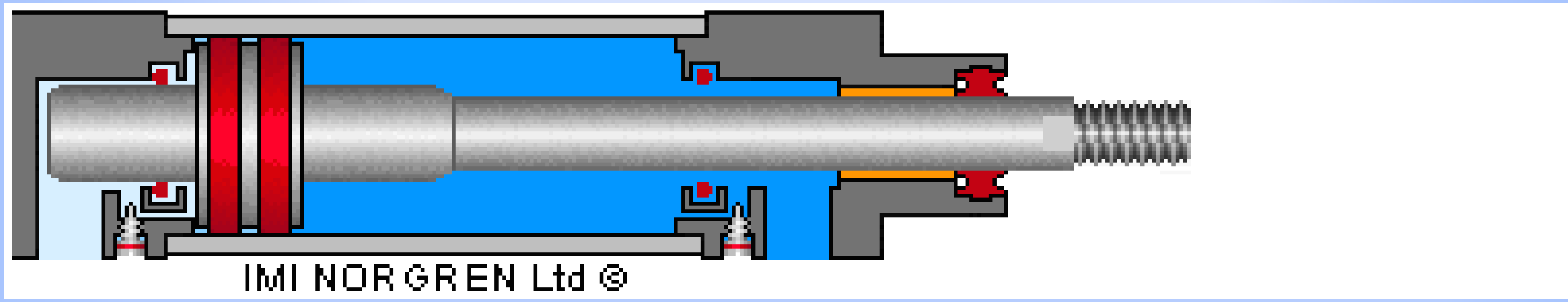
D/A adjustable cushions

- **progressively slows the piston rod down over the last part of stroke**





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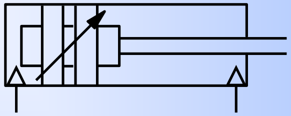
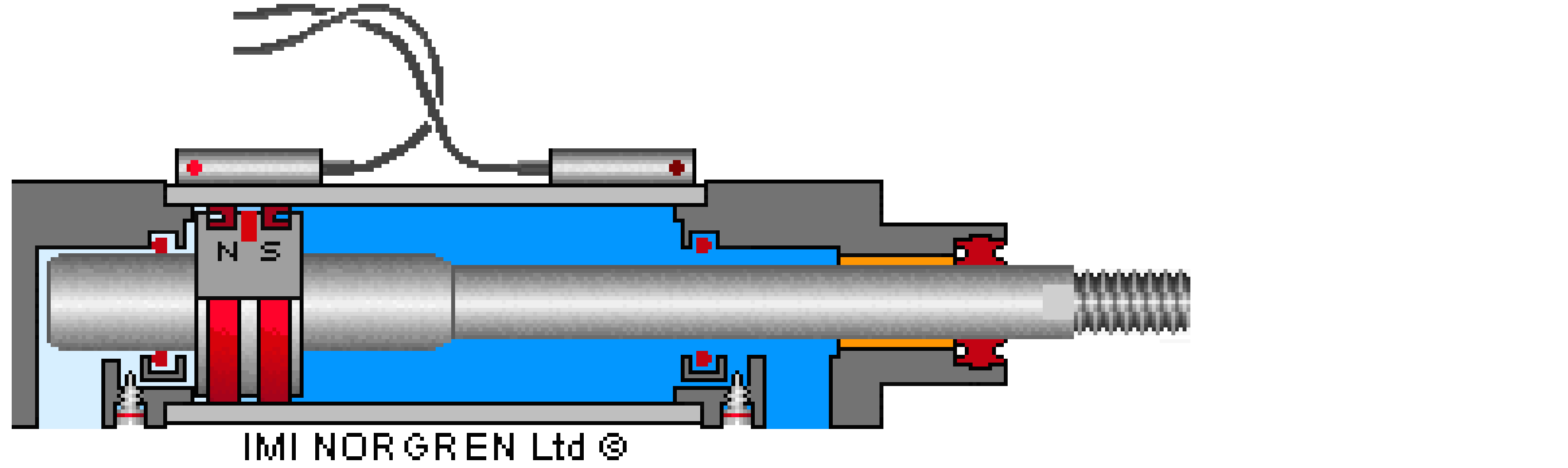
Double acting magnetic

- A magnetic band around the circumference of the piston operates reed switches to indicate positions of stroke.





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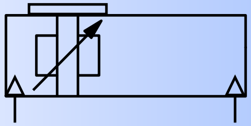
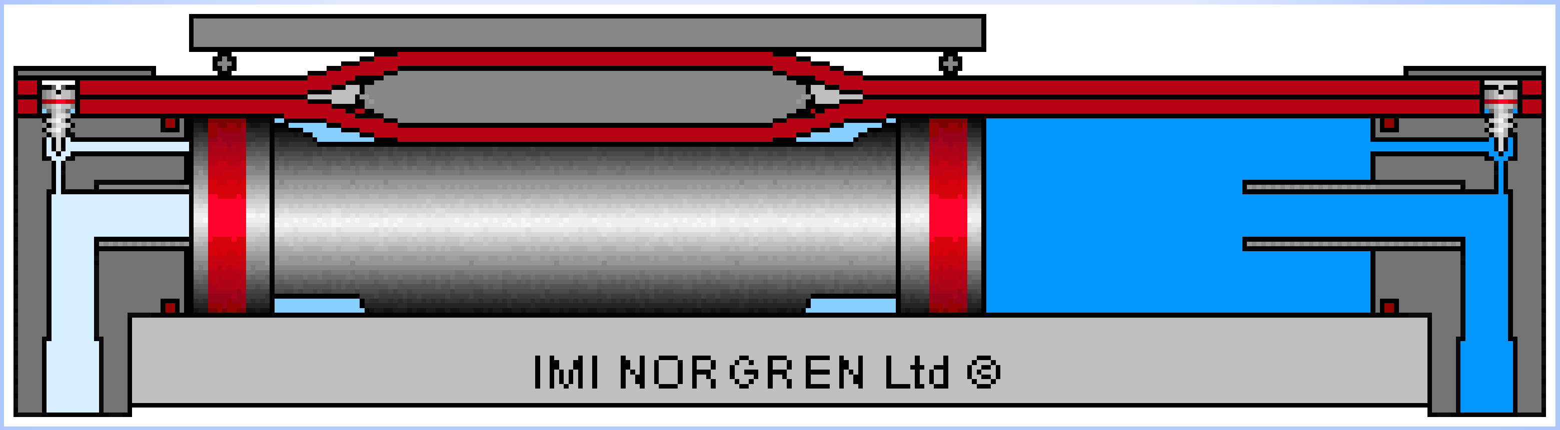
Rodless cylinders

- Contain the movement produced within the same overall length taken up by the cylinder body.
- For example, action across a conveyor belt, or for vertical lifting in spaces with confined headroom.
- Movement is from a carriage running on the side of the cylinder barrel.
- A slot, the full length of the barrel allows the carriage to be connected to the piston.
- Long sealing strips on the inside and outside of the cylinder tube prevent loss of air and ingress of dust.

Rodless cylinder

- **Double acting with adjustable cushions**





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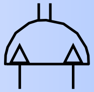
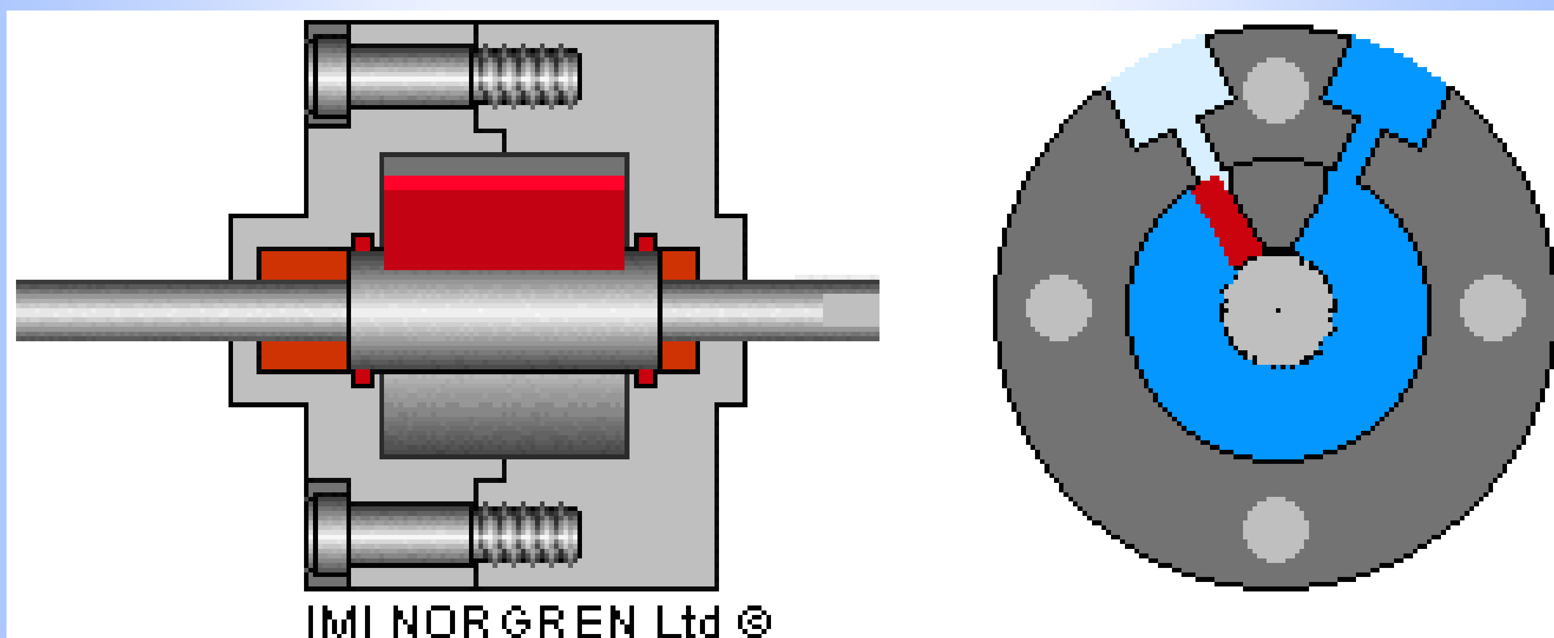
Rotary Actuators

- Used for turning components, operating process control valves, performing a wrist action in robotic applications.
- Provide angular reciprocating rotation up to 360^{o}
- Rotary vane types
- Rack and pinion types

Rotary vane

- **Double acting with 270º angle of rotation**





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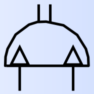
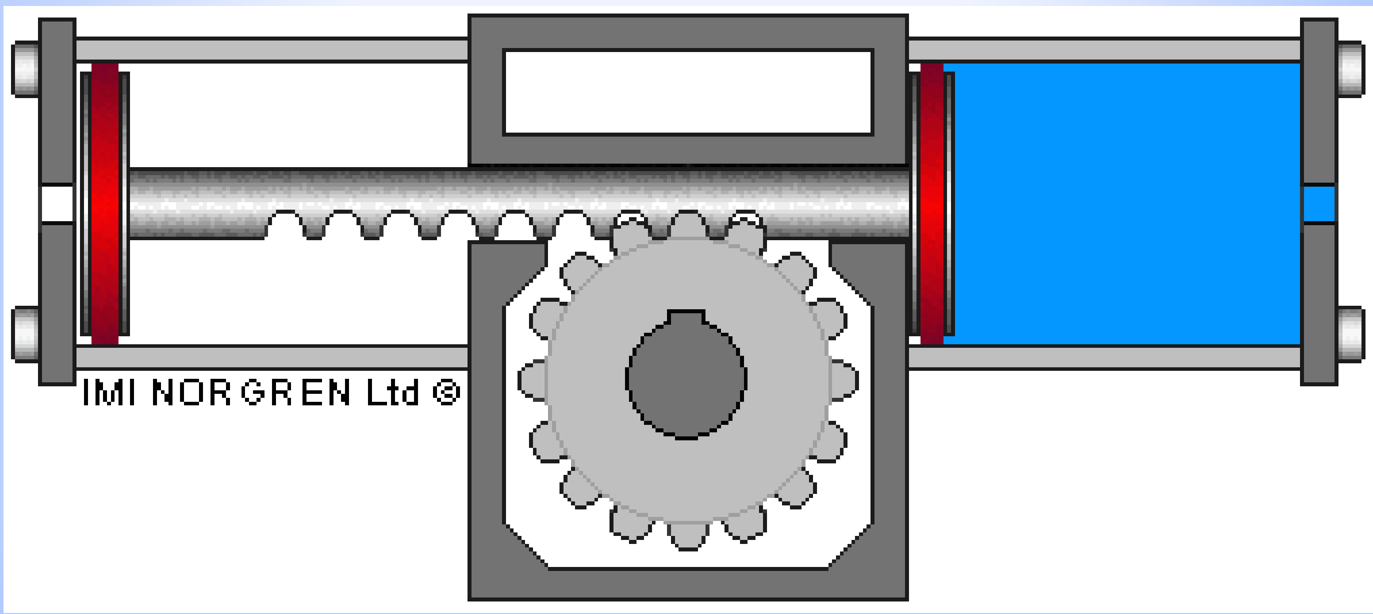
Rotary rack and pinion

- **Double acting rack and pinion**





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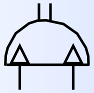
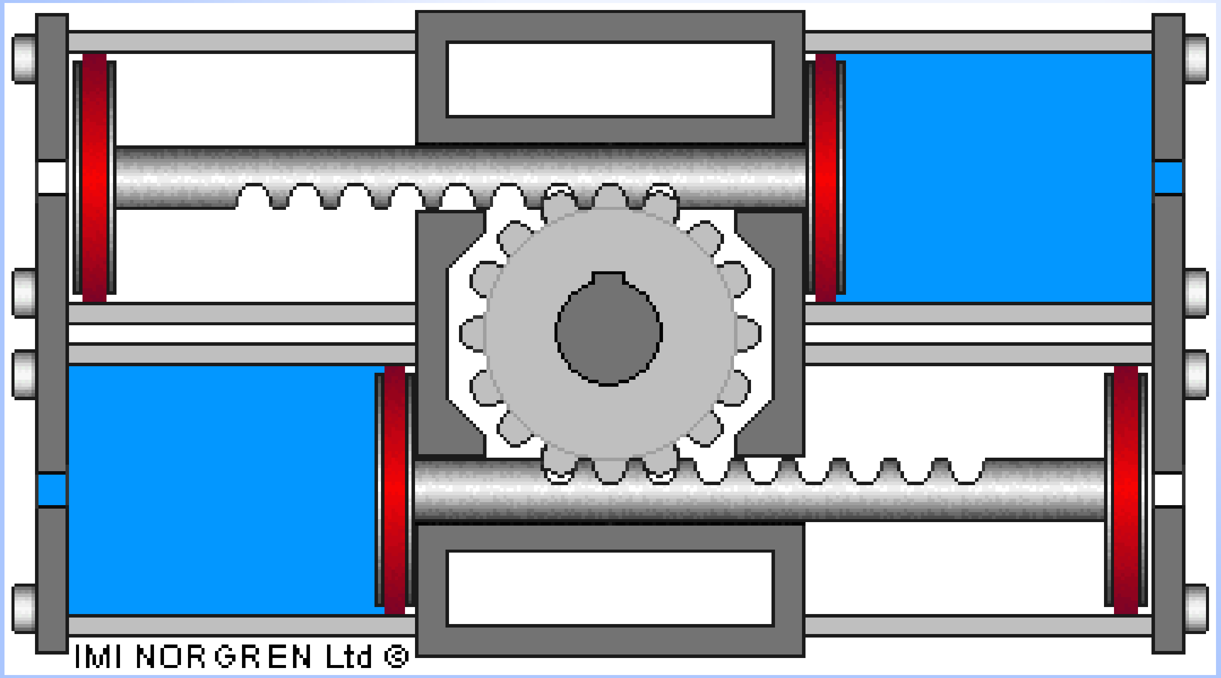
Rotary rack and pinion

- **Double acting double torque**





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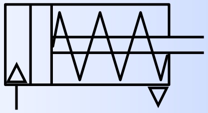
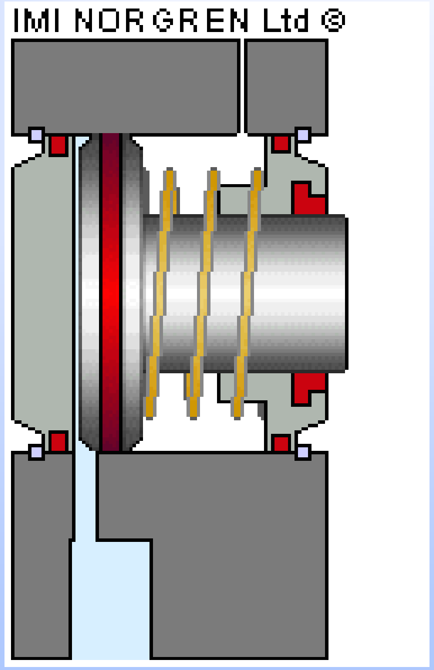
Clamping Cylinders

- For use in confined spaces where only a short stroke is required.
- Short axial overall dimension for their bore size.
- Generally used in light duty applications
- Mostly used in single acting versions, but also available in double acting through-rod styles

Clamping cylinder

- **Normally sprung instroked**





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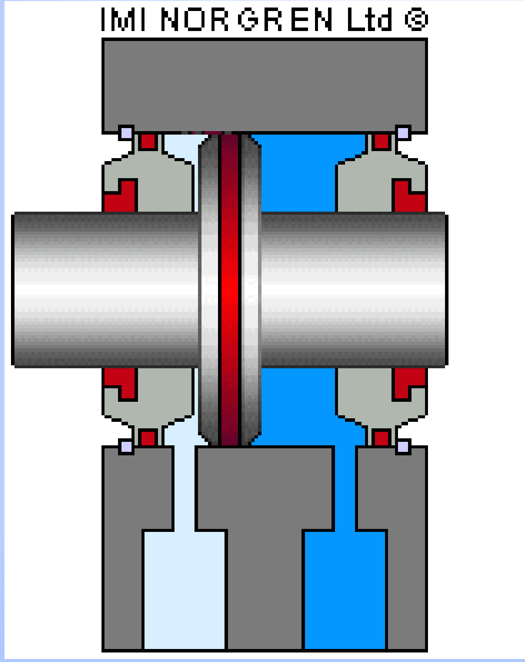
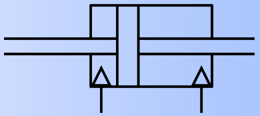
Clamping cylinder

- **Double acting double ended piston rod**





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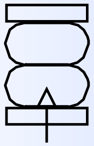
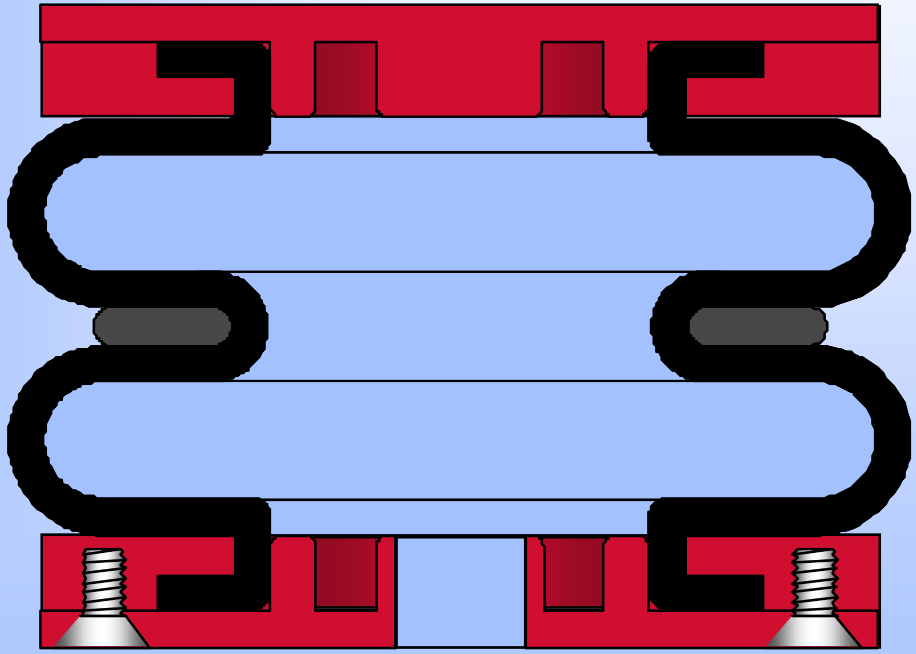
Bellows

- Bellows are durable single acting concertina like actuators.
- Extend when inflated.
- Provide powerful short strokes.
- Have all round compliance allowing them to bend in any direction.
- Can be used as air springs and are ideal for insulating the vibration of supported loads.
- Caution: the maximum extension and compression of the bellows must be limited by external restraints. The bellows must never be pressurised while unrestrained as it will over extend and the end plate is likely to be blown free and could cause serious injuries. When the bellows is exhausted the load must be prevented from crushing it.

Bellows

- **Double convolution type**

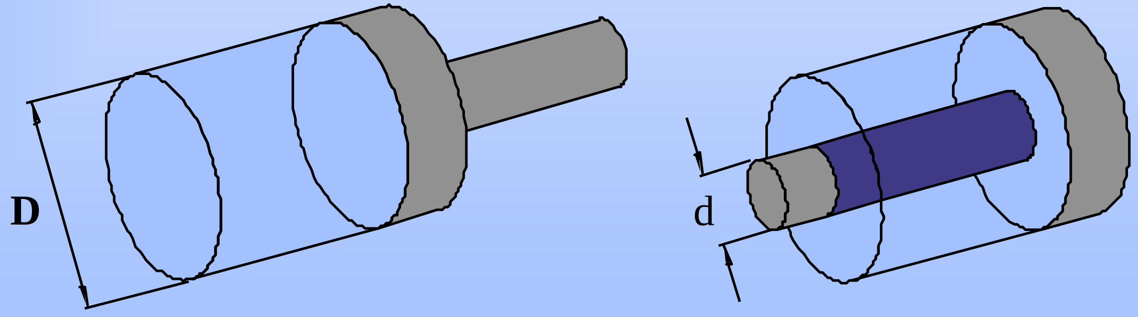




Force

Cylinder sizing for thrust

- The theoretical thrust (outstroke) or pull (instroke) of a cylinder is calculated by multiplying the effective area of the piston by the working pressure.
- The effective area for thrust is the full area of the cylinder bore “D”.
- The effective area for pull is reduced by the cross section area of the piston rod diameter “d”.



Cylinder sizing for thrust

- **In the formula, P is divided by 10 to convert bar to Newtons per square millimetre (1 bar = 0.1 N/mm^2)**

$$Thrust \quad F = \frac{\pi D^2}{4} \frac{P}{10} \quad Newtons$$

Where

D = Cylinder bore in millimetres
P = Pressure in bar
F = Thrust or Pull in Newtons

Cylinder sizing for thrust

- **Pulling force F will be less than the thrust due to the area lost to the piston rod**

$$Pull \qquad F = \frac{\pi (D^2 - d^2) P}{40} \qquad Newtons$$

Where

D = Cylinder bore in millimetres
d = Piston rod diameter in millimetres
P = Pressure in bar
F = Thrust or Pull in Newtons

Cylinder sizing for thrust

- **Example; find the theoretical thrust and pull of a 50 mm bore cylinder supplied with a pressure of 8 bar.**

$$\textit{Thrust} \quad F = \frac{\pi \;\; 50^2 \;.\; 8}{40}$$

$$= 1571 \;\; \textit{Newtons}$$

$$\textit{Pull} \quad F = \frac{\pi \; (50^2 - 20^2) .\; 8}{40}$$

$$= 1319 \;\; \textit{Newtons}$$

Opposing spring force

- Calculating the thrust or pull of single acting cylinders with a spring is more complicated. The spring force opposing the thrust or pull will progressively increase as more of the stroke is achieved. This must be subtracted to find the theoretical force.

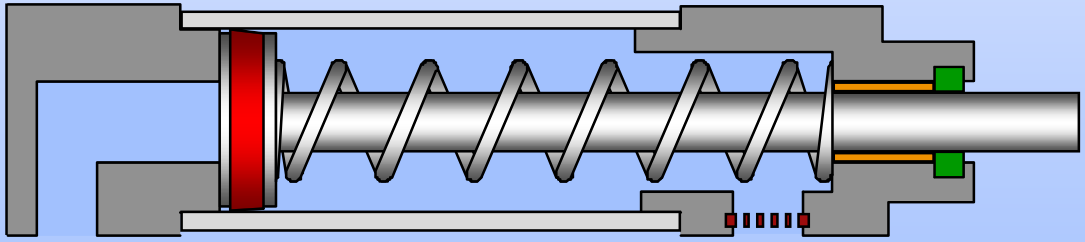


Table of thrust and pulls s/a

- Tables of cylinder forces can be found in catalogues
- The values shown here are for a working pressure of 6 bar
- For another pressure in bar, multiply the thrust value in the table by that pressure then divide by 6

Cylinder bore mm	Thrust N at 6 bar	Min Pull of spring N
10	37	3
12	59	4
16	105	7
20	165	14
25	258	23
32	438	27
40	699	39
50	1102	48
63	1760	67
80	2892	86
100	4583	99

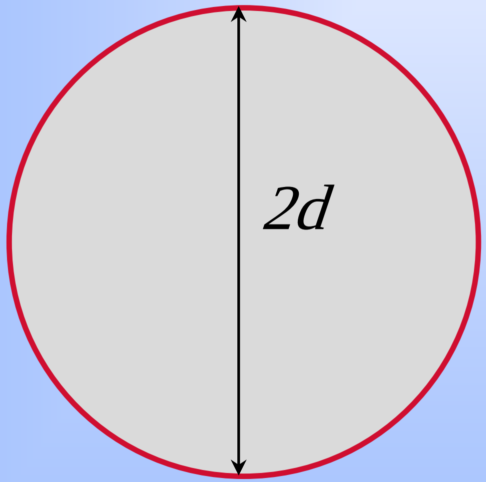
Table of thrust and pulls d/a

Cylinder bore mm (inches)	Piston rod diameter mm (inches)	Thrust N at 6 bar	Pull N at 6 bar
8	3	30	25
10	4	47	39
12	6	67	50
16	6	120	103
20	8	188	158
25	10	294	246
32	12	482	414
40	16	753	633
44.45 (1.75)	16	931	810
50	20	1178	989
63	20	1870	1681
76.2 (3)	25	2736	2441
80	25	3015	2721
100	25	4712	4418
125	32	7363	6881
152.4 (6)	(1 1/2)	10944	10260
160	40	12063	11309
200	40	18849	18095
250	50	29452	28274
304.8 (12)	(2 1/4)	43779	42240
320	63	48254	46384
355.6 (14)	(2/14)	59588	58049

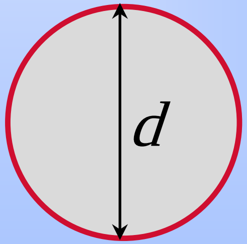
- The pull values are lower due to the annular area of the piston
- The values shown here are for a working pressure of 6 bar
- For another pressure in bar, multiply the thrust values in the table by that pressure then divide by 6

Thrust

- **When estimating the relative thrusts of cylinders with different bore sizes, it can be useful to remember that thrust increases with the square of the diameter. In other words if you double the bore you will quadruple the thrust**



This is 4 times the area of this



Useable Thrust

- When selecting a cylinder size and suitable operating pressure, an estimation must be made of the actual thrust required.
- This is then taken as a percentage of the theoretical thrust of a suitably sized cylinder.
- The percentage chosen will depend on whether the application requires static or dynamic thrust.
- Static thrust at the end of movement for clamping.
- Dynamic thrust during movement for lifting.

Clamping Applications

- In a clamping application the force is developed as the cylinder stops. This is when the pressure differential across the piston reaches a maximum. The only losses from the theoretical thrust will be those caused by friction.
- As a general rule, make an allowance of 10% for friction. This may be more for very small bore cylinders and less for very large ones.

Dynamic Applications

- The thrust or pull developed in dynamic applications is divided into two components
- One for moving the load
- The other for creating a back pressure to help expel the air on the exhausting side of the piston
- For a lightly loaded cylinder, most of the thrust is used to expel the back pressure
- As a general rule, the estimated thrust requirement should fall between 50% and 75% of the theoretical thrust

Piston rod buckling

Piston rod buckling

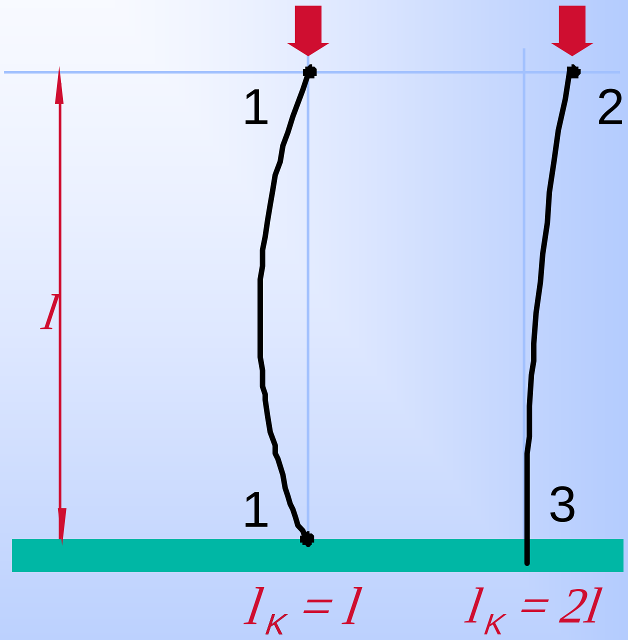
- Some applications require very long stroke cylinders.
- If there is a compressive axial load applied to the piston rod, care must be taken to ensure that the system parameters of rod length, diameter and load are within the safety limits to prevent buckling.
- Euler's Formulae for Elastic Instability is expressed by:

$$F_K = \frac{\pi^2 E I}{l_K^2}$$

Where
Fk = Euler Load (Force to buckle)
E = Modulus of elasticity
I = Second moment of area
lk = Equivalent free buckling length

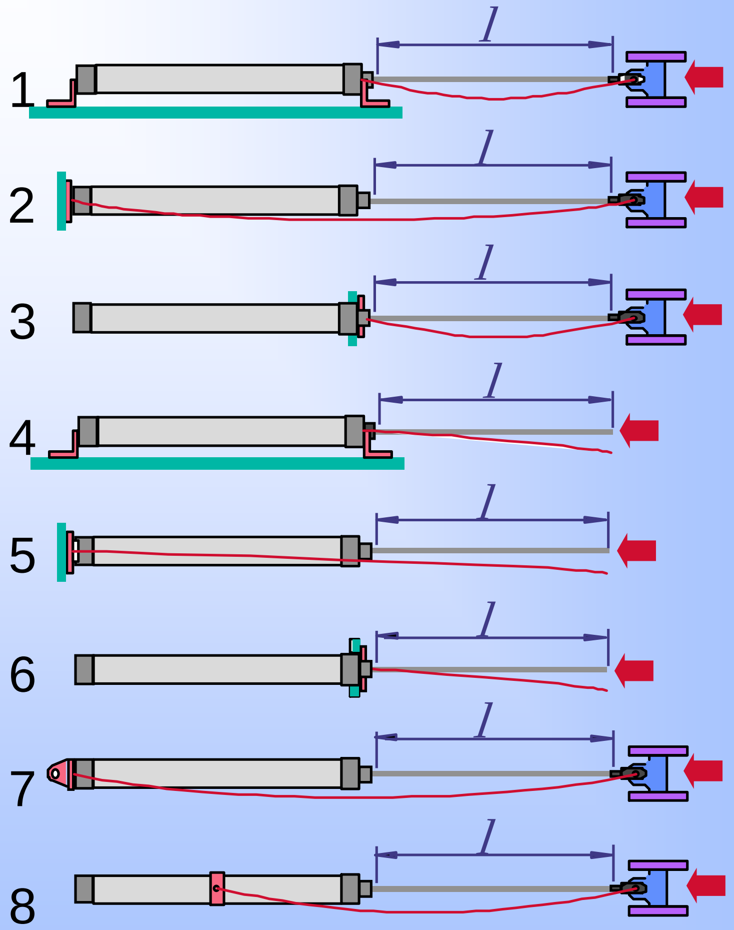
Piston rod buckling

- The equivalent free buckling length l_k used in the formula is determined by the installation.
- For a pin jointed slender column (Euler case 2) the free buckling length l_k is the same as the length l between joints. For a slender column with one end free and the other end fixed (Euler case 1) l_k = 2l



Piston rod buckling

- 1,2 & 3, a worn rod bearing will allow initial buckling as if the rod were pin jointed. assume $l_k = l$. (Euler case 2)
- 4,5 & 6, the end of the rod is free laterally assume $l_k = 2l$. (Euler case 1)
- 7 special case $l_k < 2l$
- 8 special case $l_k < 1.5l$



Piston rod buckling

- Guide table to maximum stroke lengths mm. Safety factor "s" = 5 load is the thrust developed at the given pressure.

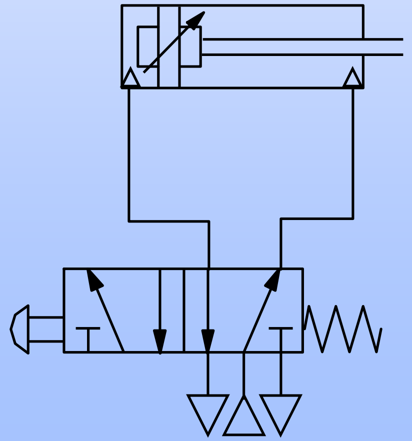
Cylinder	Bar	case 1,2,3	case 4,5,6	case 7	case 8
8032	2	1000	450	960	1100
	6	860	390	530	610
	10	650	290	390	450
	16	500	210	290	340
8040	2	1200	500	1370	1580
	6	1200	500	760	880
	10	950	430	570	660
	16	730	320	430	500

Cylinder	Bar	case 1,2,3	case 4,5,6	case 7	case 8
8050	2	1300	450	1740	1990
	6	1300	450	960	1110
	10	1100	450	720	840
	16	920	410	550	640
8063	2	1300	500	1360	1550
	6	1200	500	750	860
	10	920	410	560	640
	16	700	300	420	490
8080	2	1600	600	1680	1930
	6	1500	600	920	1060
	10	1100	510	690	800
	16	880	380	520	600
8100	2	1500	600	1320	1500
	6	1100	530	710	810
	10	890	380	520	600
	16	670	280	390	450

Speed control

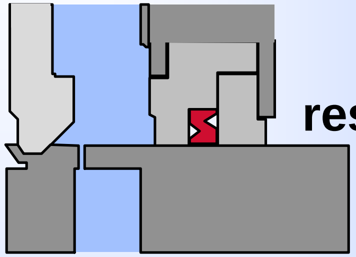
Speed control

- The maximum natural speed of a cylinder is determined by:
  - the cylinder size,
  - the ports size,
  - inlet and exhaust valve flow,
  - the air pressure,
  - the bore and length of the hoses,
  - the load against which the cylinder is working.

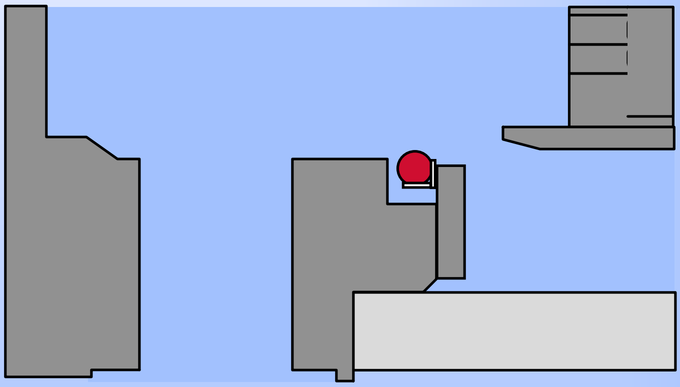


Speed control

- From the natural speed it is possible to increase or reduce it.
- Normally a smaller valve reduces cylinder speed.
- A larger valve might increase cylinder speed.
- A limiting factor will be the aperture in the cylinder ports



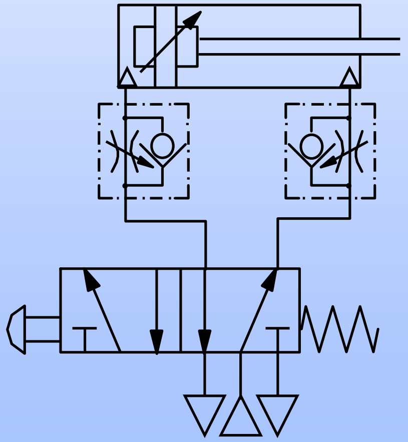
restricted aperture



unrestricted aperture

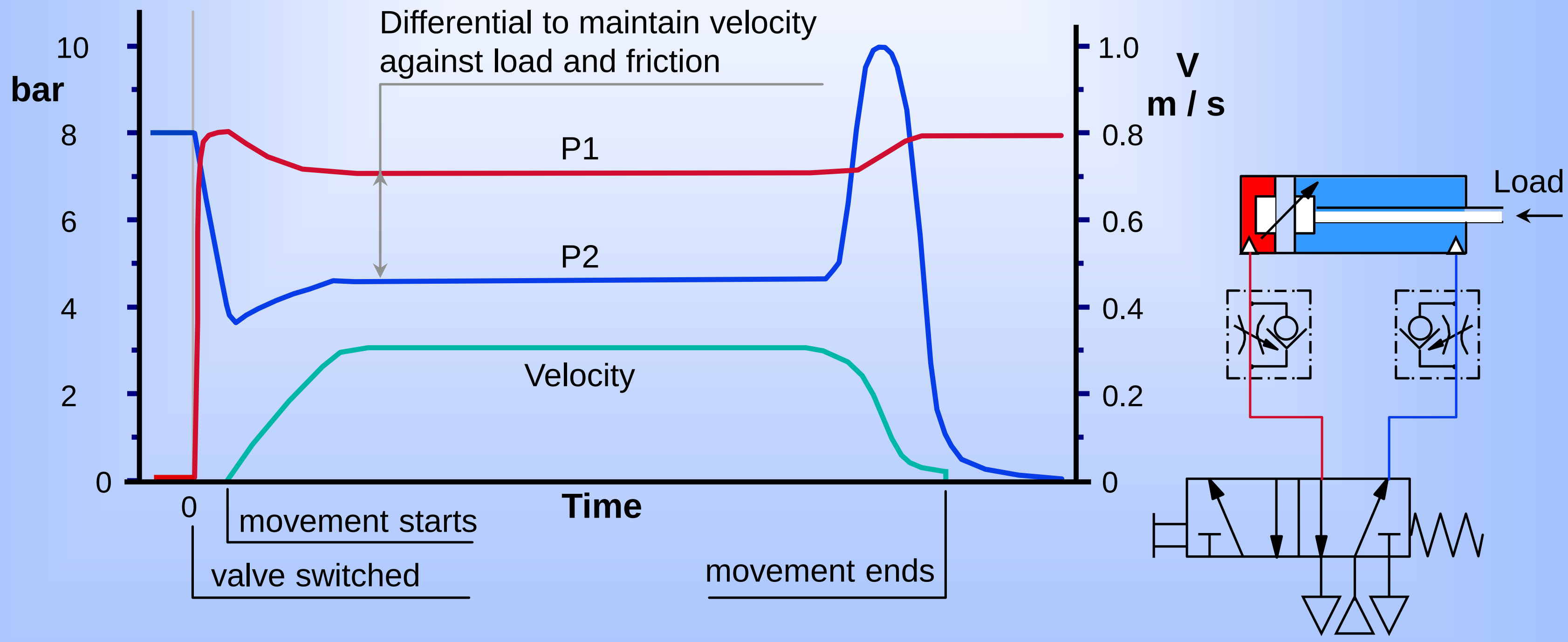
Speed control

- Once a valve, cylinder, pressure and load are selected, adjustable speed control is effected with flow regulators.
- Speed is regulated by controlling the flow of air to exhaust
- The front port regulator controls the outstroke speed and the rear port regulator controls the instroke speed.



Pressure / Velocity graph

- **The behavior of pressure and speed during the stroke of a typical cushioned cylinder fitted with flow regulators.**

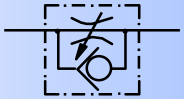


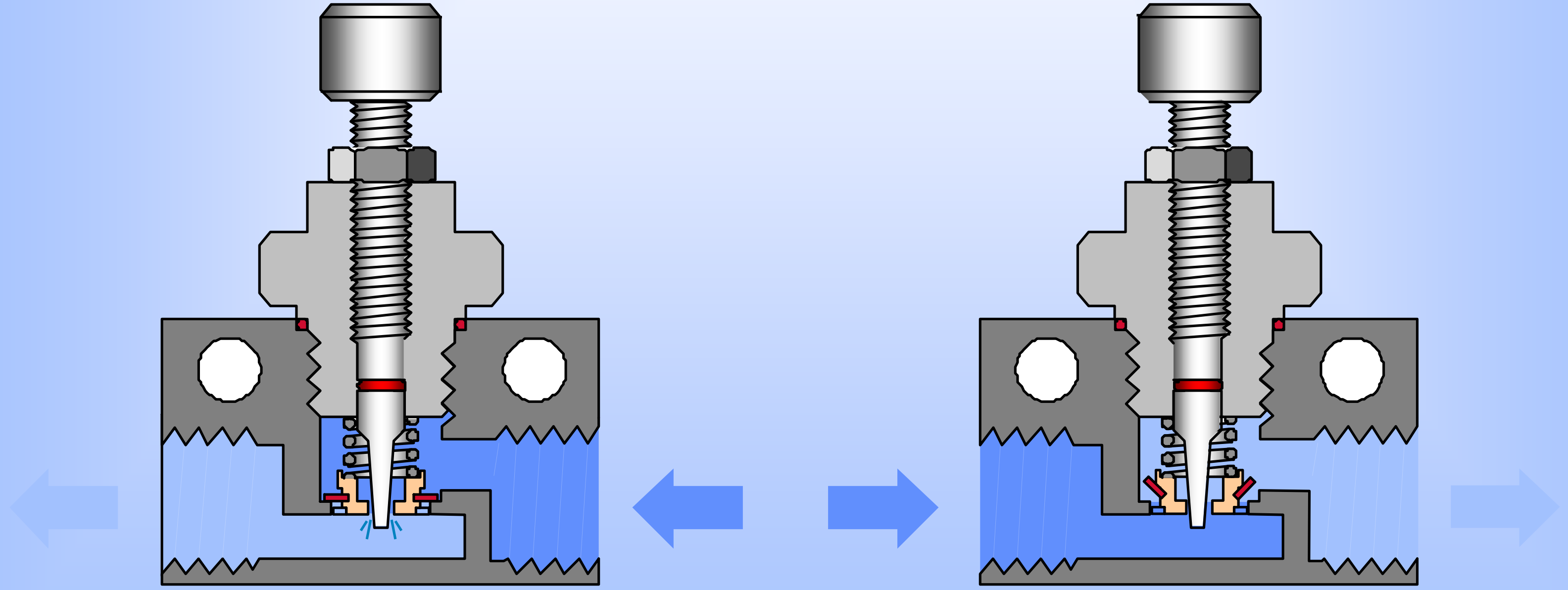
P1 pressure driving the piston forward

P2 back pressure on the annular side of the piston

Flow regulator

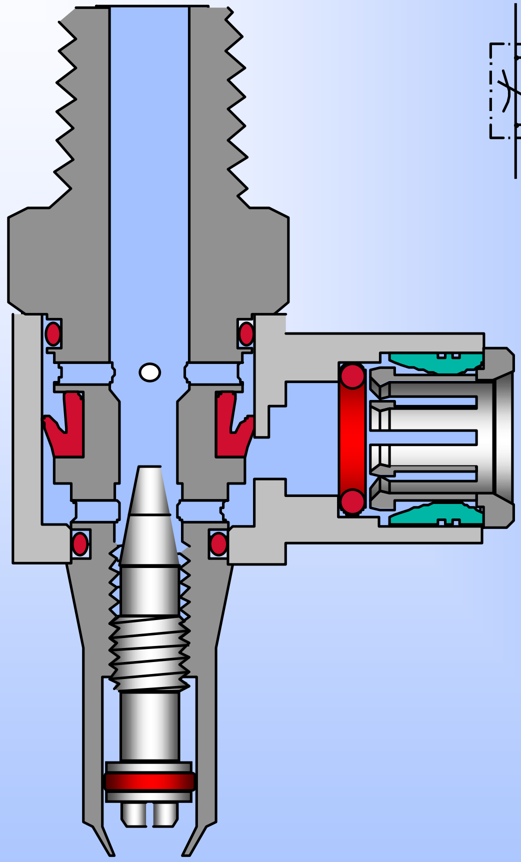
- Uni-directional, line mounted adjustable flow regulator
  - Free flow in one direction
  - Adjustable restricted flow in the other direction

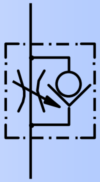




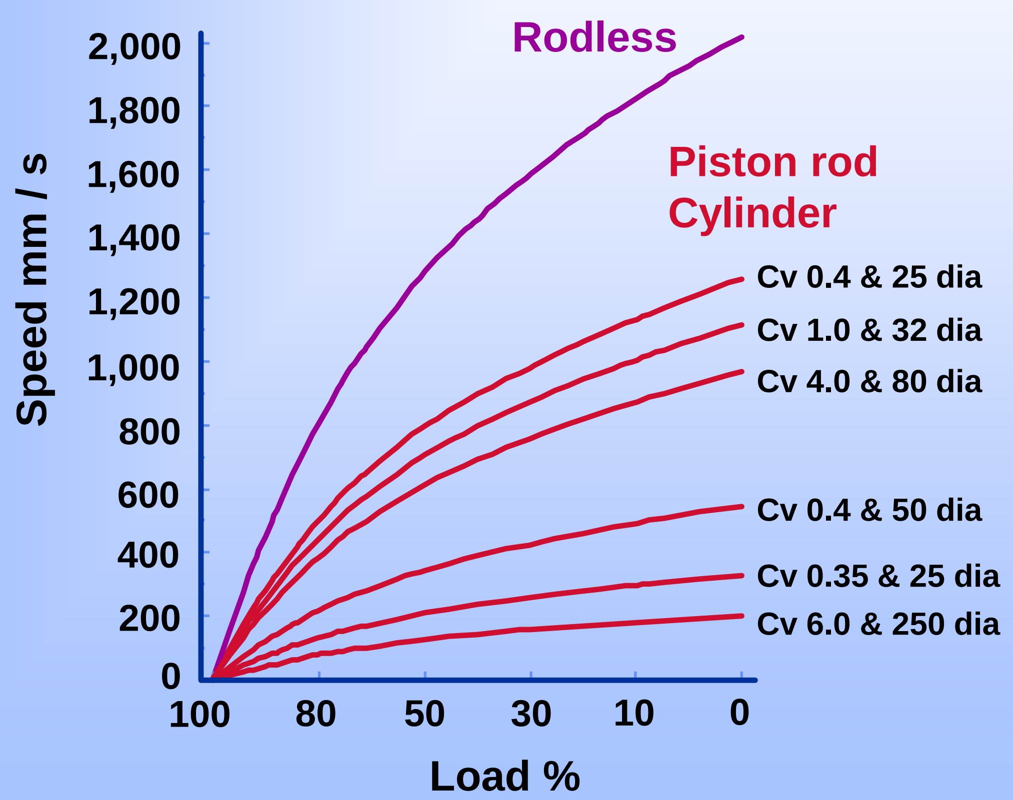
Banjo flow regulator

- Designed to fit directly in to the cylinder port, so placing adjustment at the appropriate cylinder end. Select the type to give conventional flow restriction out of the cylinder and free flow in.





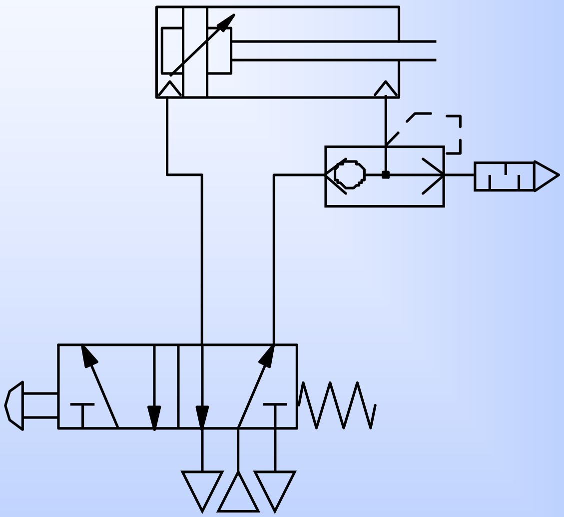
Guide to cylinder speed



- As an approximate guide, the graph shows the likely maximum speeds that can be achieved with typical combinations of valve Cv and cylinder bore against percentage loading.

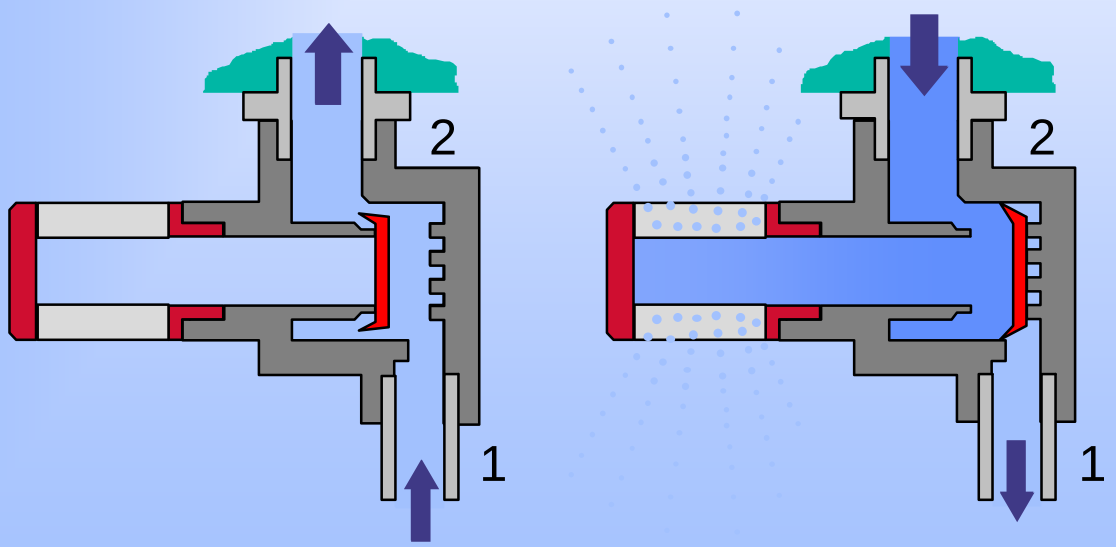
Increasing speed

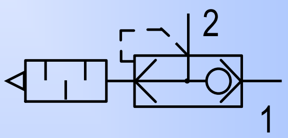
- In some applications cylinder speed can be increased by 50% when using a quick exhaust valve.
- When operated, air from the front of the cylinder exhausts directly through the quick exhaust valve.
- Built in cushioning will be less effective.



Quick exhaust valve

- Air flows from the control valve in to the cylinder past a poppet lip seal.
- When the control valve is operated the falling pressure from the valve allows the poppet seal to snap open.
- The air in the cylinder rapidly exhausts through the large exhaust port and silencer.





Response times

- Likely time of one cycle.
  - overall response time of the valve and cylinder.
- Table of guide times for double acting cylinders.
  - 150-mm stroke.
  - one cycle out and instroke
  - 5/2 solenoid / spring valve.
  - 6 bar pressure supply.
  - 1m of tubing between valve and cylinder.
  - no load on the piston rod

Bore	Valve ports	Cv	Time m secs
20	1/8	0.3	225
50	1/8	0.4	700
63	1/4	1.0	525
100	1/4	1.0	1100
160	½	3.5	950
200	½	3.5	1560
200	1	7.8	650
320	1	7.8	1280

Air consumption

Cylinder air consumption

- There are two parts to the air consumption of a cylinder.
- One is the volume displaced by the piston multiplied by the absolute working pressure.
- Two is the unswept volume such as cavities in the end cover and piston, the cylinder ports, tubing and valve cavities, all multiplied by the gauge pressure.
- The unswept part is likely to be a small percentage and will vary with individual installations. A general allowance of around 5% can be added to cover this.

Cylinder air consumption

- For a double acting cylinder the volume of free air displaced by the piston in one complete cycle
- Push stroke $$V = \frac{\pi D^2}{4} \cdot S \cdot (P_s + P_a) \cdot 10^{-6}$$
- Pull stroke

$$V = \frac{\pi (D^2 - d^2)}{4} \cdot S \cdot (P_s + P_a) \cdot 10^{-6}$$

Where
D = cylinder bore mm
d = rod diameter mm
V = volume in dm^3 free air
S = stroke mm
P_s = supply gauge pressure bar
P_a = atmospheric pressure (assumed to be 1 bar)

Cylinder air consumption

- To estimate the total average air consumption of a pneumatic system make a calculation for each cylinder in the system. Add these together and add 5% .
- It is important to understand that the instantaneous flow requirement for a system will be higher than the average and in some cases very much higher.

Table of consumption

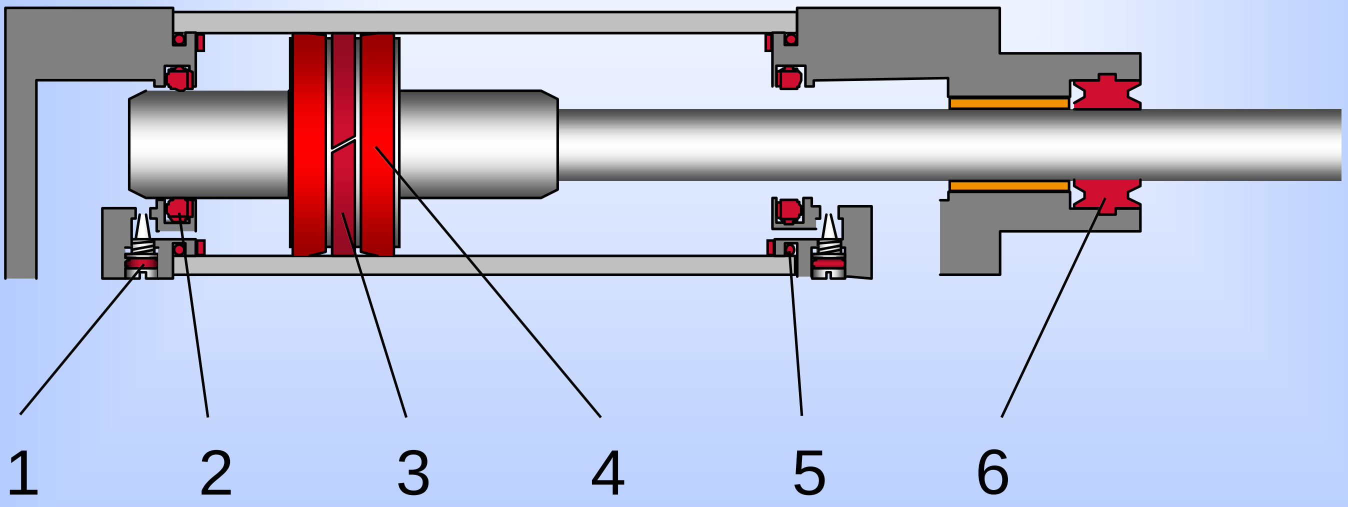
Bore mm	Rod mm	Push stroke consumption dm3/mm of stroke at 6 bar	Pull stroke consumption dm3/mm of stroke at 6 bar	Combined consumption dm3/mm of stroke/cycle
10	4	0.00054	0.00046	0.00100
12	6	0.00079	0.00065	0.00144
16	6	0.00141	0.00121	0.00262
20	8	0.00220	0.00185	0.00405
25	10	0.00344	0.00289	0.00633
32	12	0.00563	0.00484	0.01047
40	16	0.00880	0.00739	0.01619
50	20	0.01374	0.01155	0.02529
63	20	0.02182	0.01962	0.04144
80	25	0.03519	0.03175	0.06694
100	25	0.05498	0.05154	0.10652
125	32	0.0859	0.08027	0.16617
160	40	0.14074	0.13195	0.27269
200	40	0.21991	0.21112	0.43103
250	50	0.34361	0.32987	0.67348

- **Take each figure and multiply by the stroke in mm. For pressures other than 6 bar multiply by the absolute pressure divided by seven.**

Seals

Seals

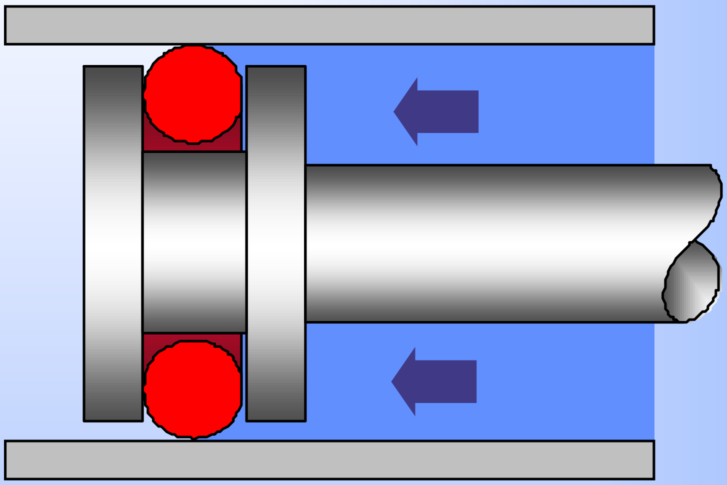
- **Identification of seals in a double acting adjustable cushioned cylinder**



1 Cushion screw seal
2 Cushion seal
3 Wear ring
4 Piston seal
5 Barrel seal
6 Piston rod/wiper seal

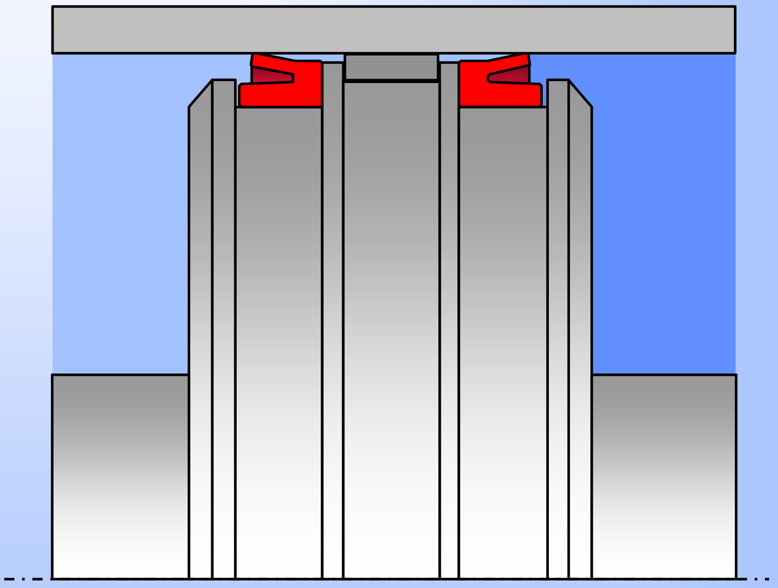
‘O' Ring piston seals

- An ‘O'-ring piston seal is a loose fit in the groove, with the outer diameter just in contact with the cylinder bore. When pressure is applied the ‘O'-ring is pushed sideways and outwards to seal the clearance between the outer diameter of the piston and the cylinder wall.



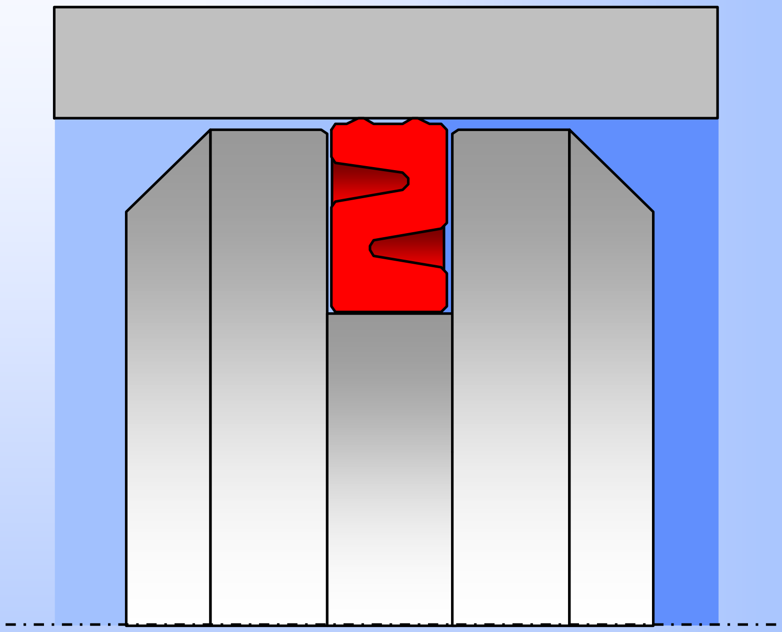
Cup seals

- Used on medium and large bore cylinders.
- Seal in one direction only.
- One for single acting
- Two for double acting
- Low radial exertion to reduce the static break out friction
- High compliance



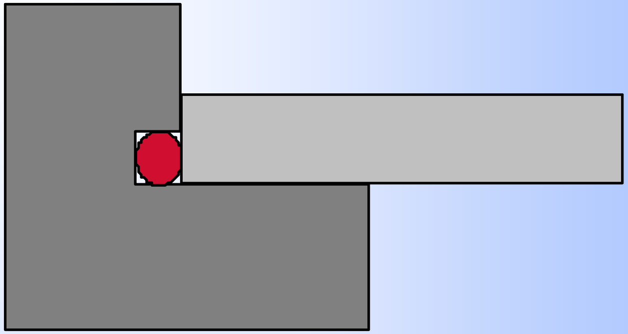
Z Rings

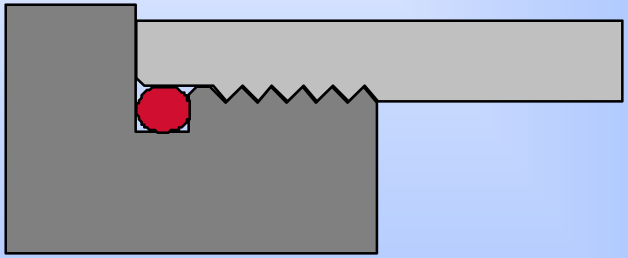
- Used for piston seals on smaller bore cylinders
- Seals in both directions
- Take up less space
- Z shape acts as a light radial spring providing low radial exertion and high compliance.



‘O' Ring barrel seals

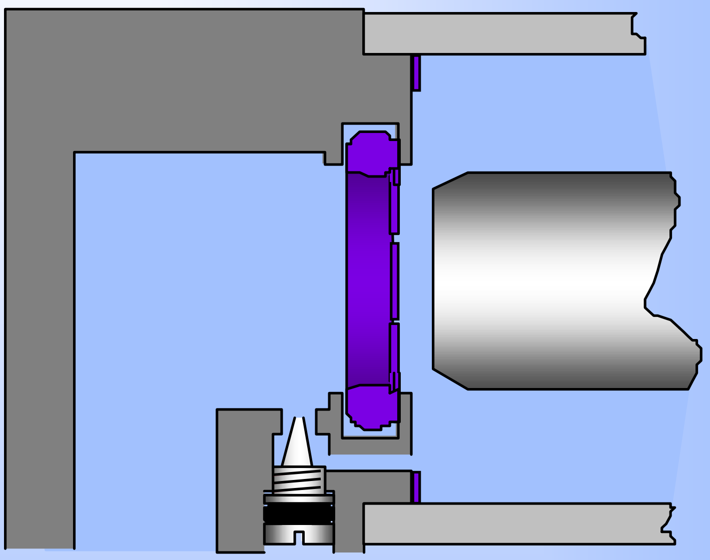
- These are static seals and will be a tight fit in their groove locations
- Butt joint seal for tie rod construction.
- Screwed barrel and end cover





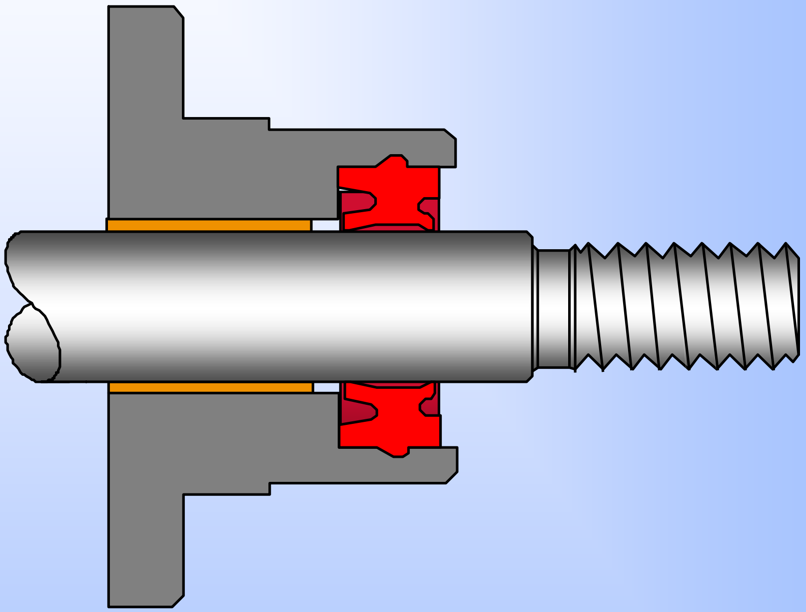
Cushion seals

- These seals perform a dual role of seal and non return valve.
- Sealing on the inside diameter and one face when cushioning.
- Air flows freely around the outside diameter and grooves in the other face when the piston is driven out.



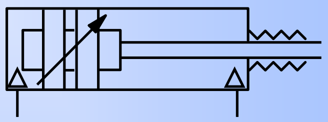
Piston rod seals

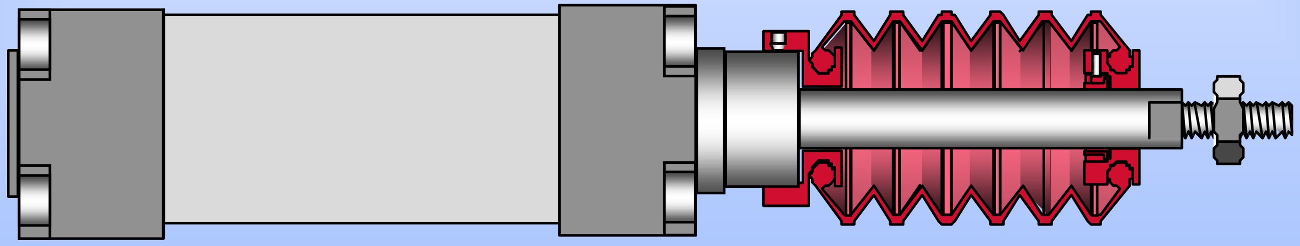
- One piece seal serves the dual role of pressure seal and wiper seal.
- Outer body of the seal is a pressure tight fit within the bearing housing.
- Cleaning action removes abrasive particles that can settle on the rod when outstroked.
- Special seal for harsh environments



Piston rod bellows

- Alternative to special wiper seals, also referred to as gaiters.
- Specify as original equipment, as the cylinder requires a slightly longer than standard piston rod.
- Ideal solution where the outstroked piston rod is likely to be scratched or abraded by falling debris.



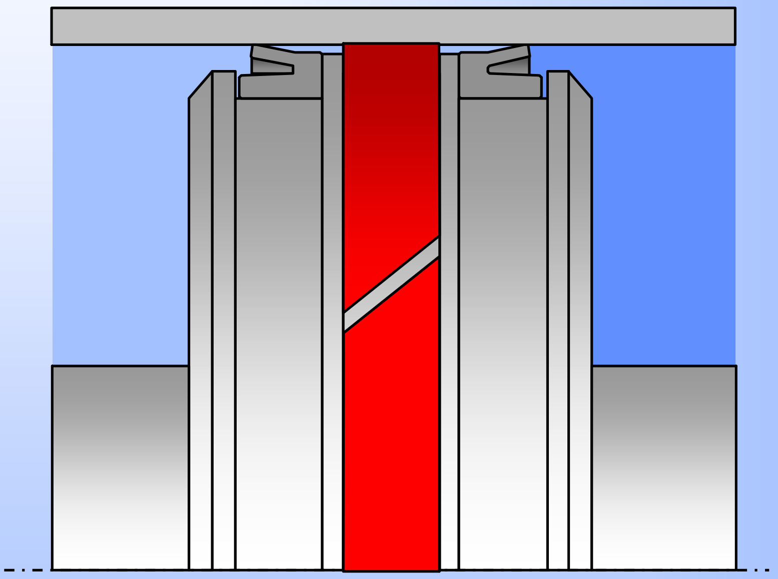


Extreme operating temperatures

- Standard seals are generally recommended for continuous running in the range +2ºC to +80ºC.
- Higher temperatures will soften the seals so that they wear quickly and produce more friction. Lower temperatures will harden the seals which make them brittle and liable to splitting and cracking.
- For high temperature applications with continuous running at an ambient up to 150ºC, cylinders fitted with "Viton" seals should be specified.

Wear ring

- A wear ring is an open band fitted around the piston.
- It is made from a hard plastic material.
- In the event of a high side load, it becomes a bearing that prevents excessive distortion of the seals.
- Protects against scoring of the barrel from the piston.



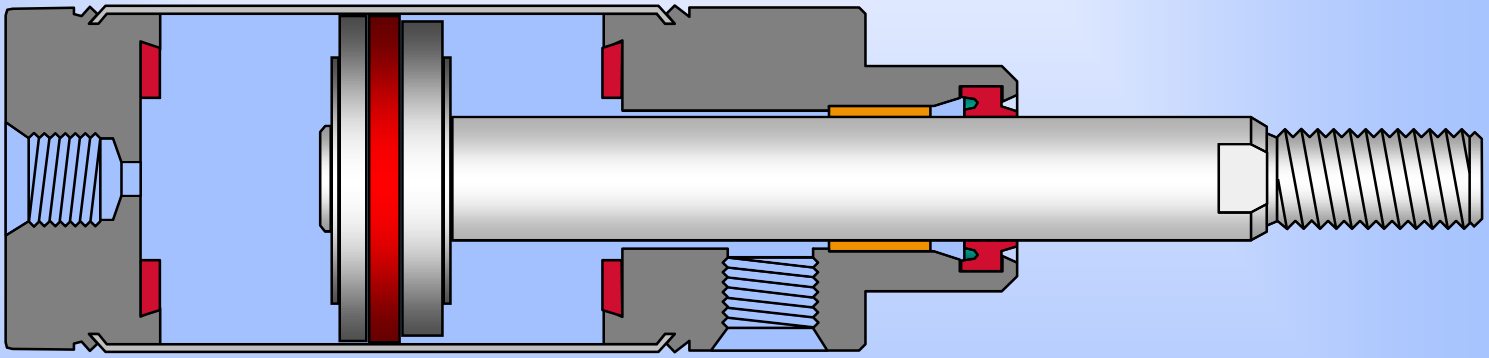
Cushion design

Cushion design

- Cushioning protects a cylinder and load by absorbing the energy at the end of stroke. This results in progressive deceleration and gentle contact between the piston and end cover.
- Fixed cushioning with shock absorbing pads is applied to small light duty cylinders which have low mass in the piston, rod and load.
- Larger cylinders have adjustable pneumatic cushions which function over the final 2 cm of stroke.

Fixed cushion design

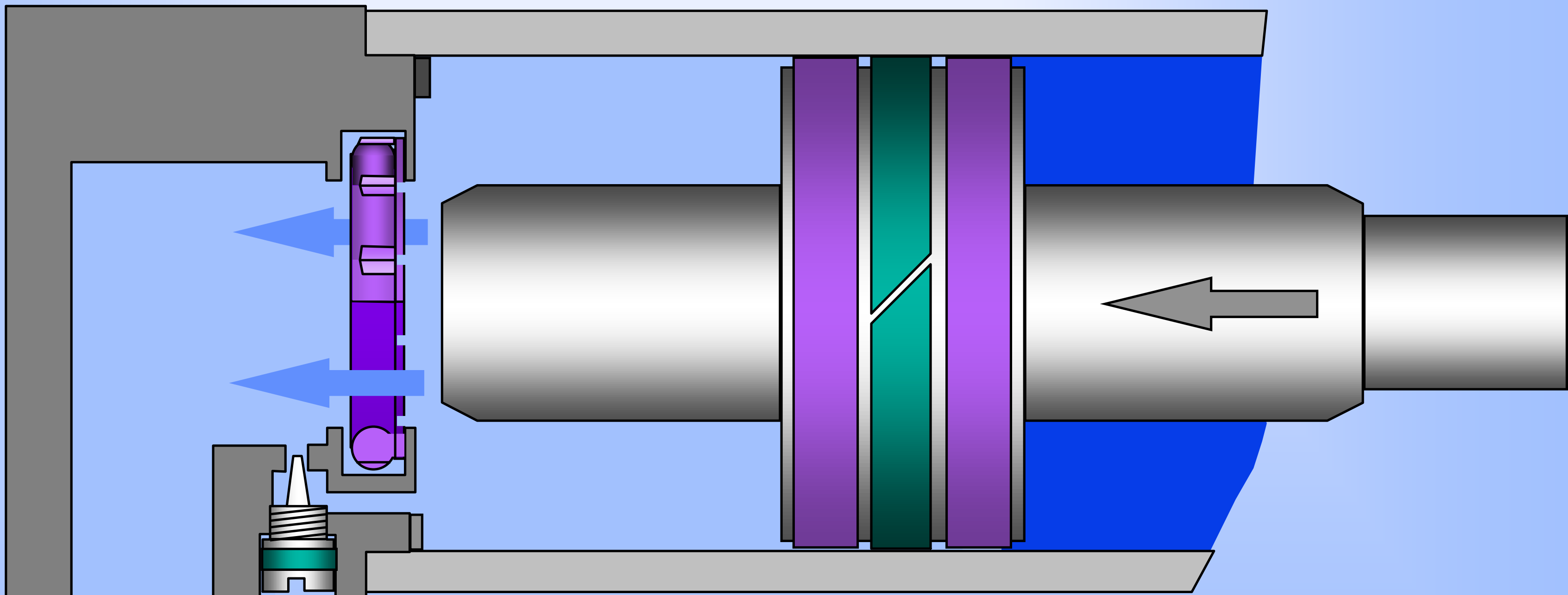
- Shock absorbent discs set into the end covers cushion the impact of the piston



Adjustable cushion design

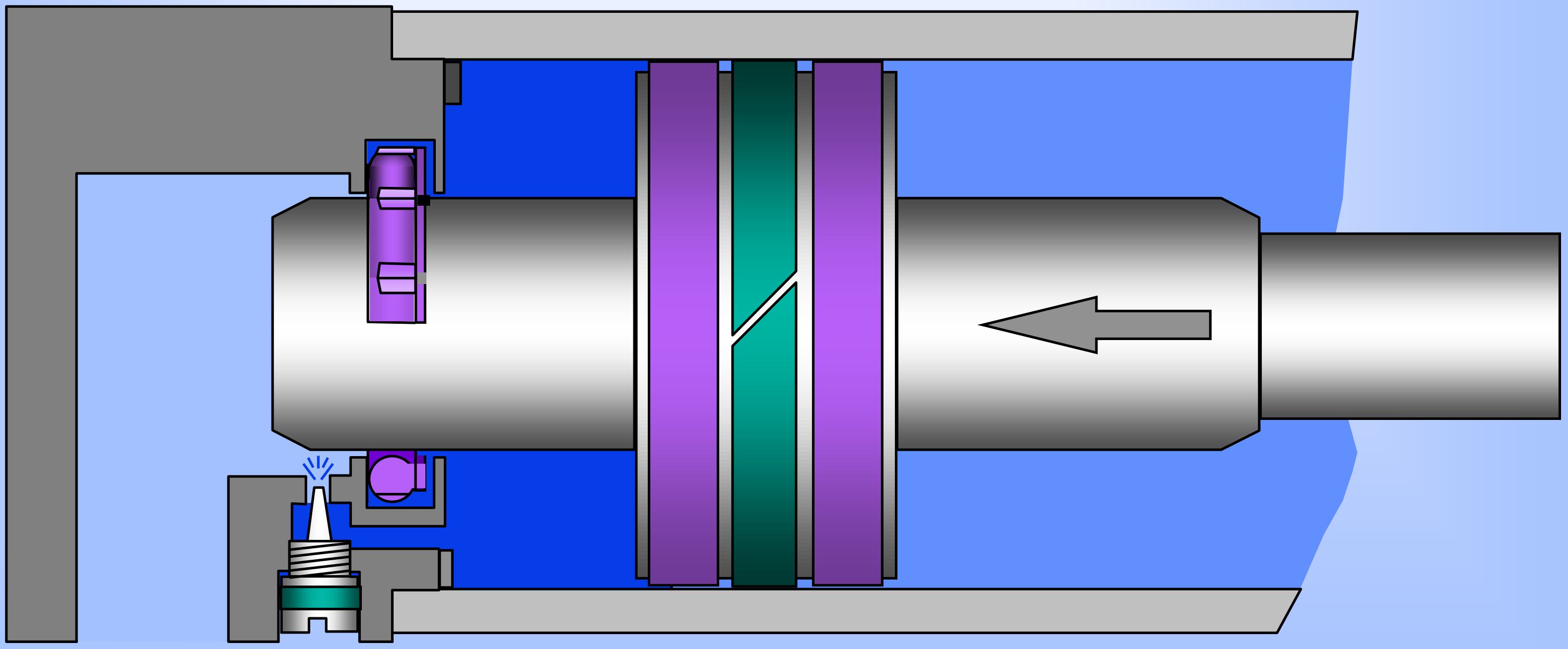
Adjustable cushion design

- The piston is moving to the left at speed.
- Air is venting through the centre of the seal.



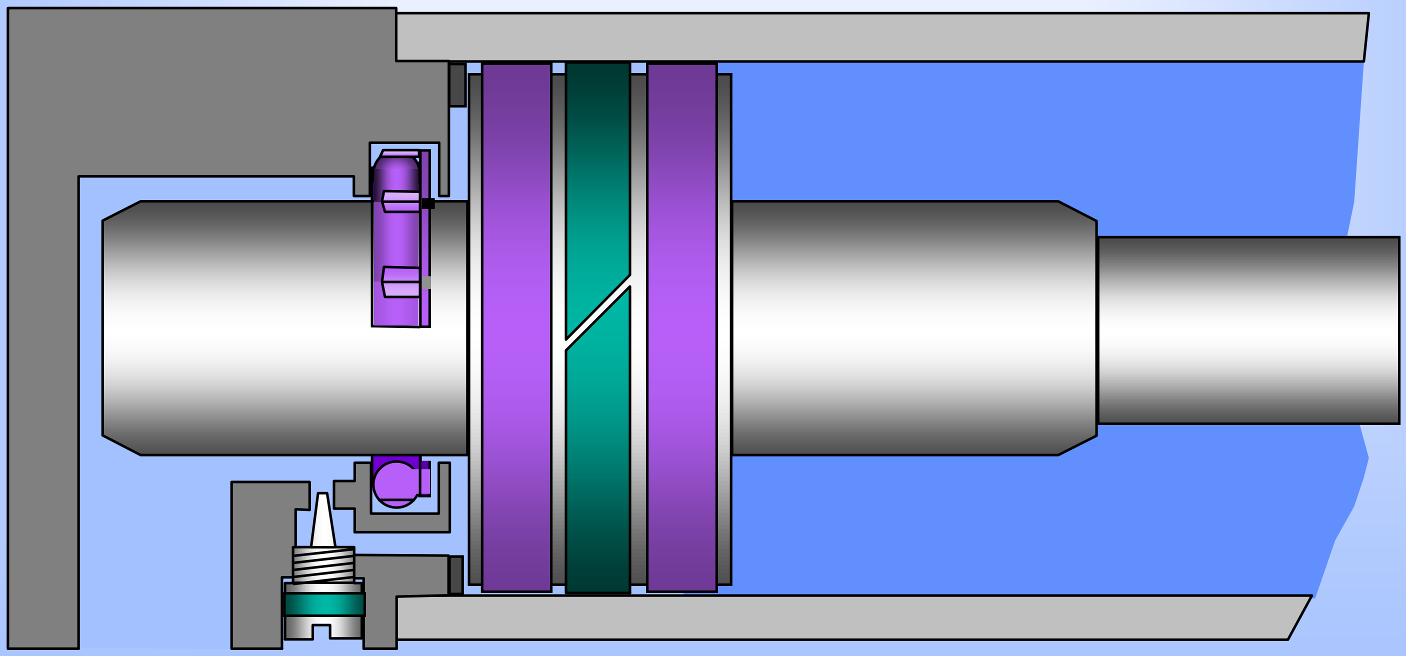
Adjustable cushion design

- The cushion seal is pushed to the left and seals against it’s left hand edge and inside diameter.
- Air can only escape past the cushion screw. The pressure builds up and cushions the piston.



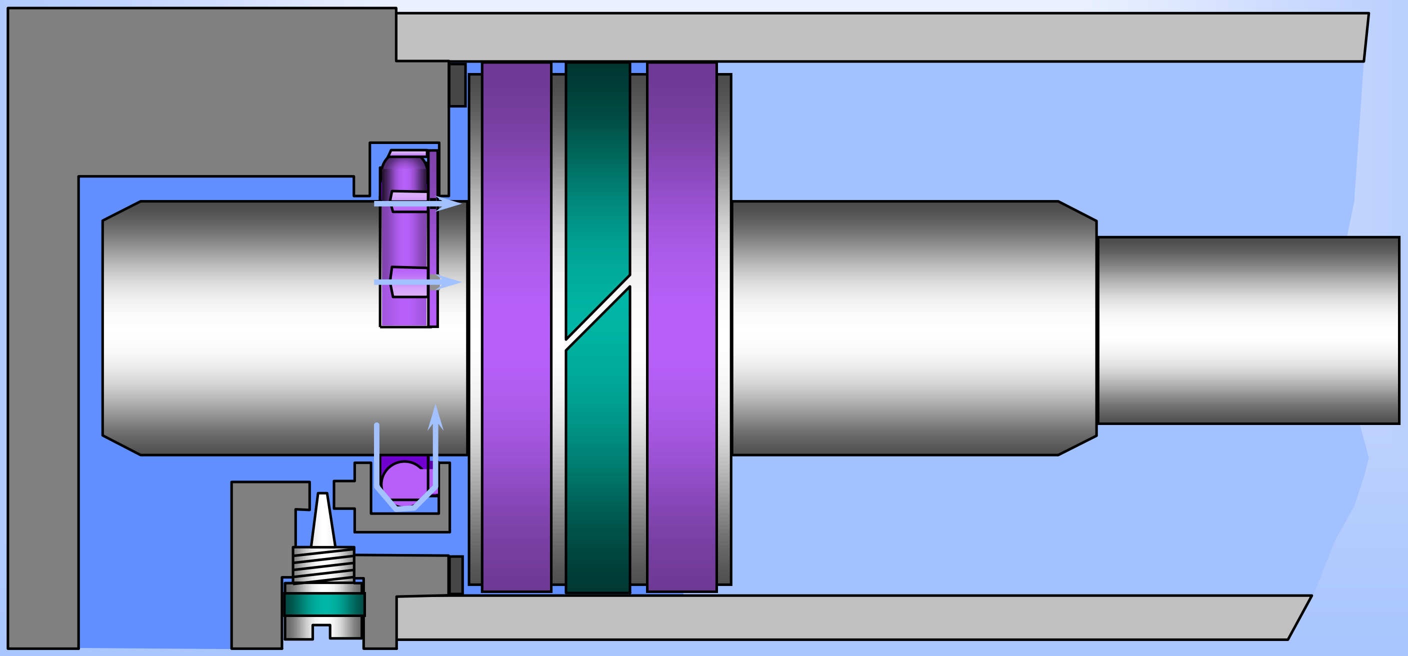
Adjustable cushion design

- The screw is set to bring the piston, rod and load to a gentle halt against the end cover.



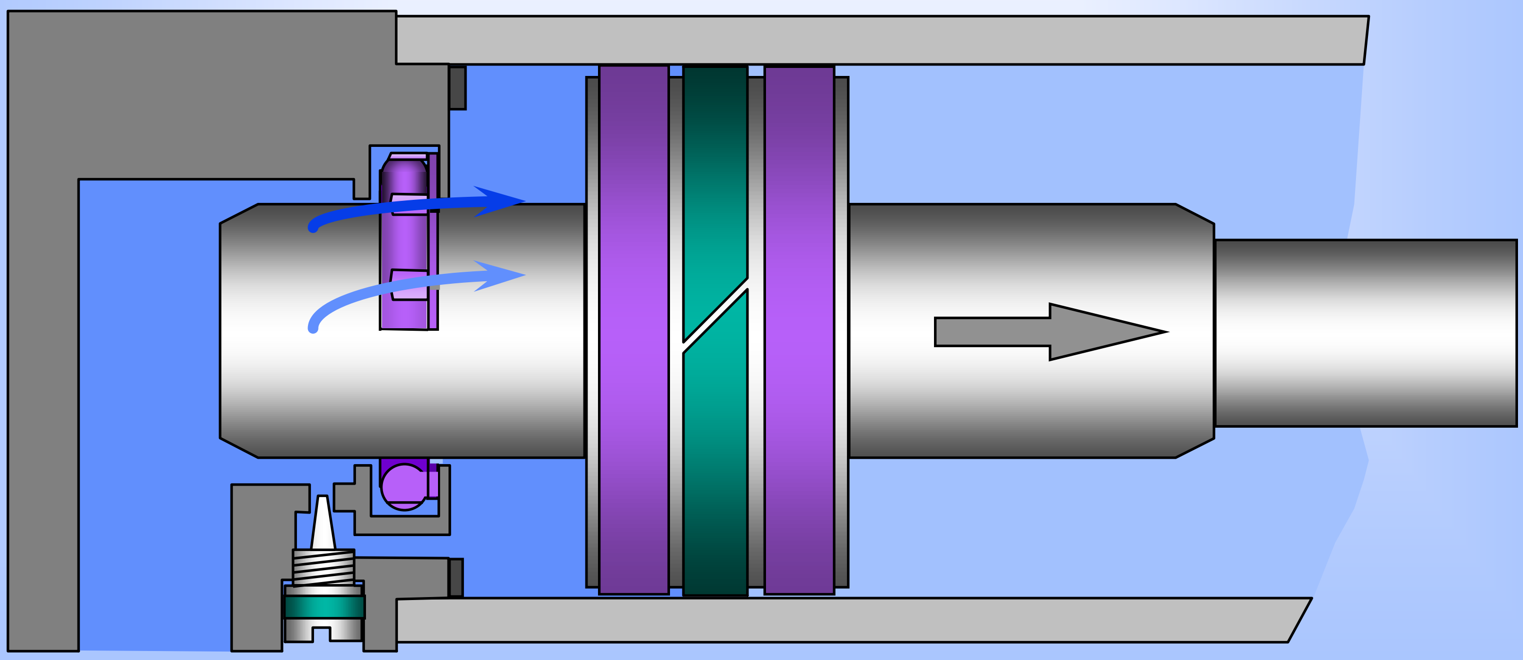
Adjustable cushion design

- A valve has been operated to power the piston out.
- The cushion seal is pushed to the right. Grooves in the right hand edge and outside diameter bypass the screw.



Adjustable cushion design

- The piston is started in the other direction un-restricted by the cushion screw setting.



Shock absorbers

Shock absorbers

- For smooth deceleration of very high mass and velocity.
- Supplement or take over a cylinder's built in cushioning.
- Non adjustable self compensating units
- Adjustable units in two sizes

Self compensating

0.9 to 10 Kg

2.3 to 25 Kg

9 to 136 Kg

105 to 1130 Kg

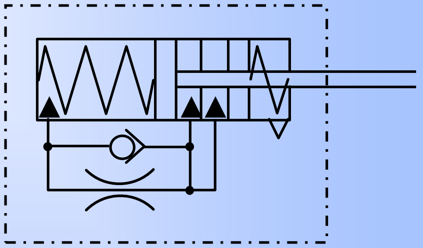
Adjustable

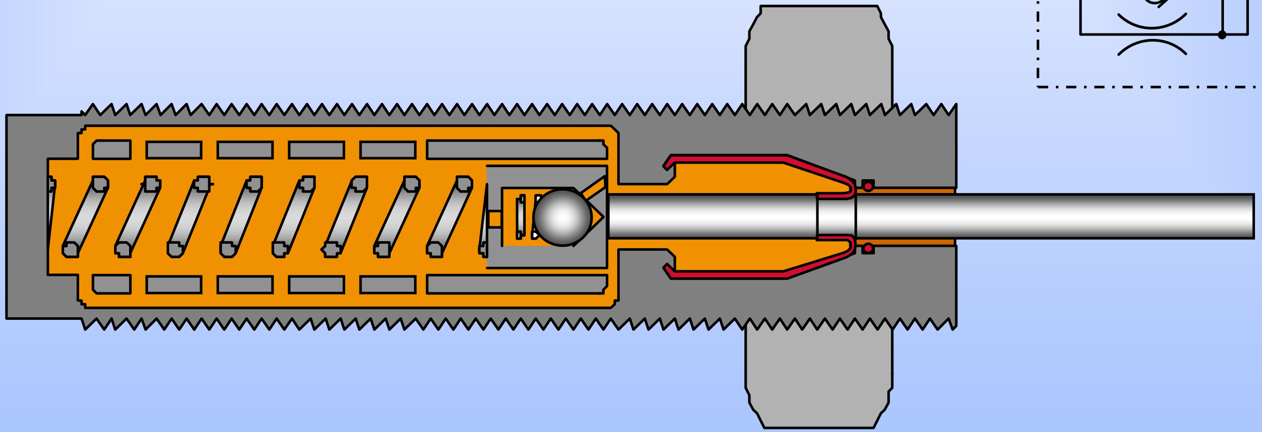
5 to 450 Kg

10 to 810 Kg

Self compensating units

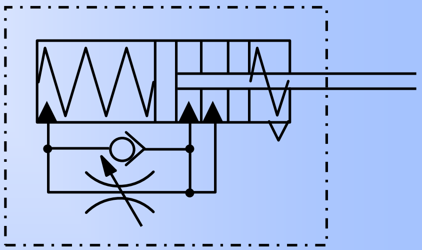
- The principle of operation is progressive flow restriction.
- The piston is pushed in easily at first, oil is displaced through a large number of graduated metering orifices.
- As the stroke progresses fewer and fewer metering orifices are available.

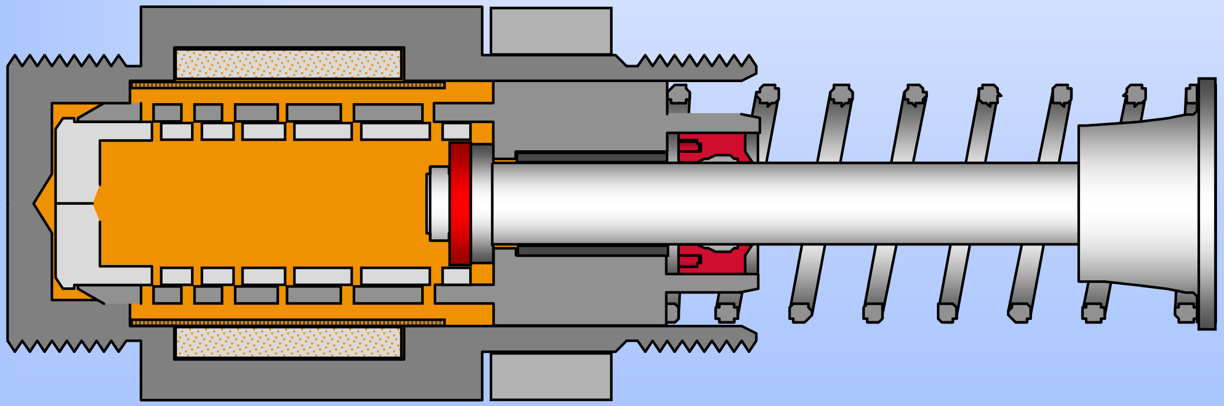




Adjustable units

- Internal accumulator containing closed cell elastomer foam as fluid displacement reservoir.
- Orifice sizes can be regulated by operating an adjusting ring. This allows precise deceleration to be achieved over a wide range of mass and velocity characteristics.





Shock absorbers

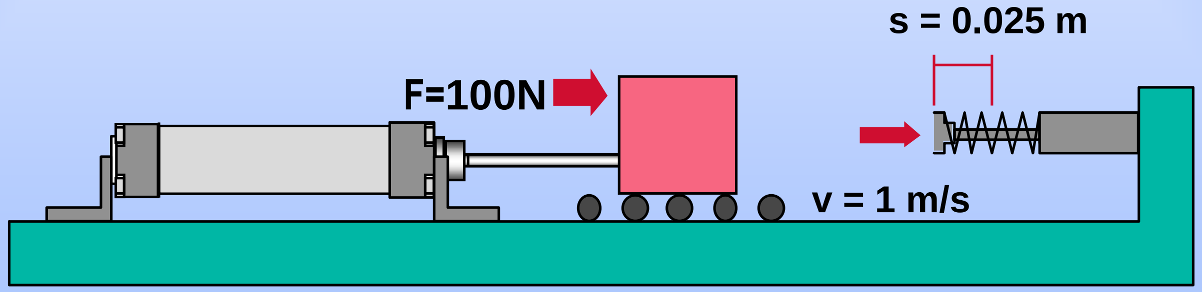
- Calculate the equivalent mass using this formula

$$me = \frac{2\ W_3}{v^2}$$

- **Where**
  - W3 = total energy W1 + W2 (Nm)
  - me = equivalent mass (kg)
  - W1 = kinetic energy = ½m.v2 (Nm)
  - W2 = energy of the force = F.s (Nm)
  - m = mass (Kg)
  - v = velocity (m/s)
  - F = propelling force (N)
  - s = stroke of shock absorber (m)

Example

- Mass of 10 kg, force 100 N, will contact the shock absorber with a velocity of 1 m/s. The stroke of the self adjusting unit is a nominal 0.025m.
  - $W1 = 10 \times 1^2 \div 2 = 5$ Nm
  - $W2 = 100 \times 0.025 = 2.5$ Nm
  - $W3 = 5 + 2.5 = 7.5$ Nm
  - $me = 2 \times 7.5 \div 1^2 = 15$ kg



Standards

Standards

- ISO 6431 and 6432 standardise the installation dimensions of specified pneumatic cylinders and their fitted mountings. Mountings from one manufacturer however may not fit with the cylinder from another.
- VDMA 24562 is a refinement of the above standards further defining dimensions, particularly tie rod centres and the attachment of mountings to them.

Standards

- ISO 6009 relates to the dimension codes used in manufacturers dimension data sheets
- There are additional mountings beyond the scope of this standard.

Non standard dimensions

- **There are many ranges of cylinder designs not bound by the dimensional restrictions of a standard.**
- **These cylinders incorporate the latest innovations in manufacturing technique to provide neat and compact designs resulting in smaller overall sizes.**

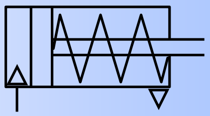
Types of construction

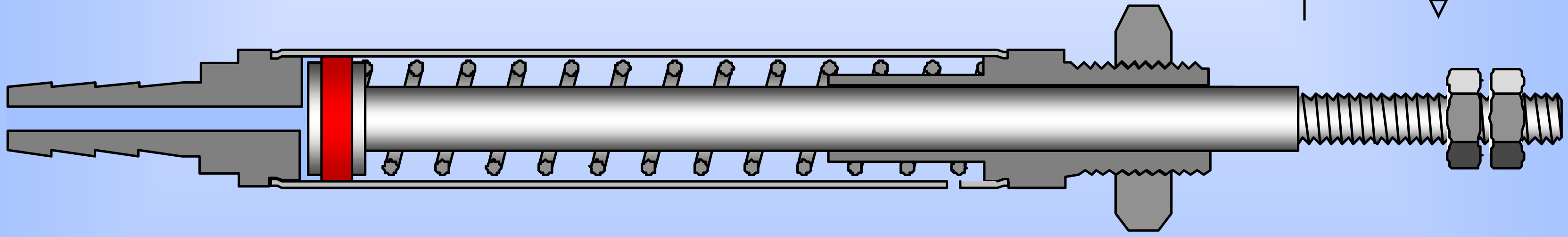
Types of construction

- The factors controlling the type of construction of a cylinder are
  - Size, duty, cost, style, standards and compatibility of materials
- Sealed for life types
  - Low cost, light duty, small to medium bore cylinders. The piston is pre-greased for life on assembly and can be operated with non lubricated or lubricated air.
  - Types: micro cylinders, round line, small bore compact
- Serviceable types
  - It is economical for the user to extend their life by replacement of worn seals and re-greasing. Also the replacement of accidentally damaged parts may be possible.
  - Types: small bore ISO, large bore compact, ISO/VDMA range, heavy duty.

Micro cylinders

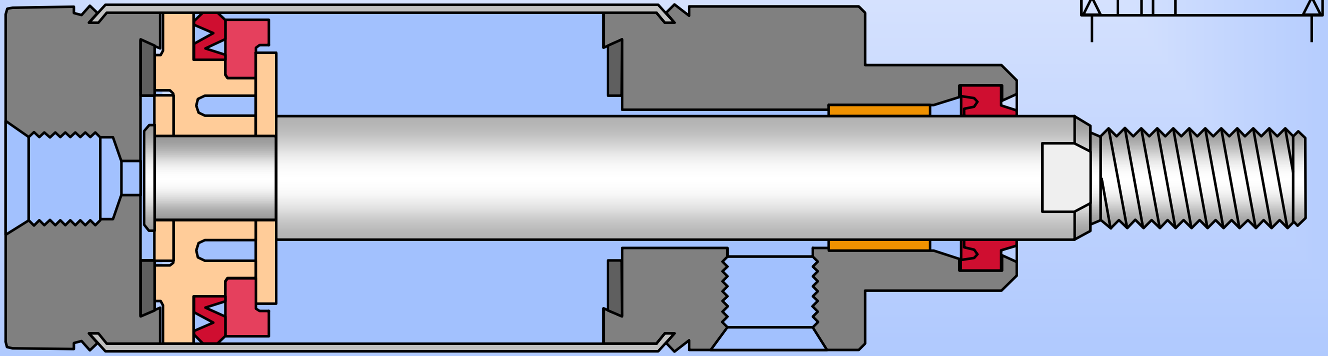
- Very small bore 2.5 mm to 6 mm diameter, mainly single acting sprung to the instroke.
- For use in light duty miniature assembly and manufacturing
- For operation in the pressure range 2.5 bar to 7 bar.
- Sealed for life

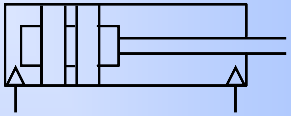




Round line cylinders

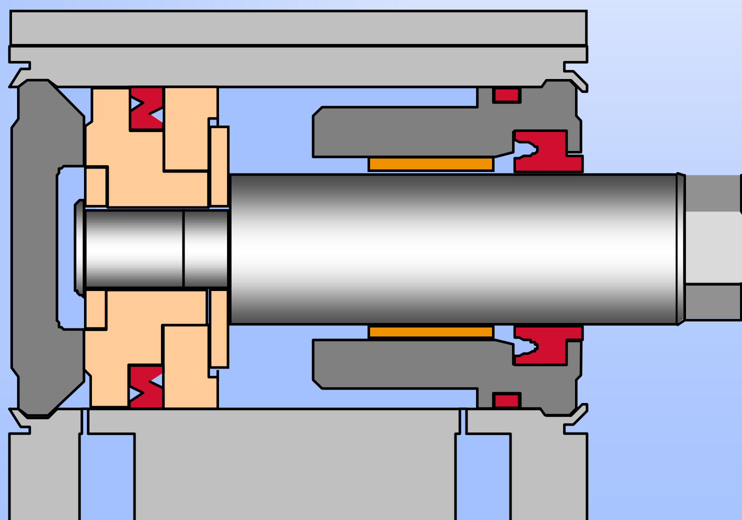
- Low cost, light duty, small to medium bore cylinders in the range 8mm to 63mm diameter.
- The cylinders are sealed for life by rolling the barrel ends and end covers down to make a pressure tight seal.
- For operation in the pressure range 1 to 10 bar.

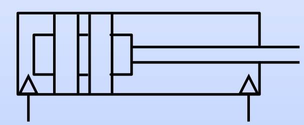




Compact cylinders 12 - 40 mm

- **Short overall dimension that is approximately one third of the zero stroke length of a comparable ISO design.**
- **A magnetic piston is standard on the single acting versions**
- **Non-magnetic and magnetic types in the double acting**
- **pressure range from 1 bar to 10 bar. Sealed for life.**



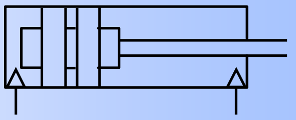


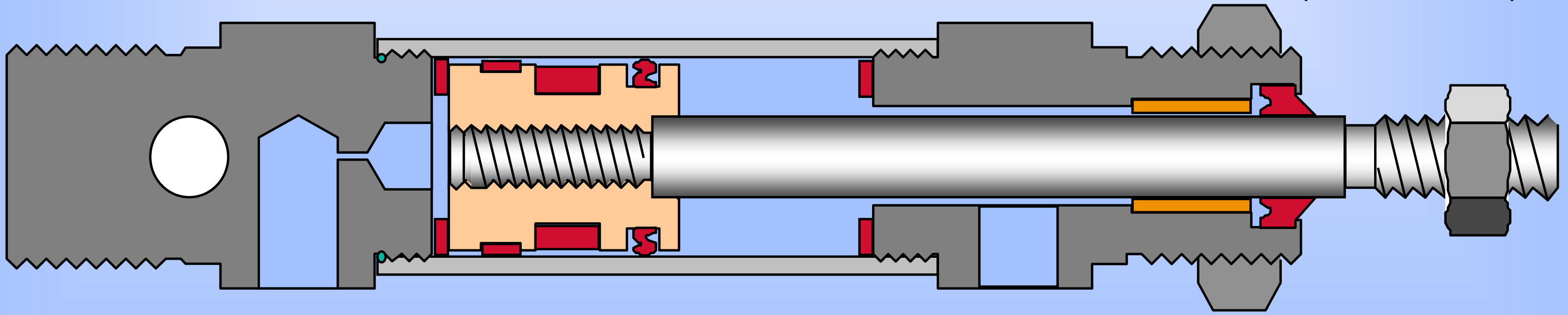
Serviceable

- Light and Medium Duty
- These designs can be dismantled and reassembled by the user. It can be economical to service these cylinders and extend their life by replacing worn seals and re-greasing.
- Typical types of construction are:
  - screwed barrel and end covers
  - end covers retained by circlips
  - end covers clamped by tie rods

Small bore ISO

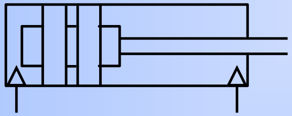
- ISO dimensioned cylinders in the range 10 mm to 25 mm bore both single and double acting screwed barrel construction.
- A threaded rear end cover provides a choice of mounting by clamp nut or built in rear eye.
- For operation with non-lubricated or lubricated air in the pressure range from 1 bar to 10 bar.

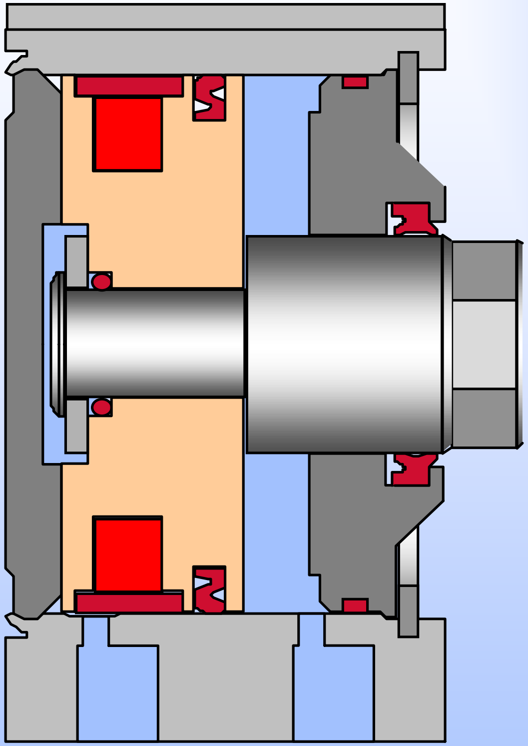




Compact cylinders 50 - 63 mm

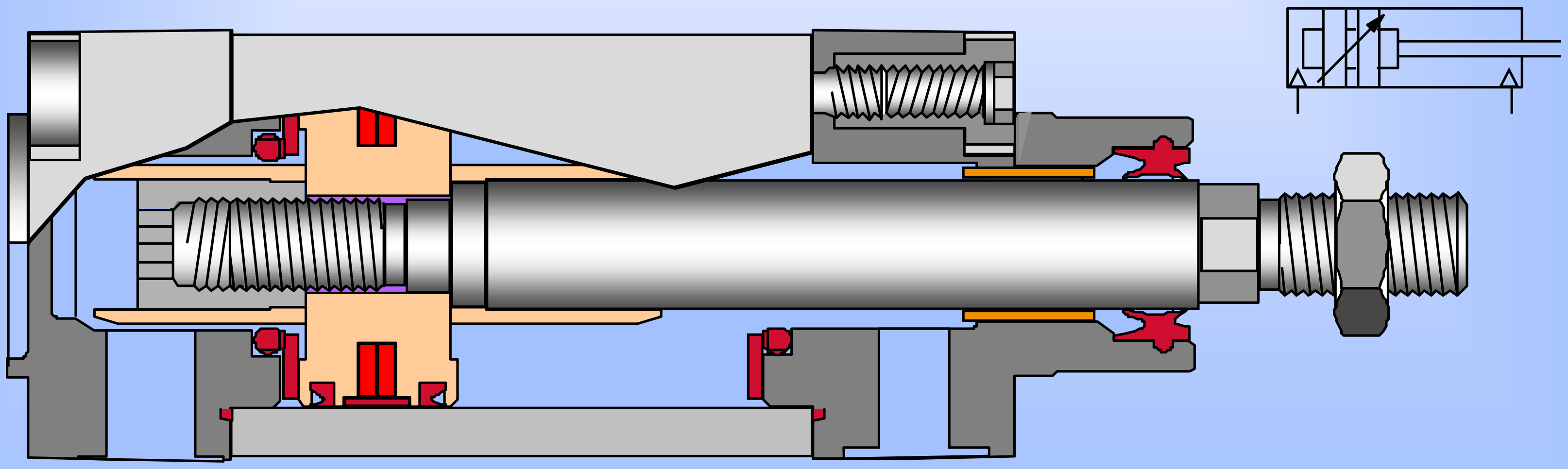
- Removable front end cover retained by a circlip.
- This allows for the replacement of seals





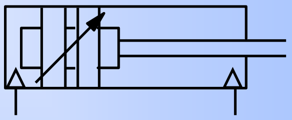
ISO / VDMA cylinders

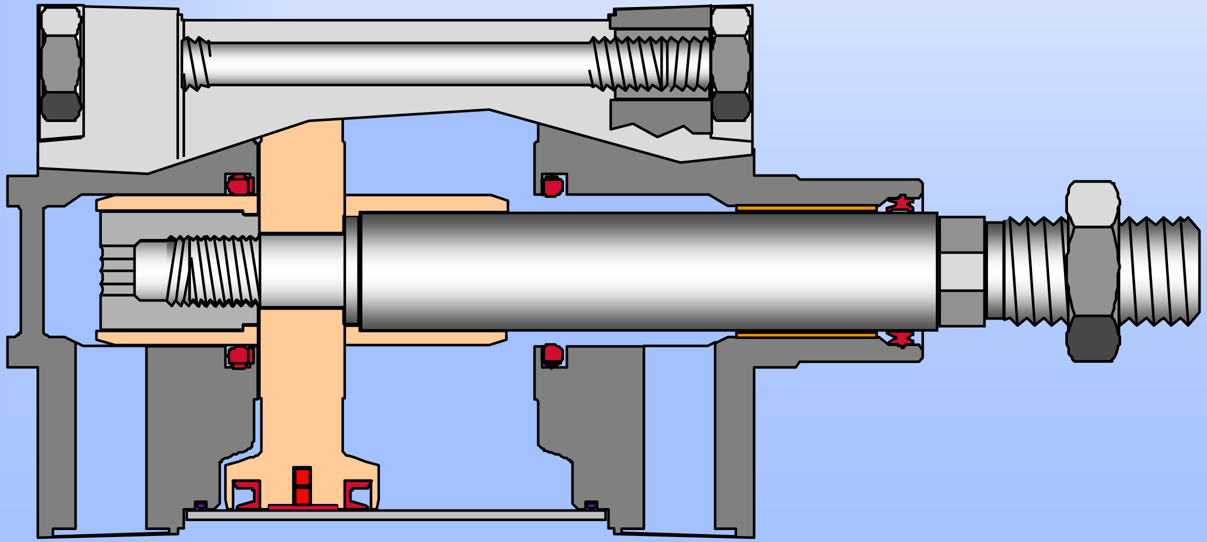
- Conforming to ISO and VDMA dimensions and with a wide range of mounting options.
- Lightweight profile, double acting cylinders with integral tie rod construction in magnetic and non-magnetic versions.
- Bore sizes range from 32mm to 125 mm diameter.



ISO / VDMA

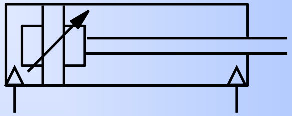
- Large bore double acting range external tie rod design
- 125 mm to 320 mm diameter
- Magnetic version up to 200 mm non magnetic in all sizes.
- Wide range of mountings.
- 1 to 16 bar (up to 200 mm) 1 to 10 bar (250 to 320 mm bore).

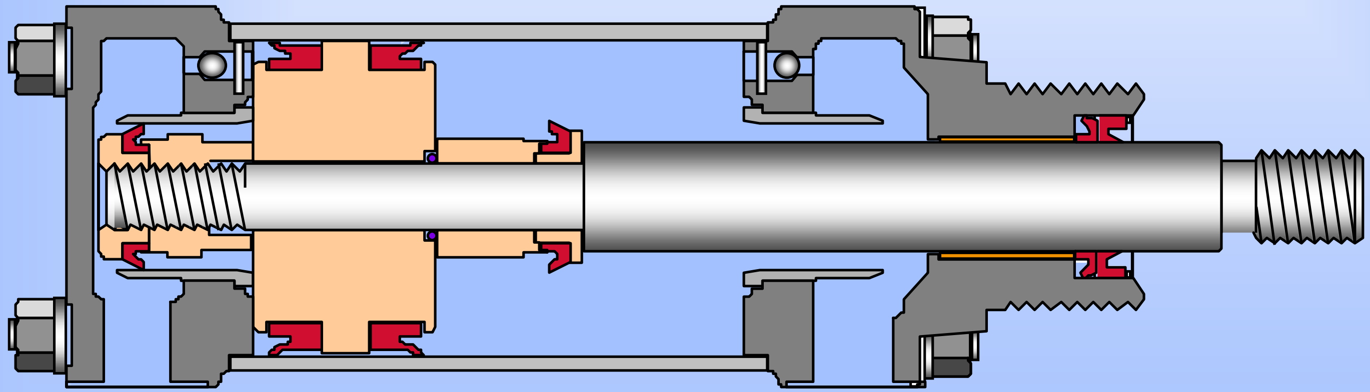




Heavy duty

- Extremely rugged, hard wearing, heavy weight tie rod construction. Bore sizes 2" to 12" diameter
- Large diameter piston rod and long adjustable cushioning.
- arduous work in mines, quarries, steel plants, foundries and other demanding applications.

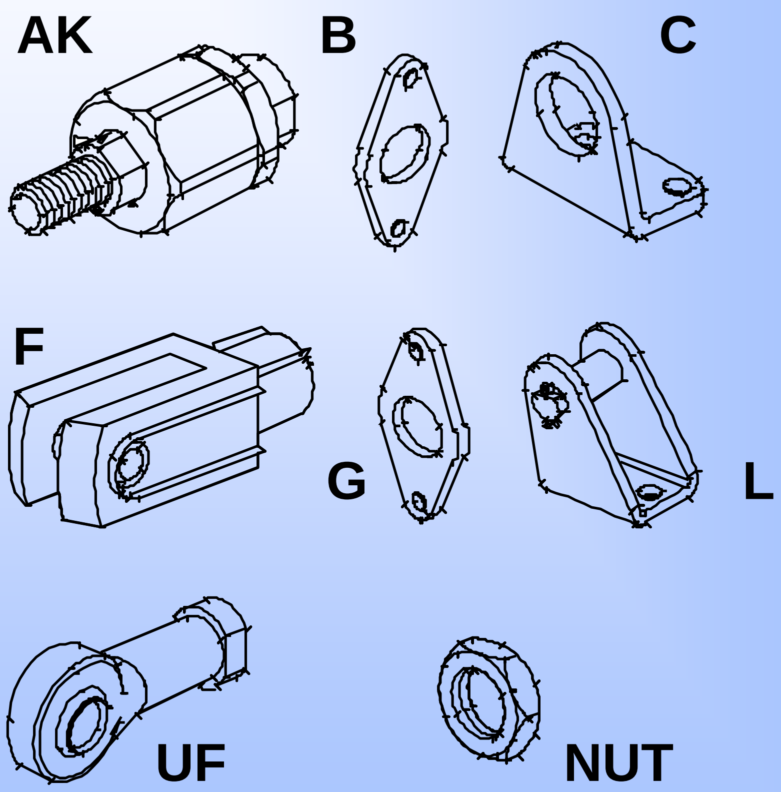




Mountings

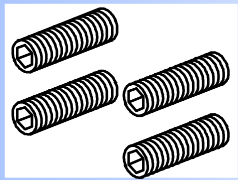
- Cylinder rigidly fixed to the machine or allowed to swivel as part of a linkage in one or more planes.
- Fixing points will be the cylinder body and piston rod end.

Mountings for small bore

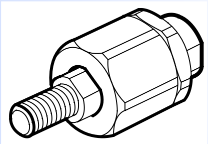


Mountings

Mountings for tie rod cylinders



A



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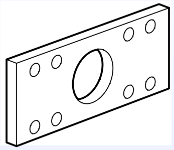

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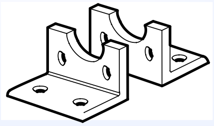

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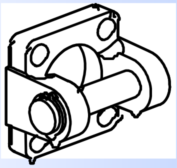

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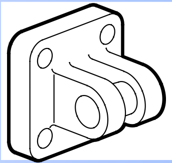

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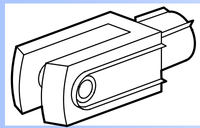

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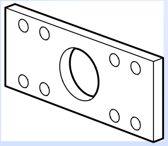

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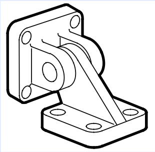

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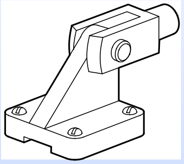

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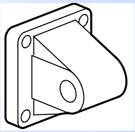

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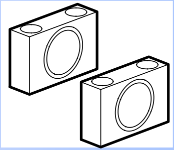

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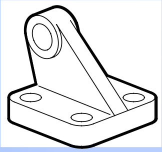

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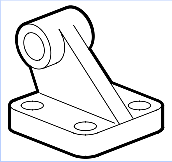

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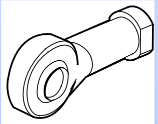

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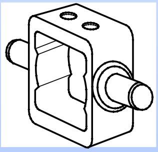

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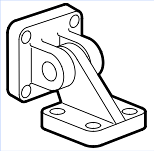

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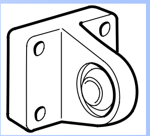

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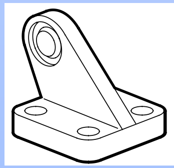

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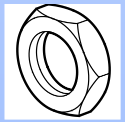
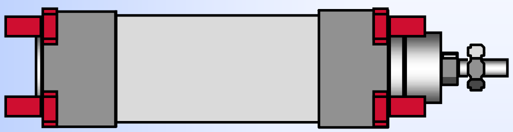
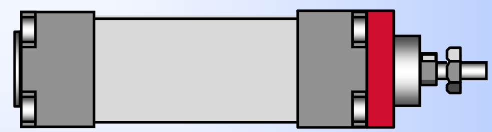


NUT

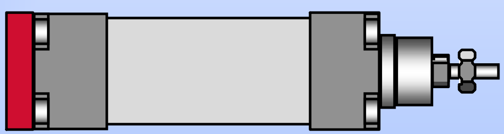
Rigid mountings



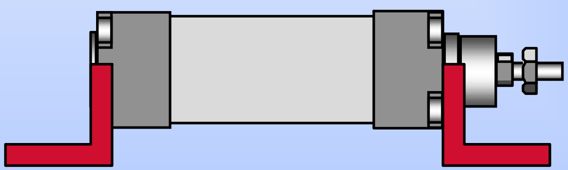
A Tie rod extension



G Front Flange

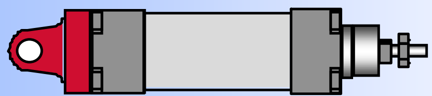


B Rear Flange

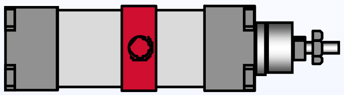


C Foot

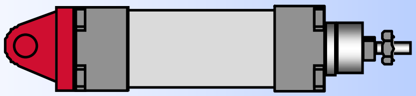
Articulated mountings



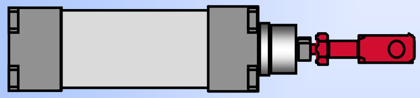
D Rear Clevis



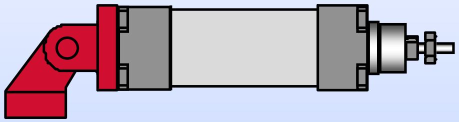
H Centre
Trunnion



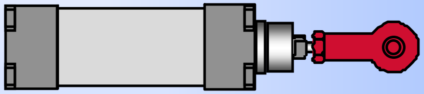
R Rear Eye



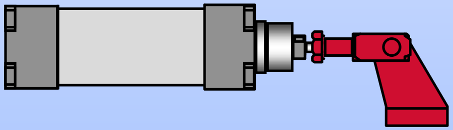
F Rod Clevis



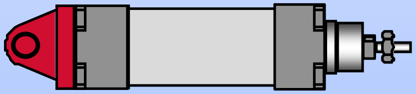
L Rear Hinge



UF Universal rod Eye



M Front Hinge



UR Universal
rear Eye

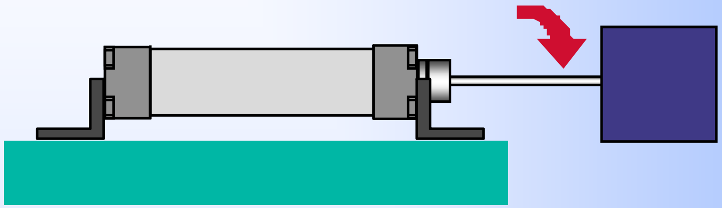
Installation

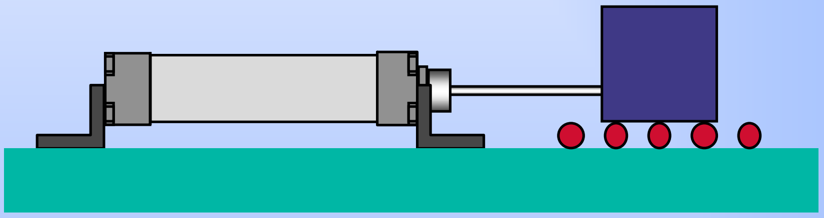
Installation

- A cylinder should be installed so that side loads on the piston rod bearing are reduced to a minimum or eliminated.
- A side load is a force component acting laterally across the axis of the bearing.
- Five typical installations that produce a side load follow with their possible solutions.
- Side loads can rarely be eliminated completely, but by employing good engineering practice they can be reduced to an acceptable level.

Side load one

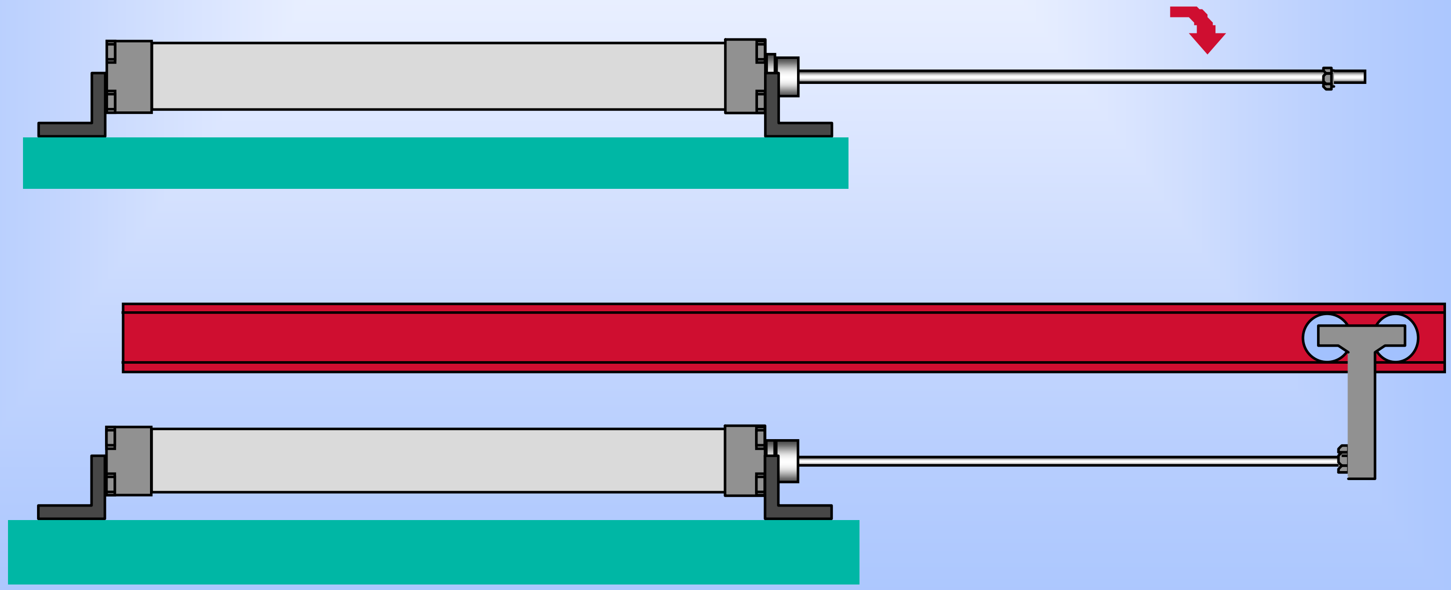
- Avoid attaching an unsupported load to the piston rod.
- Wherever possible support the load on slide or roller guides





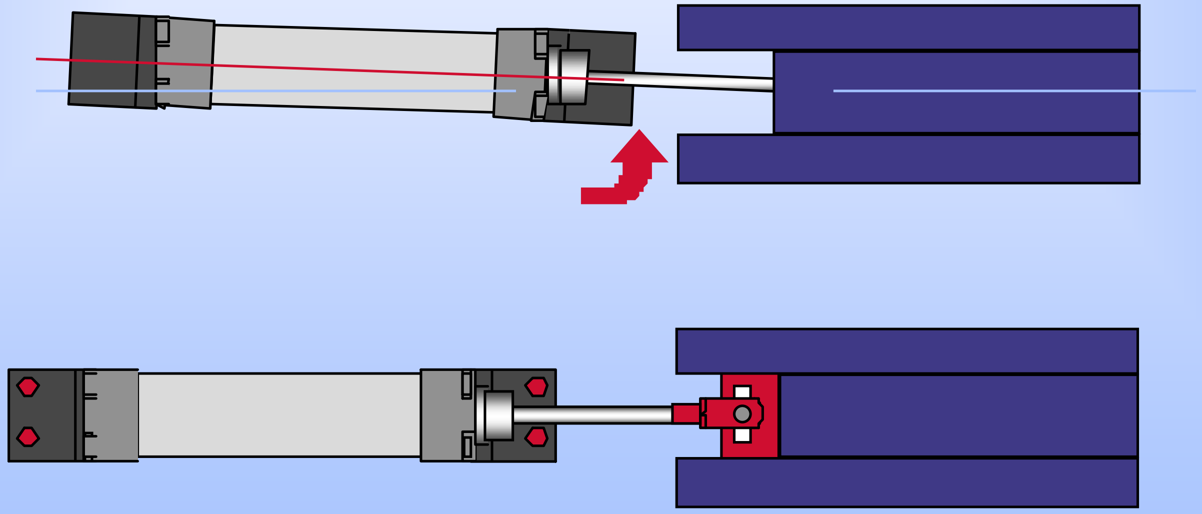
Side load two

- The weight of a long outstroked piston rod alone can produce a high bending moment.
- It may be possible to hang the rod end from a roller track.



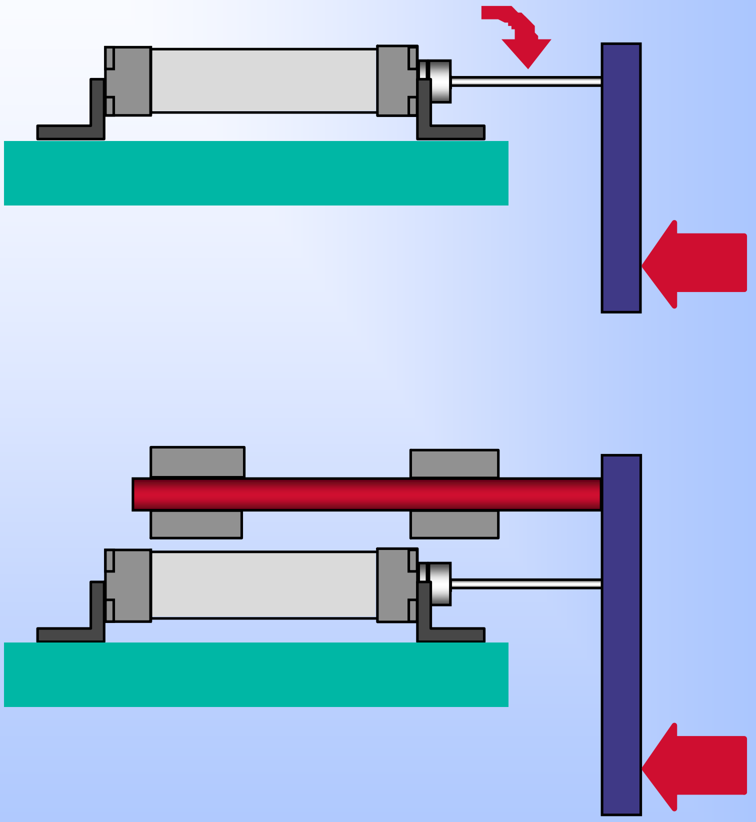
Side load three

- Misalignment of the cylinder and a guided load can easily jamb the cylinder completely.
- Installation of a front fork and slot will eliminate this type of side load.



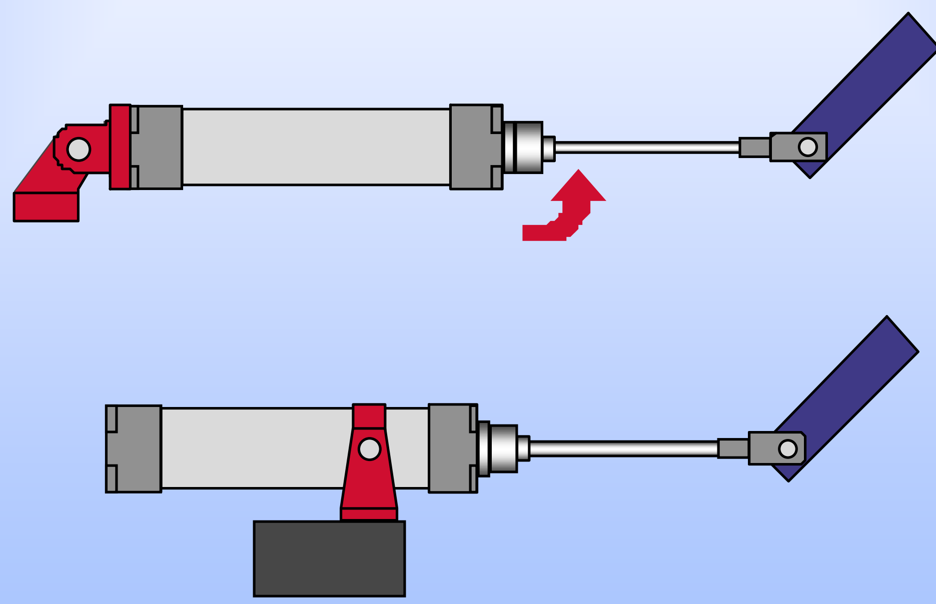
Side load four

- An offset load is a common source of bending moment acting on the end of a piston rod.
- Install external heavy duty bearings to relieve the side load on the cylinder bearing.



Side load five

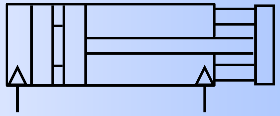
- A horizontally mounted rear hinged cylinder will have the weight of the cylinder body creating a bending moment.
- Fit a central trunnion at the point of balance

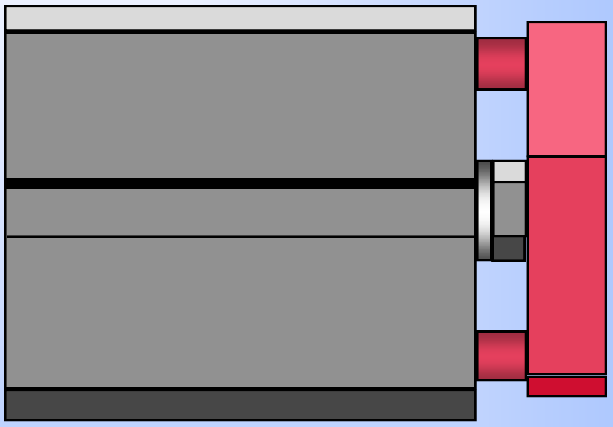


Non rotational guiding

Non rotational guiding

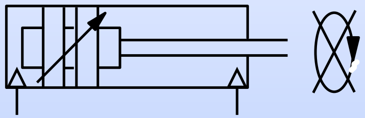
- For applications where loads attached to the piston rod end need guiding to maintain orientation
- Guided compact cylinders incorporate twin guide bars running in bearings within the extruded cylinder body

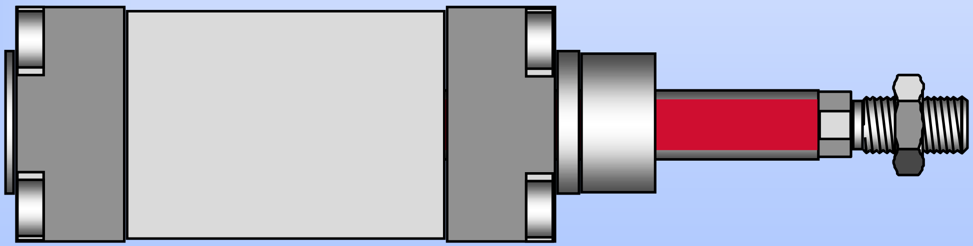


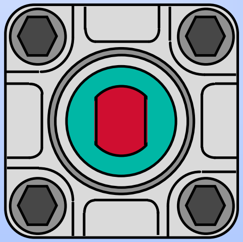


Non rotational guiding

- ISO 32 to 100 bore cylinders with non rotating piston rod.
- Feature continuous flats running the length of the rod which run in a matching bearing.
- For resisting light torsional loads only.
- twist in an outstroked rod can occur at higher torque.

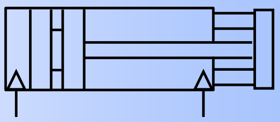


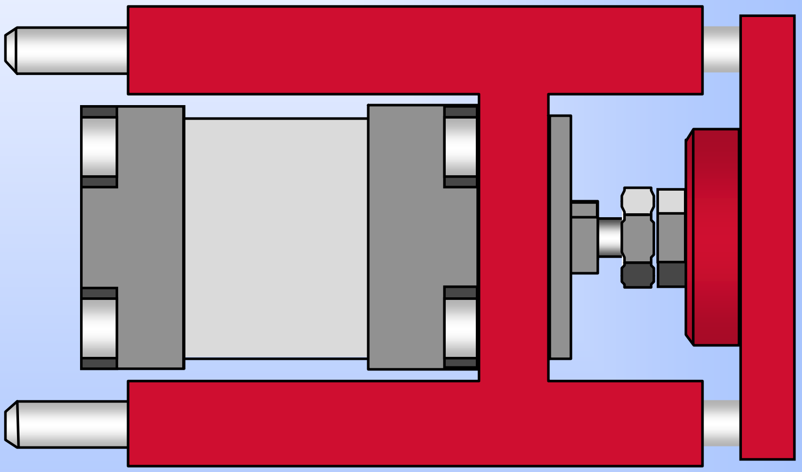




Non rotational guiding

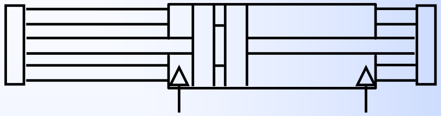
- Add on guide block units
  - with slide or roller guides.
  - provide non rotational guiding and greater support against higher loads.
  - For low friction and best support use the version with twin roller guides
  - These units can be fitted with twin passive or active locking cartridges.

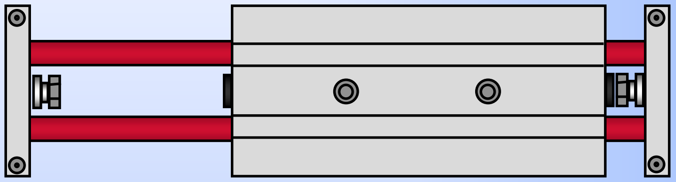




Non rotational guiding

- **Linear slide units.**
  - **For precise actuation**
  - **high quality slide bearings**
  - **provide exceptional torsional rigidity with a twin through-rod layout**
  - **magnetic piston**
  - **choice of port connection positions.**

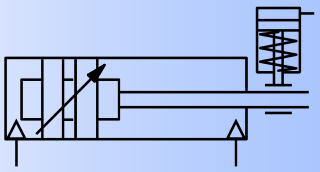


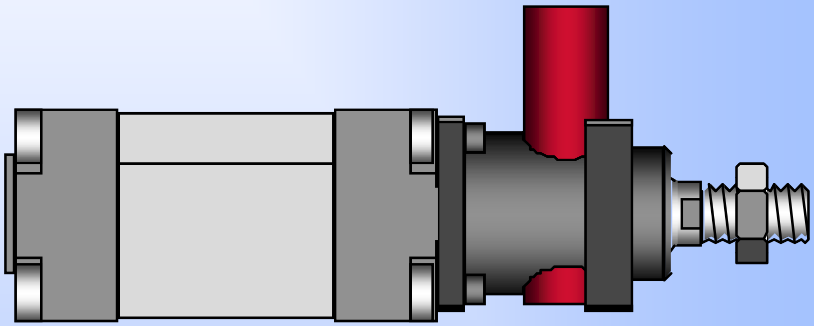


Locking and braking

Locking and braking

- For safety in the event of air failure or as part of a machine sequence.
- Stop and hold a load at any position in the stroke.
- Passive or active piston rod locking unit
- A range of these add on units is designed to suit ISO cylinders from 32 mm to 125 mm bore.





LINTRA® Rodless Cylinders

LINTRA® Cylinders

Rodless cylinders for:

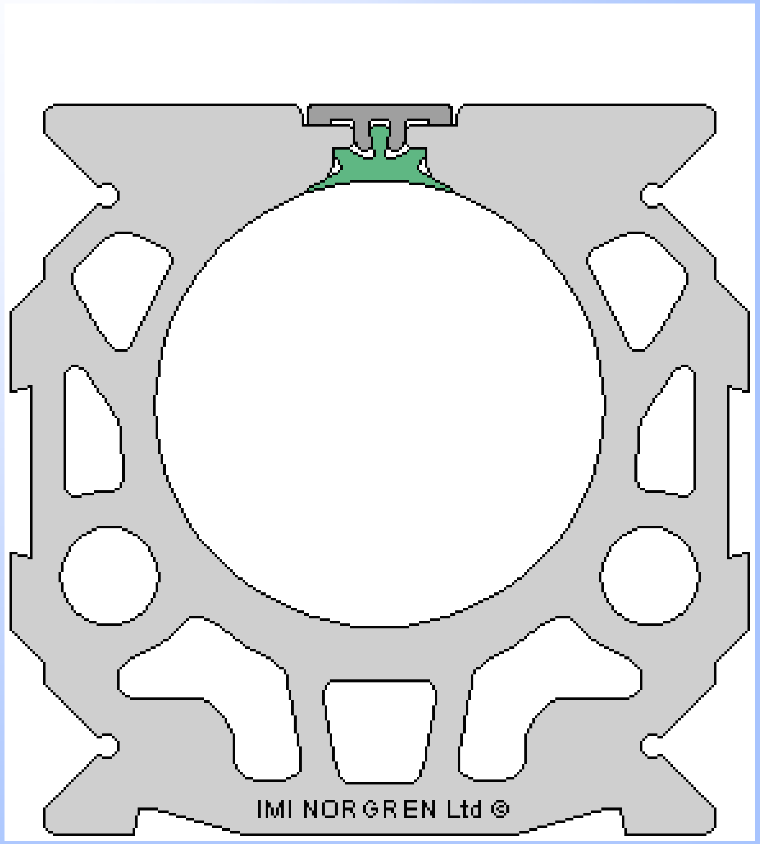
- Limited spaces
- Simple installation
- Long strokes
- Neat attractive styling
- High speed
- Precision control

Large range:

- Variants in structural strength
- Twin stroke
- Active braking
- Passive braking
- Curved design
- Electric drive
- Corrosion resistant

Operating principle

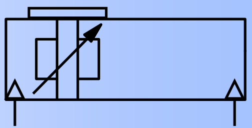
- A full length slot in the barrel joins the piston and external carriage
- The slot is sealed against pressure and dust with self holding inner seal and outer cover strips
- Strips are continuously parted and re-sealed by the piston
- The slot is only unsealed in the un-pressurised space between the piston seals

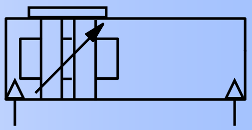


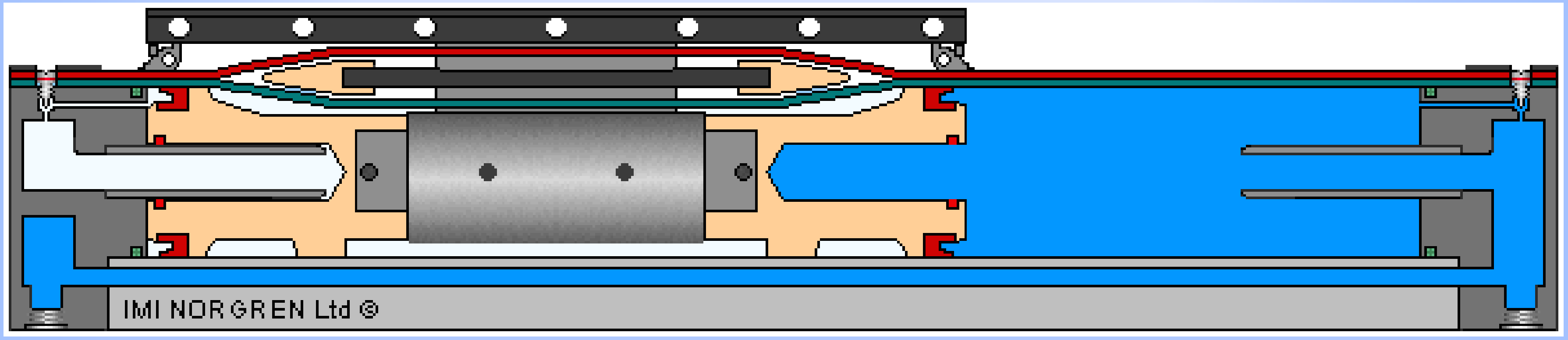
Click the illustration to start and stop animation

Operating principle

- The sealing strips are parted and closed as the piston moves through the stroke
- Adjustable cushions
- Dual connection ports at the left hand end



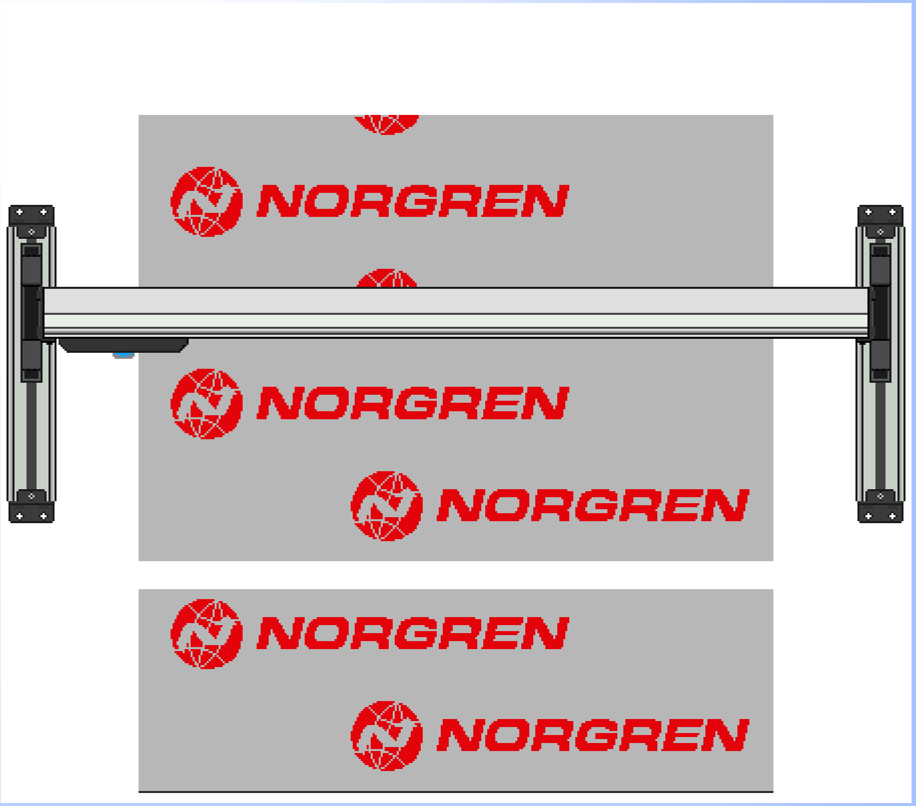




Click the illustration to start and stop animation

LINTRA® applied

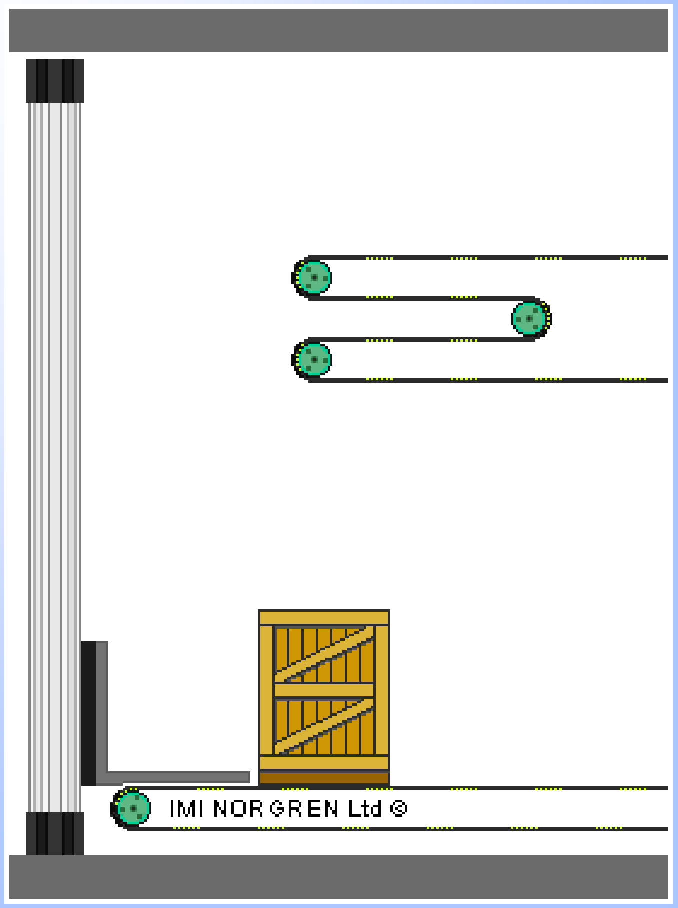
- For action across a strip process
- No overhang or mechanism required compared to a conventional piston rod cylinder
- The application shows a flying knife typical of use in the paper production industry



Click the illustration to start and stop animation

LINTRA® applied

- Lifting in places with limited headroom
- Actuation contained within the length of the cylinder body



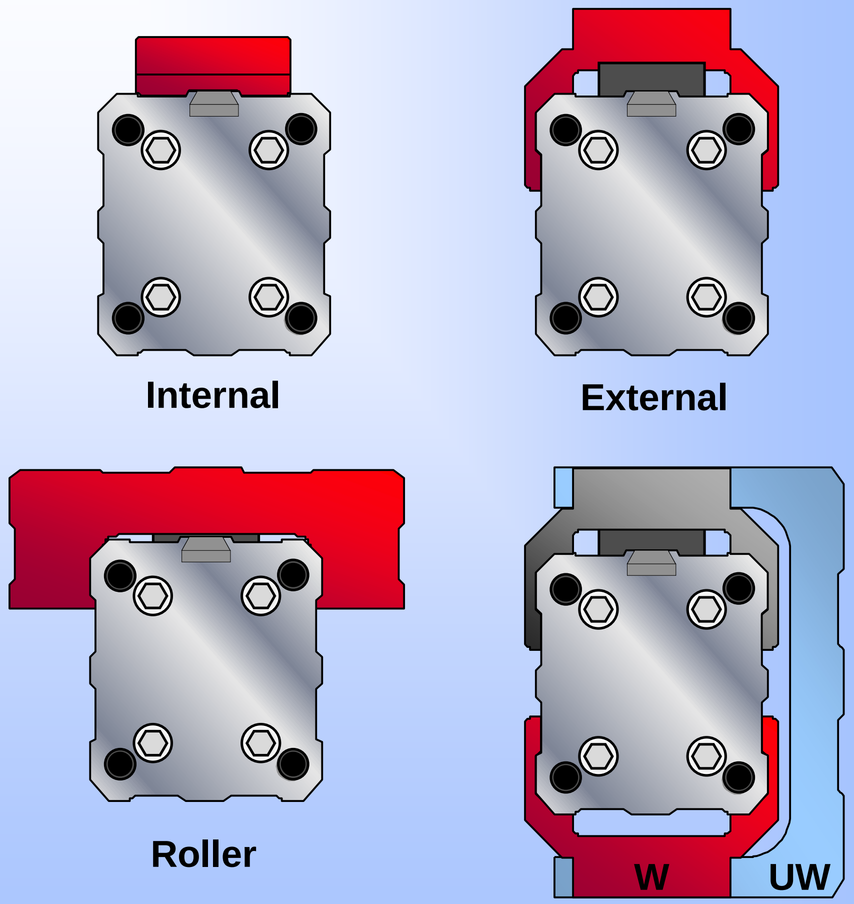
Click the illustration to start and stop animation

LINTRA® Overview

- Extruded aluminium alloy cylinder barrel with integral bearing guides
- Internally or externally guided carriage
- Roller guided carriage
- Double carriages
- Integral valve option
- Bore sizes 16 to 80mm
- Strokes up to 8.5 m
- Adjustable cushion
- Single end connections
- Magnetic piston option
- Dual integral grooves for sensor mounting

Guiding variants

- The internally guided carriage is suitable for light duty applications
- Externally guided carriage uses bearing grooves on two extrusion edges
- For precision conditions, roller guides can be used
- Secondary free carriage connected to powered carriage for guiding on all four extrusion edges

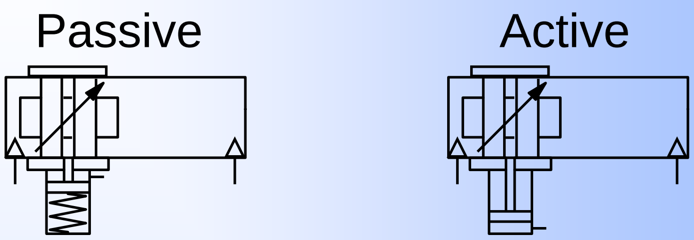


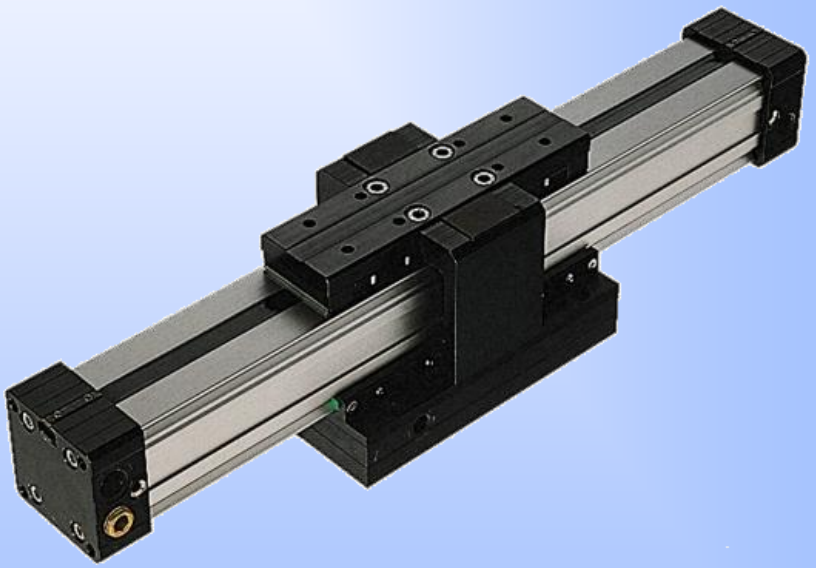
Heavy duty

- For precision movement of heavy loads
- Up to 4.5 metres stroke
- Uses a rigid aluminium profile and precision linear ball bearing guides
- Adjustable buffer end stops are standard
- Provision for adding two pairs of shock absorbers to the carriage

Braking cylinders

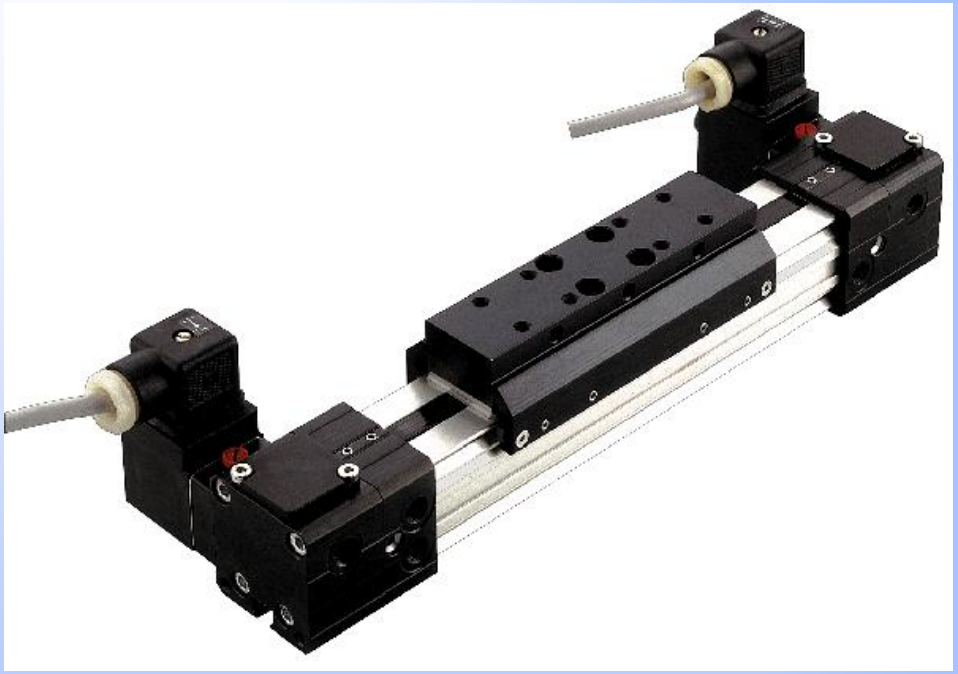
- Holds the carriage firmly in any position against a fixed or variable load
- The passive brake is held OFF by applied air pressure and clamped ON by a spring
- The active brake is clamped ON by the application of air pressure





Integrated valves

- For convenience, compact layout and fast response
- Valve adaptor kit fits directly to the end cover
- Can be fitted with 3/2 solenoid valves

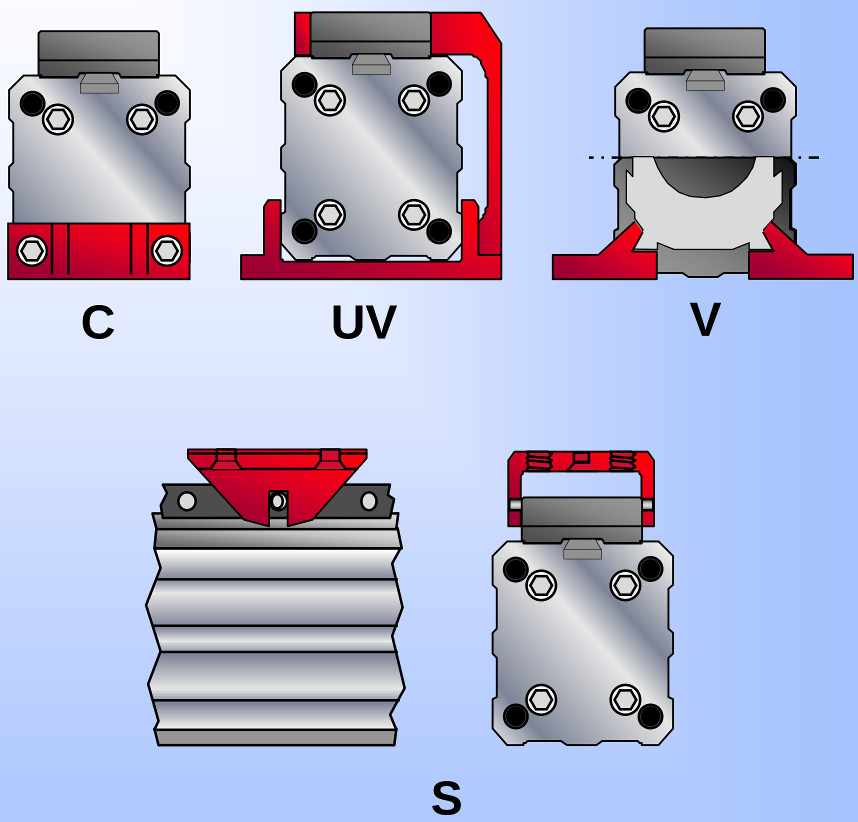


Corrosion Resistant

- For operation in hostile environments
- Suitable for use in food and drug industries
- Resistant to salt water spray
- Weather resistant for outside applications

Mountings

- A variety of mounting styles for fixing the cylinder body and load
- Foot mountings style ‘C'
- Carriage mounting plate style ‘UV'
- Centre support style ‘V' for fixing the cylinder body at mid span
- Swinging bridge style ‘S' up to 8^{O} either side and up to 4mm vertical in the axis of the cylinder



Mountings

- Provide movement in two planes
- A right angle mounting system style ‘X’ allows the carriages of two rodless cylinders of the same bore to be joined
- Styles ‘X1’ and ‘X2’ allow the combination of cylinders with different bore sizes

LINTRA®-LITE

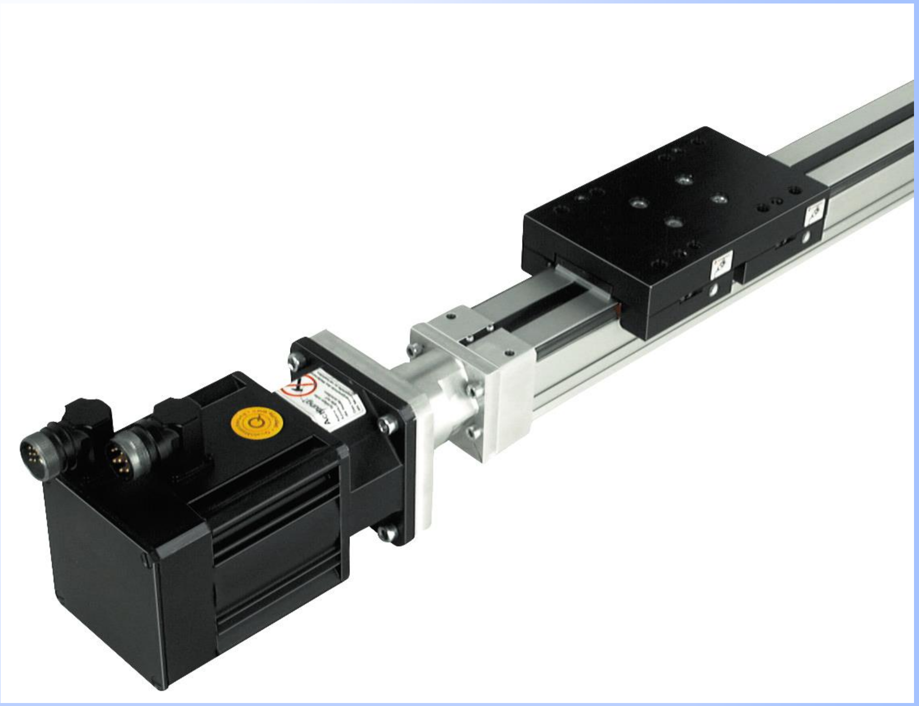
- Compact design giving smallest installation envelope
- High quality proven seal design as used in LINTRA® cylinders
- Magnetic and non magnetic option
- Fixed buffer cushion and adjustable cushion options
- Neat integrated rails for sensor mounting
- Integrated foot mounting

LINTRA®-CURVER

- Radial actuation for special applications including product handling, pick and place and the operation of curved doors and shutters
- Bore sizes 25mm, 32mm and 40mm
- Rotation angles up to 180°
- Radii 800, 1000, 1200, 1400, 1600mm

Electric Drive

- High thrust
- Precise positioning
- High repeatability
- Constant, defined high or low speed
- Proven LINTRA® slide and roller guide
- Interchangeable with LINTRA® pneumatic cylinders



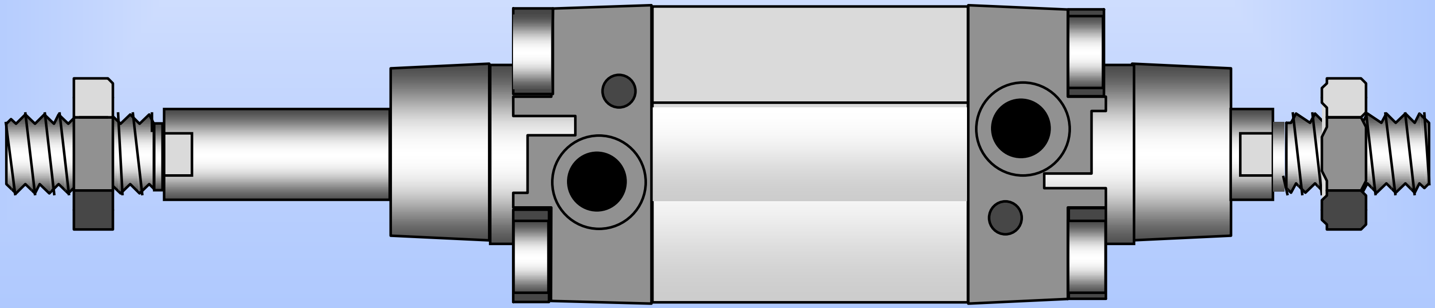
LINTRA®-CARRIER

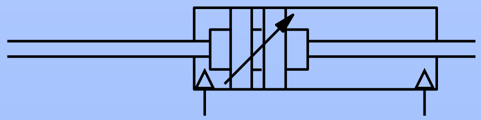
- For transportation of hanging loads
- Driving elements: Two yoke assemblies
- Guiding elements: Two roller guided carriages
- Easy installation
- Magnetic sensing
- Adjustable cushioning

Variants

Cylinder variants

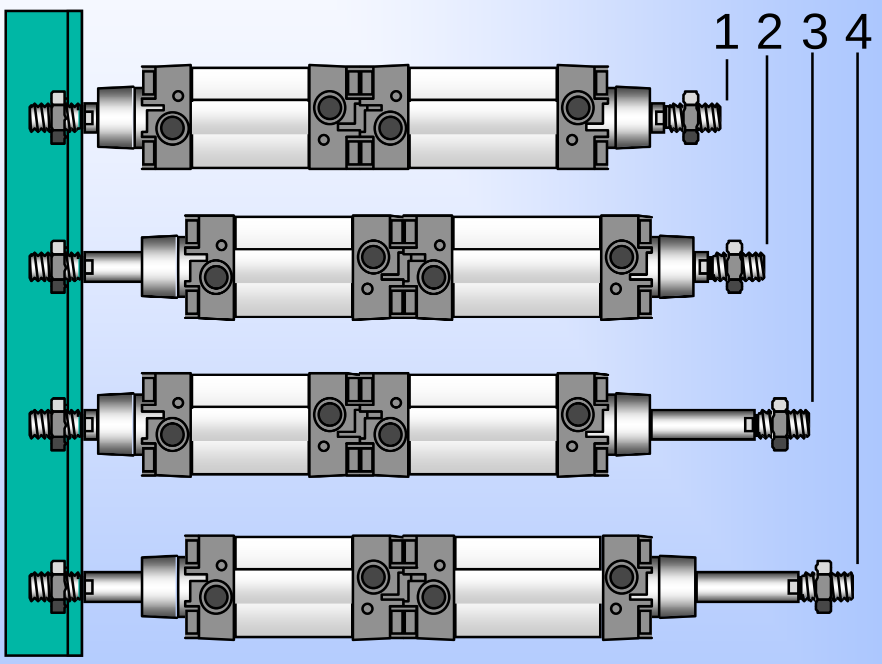
- **Double Ended Piston Rod.**
  - **Widely spaced piston rod bearings giving a more rigid construction and better stability against side loads.**
  - **The effective area of the piston is the same on both sides. Pressure equalisation creates a force balance across the piston.**
  - **One working end, other could operate limit switches.**

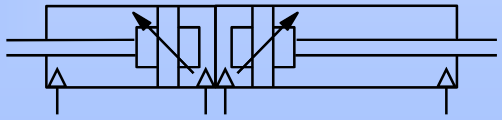




Variants

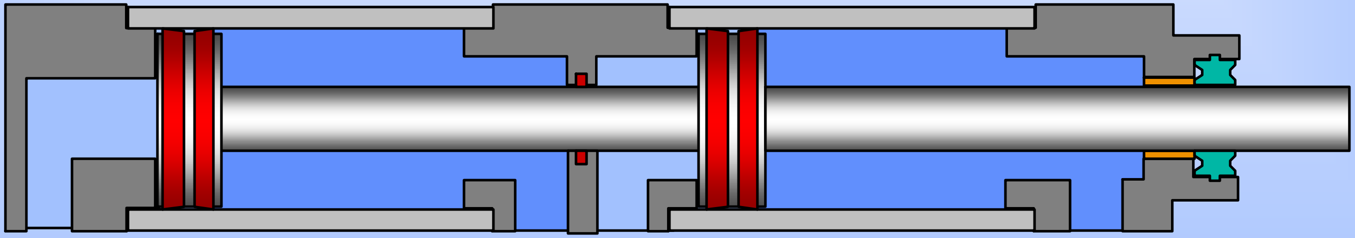
- **Multi Position**
  - **By fixing two or more cylinders together and fully instroking or outstroking them in all the possible combinations, the attached load can be moved to a number of fixed reliable positions**





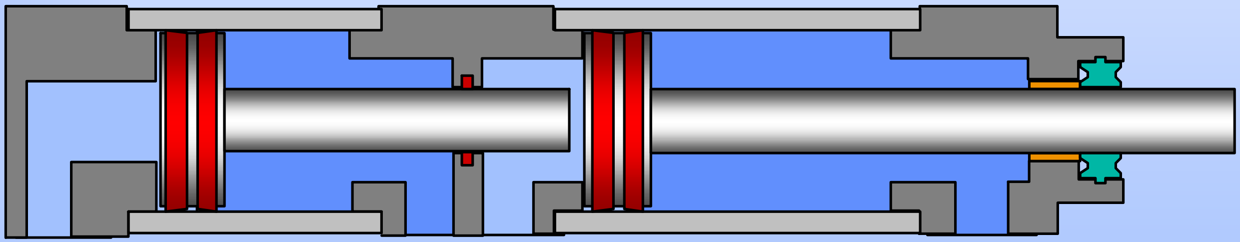
Variants

- Tandem Cylinder
  - Will double the pull and nearly double the thrust for a given bore.
  - It is suitable as an alternative to a larger bore cylinder when there is space available for length but restricted width and height.
  - Ensure the higher max thrust is within the limits for rod buckling.



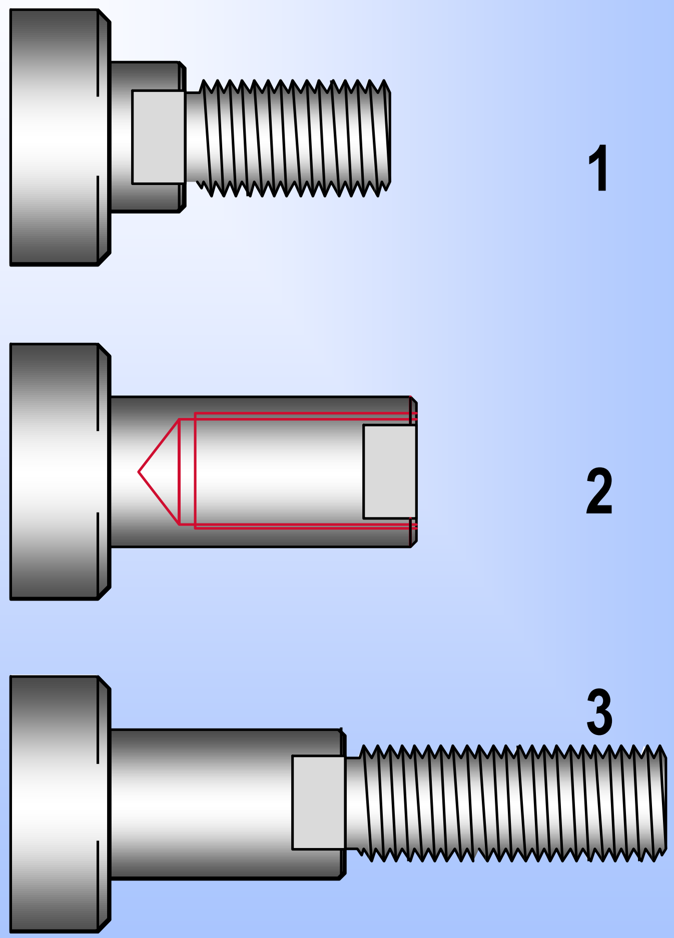
Variants

- **Duplex**
  - **The piston rods are not joined and the rear most cylinder is of a shorter stroke.**
  - **Nearly double starting thrust is achieved and maintained throughout the stroke of the shorter cylinder**
  - **Intermediate position can be set by the short cylinder only.**



Variants

- Custom Piston Rod End
  - For fitting to a device or mechanism that has an existing thread not suited to a standard rod end.
  - Typical arrangements include special thread forms, special thread lengths and internal threads



Special purpose actuators

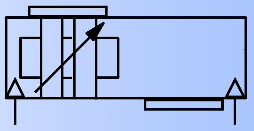
Special purpose actuators

- For special applications there are cylinder types and ranges specially designed to meet these needs.
- Twin stroke cylinders
- Positioning cylinders
- Impact cylinders

Twin stroke cylinder

Twin stroke rodless cylinders

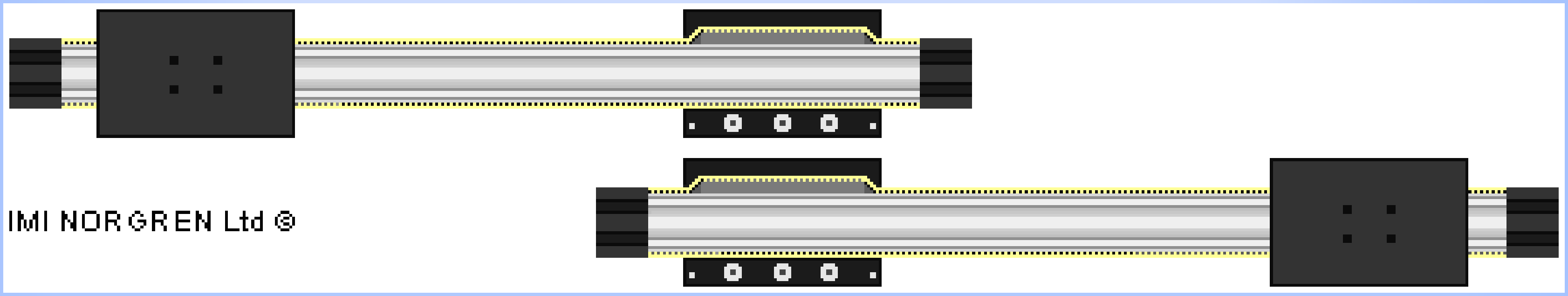
- To satisfy applications where a long reach or double movement is required.
- Twin stroke cylinders have two carriages that move in opposite directions.
- The powered carriage is connected by a belt to the free carriage.



Click the illustration to start and stop animation

Twin stroke rodless

- Fix the primary carriage to an external mounting position
- The secondary carriage will advance by twice the normal stroke
- Also a version with the port connections in the carriage to avoid long trailing pipes



Click the illustration to start and stop animation

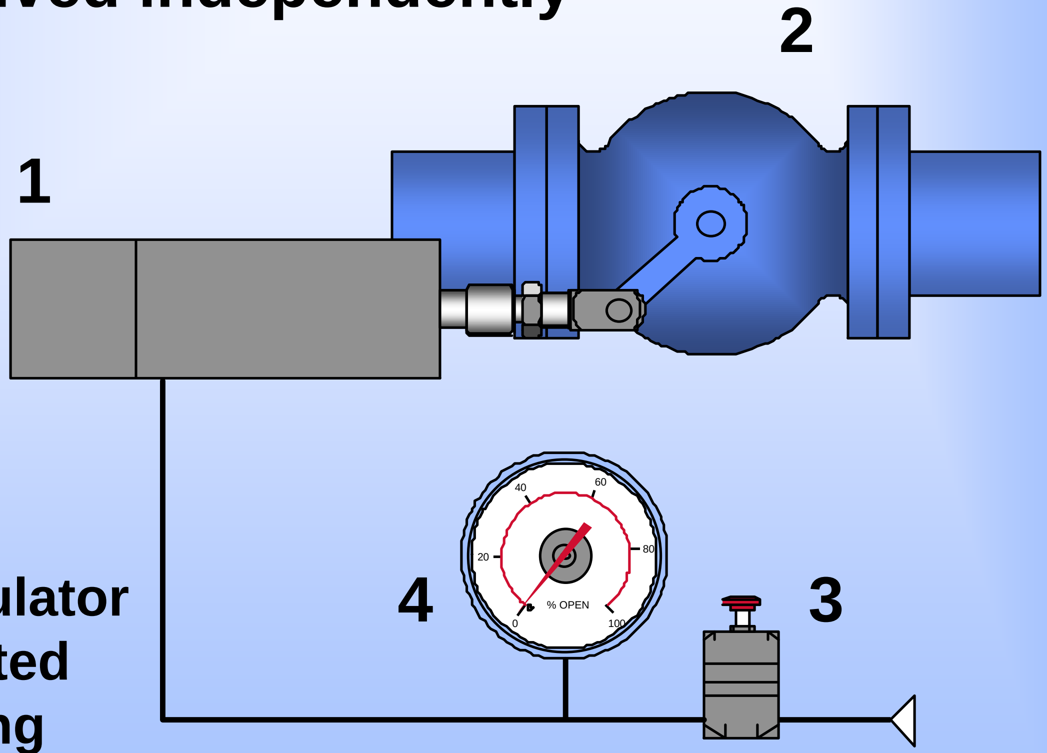
Positioners and servo cylinders

Positioners

- A positioner cylinder is controlled from a servo valve and can move to any stroke position.
- This position is maintained even under changing load conditions.
- The servo valve receives an analogue instrument control signal in the range (0.2 to 1 bar or 0.2 to 2 bar pneumatic) or (4 to 20mA electronic) which determines the percentage of piston rod stroke in proportion to the signal.
- If the load applied to the piston rod changes, the servo valve will change the pressure conditions within the cylinder to ensure that the position is maintained.

Positioners and servo cylinders

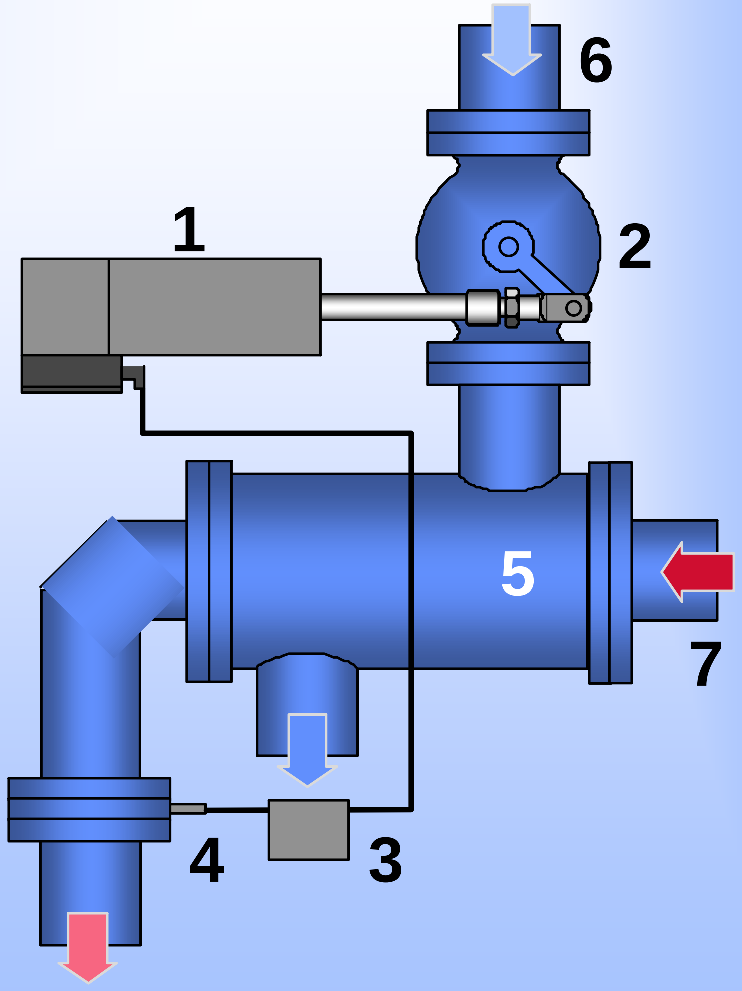
- Open Loop Application
- Control signal derived independently



1. In-line Positioner
2. Butterfly valve
3. Precision pressure regulator
4. Pressure gauge calibrated to show angle of opening

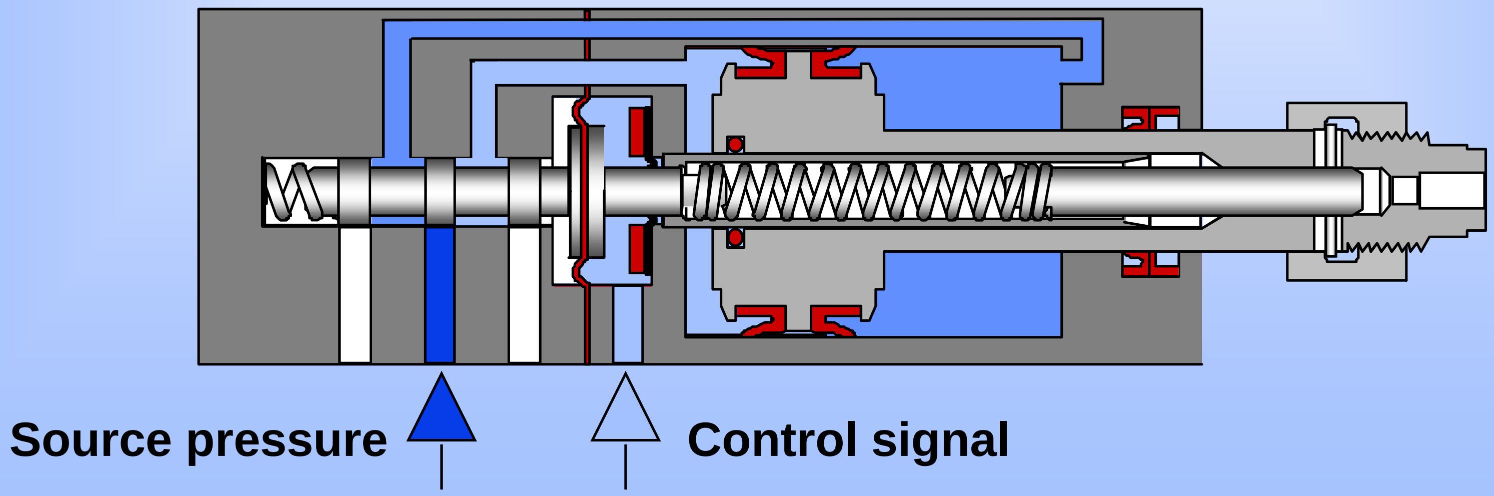
Positioners and servo cylinders

- Closed Loop application signal derived from the result of the process
- Valve 2 supplies cooling water entering at 6 to a heat exchanger 5.
- A hot gas entering at 7 is cooled an measured at 4
- The signal is processed at 3 and transmitted to adjust the position of the positioner 1
- As the temperature at 4 changes the positioner adjusts to correct it



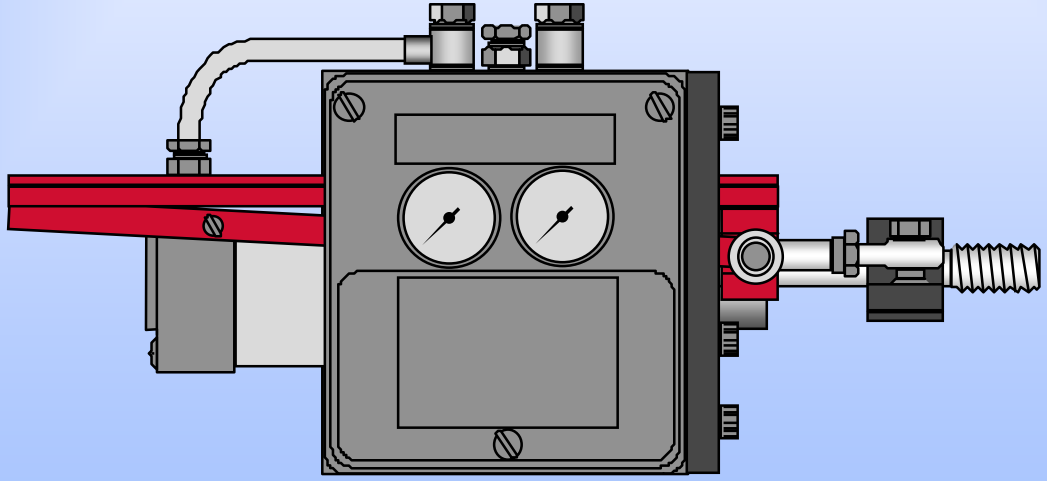
In-line positioners

- Integrated servo valve and cylinder
- Increasing control signal moves the spool to the left and outstrokes the cylinder
- Increasing force from the spring pulls the spool back to the right to stop the piston
- Every control signal has a piston position to balance forces



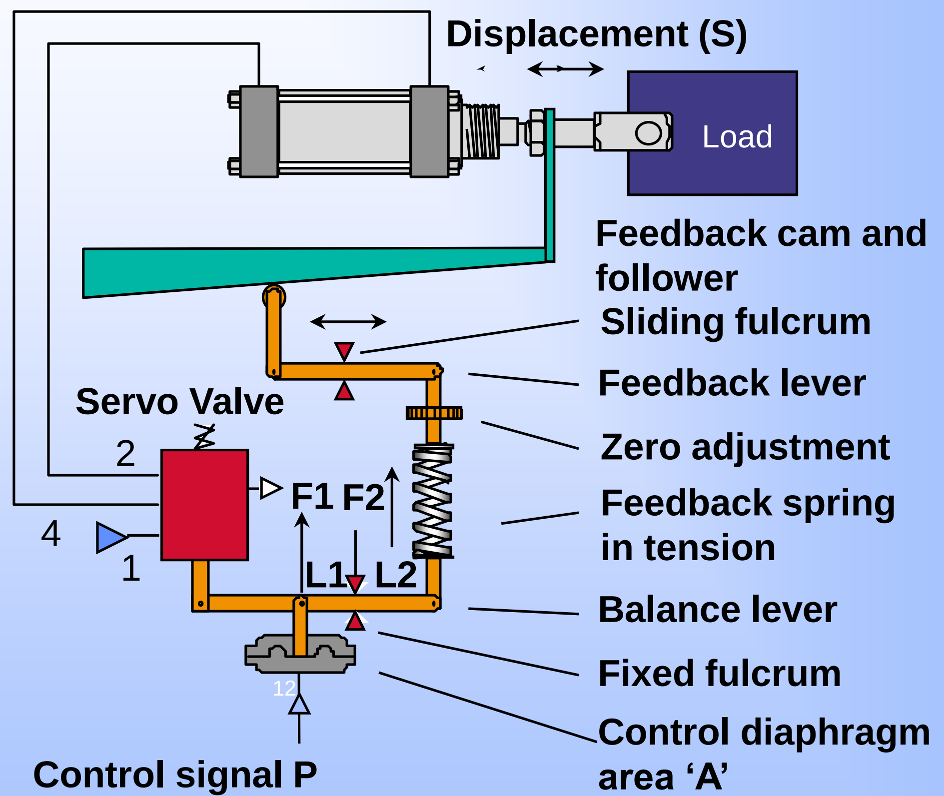
Servo cylinders

- For positioning cylinders bore 63-80mm and 2.5 - 12 inch
- Stroke dimensions 50 - 1000 mm
- Control from a universal positioner 0.2-2 bar or 0.2-1 bar.
- Positional feedback is from a roller running on a sliding wedge linked to the piston rod.



Universal positioner

- If the control signal P is increased, the valve spool is pushed in by force F1 to drive the cylinder out
- The feedback cam pushes the roller down to increase the tension in the spring F2
- When the forces F1 & F2 are balanced the spool will be centralised and stop the cylinder
- For every value of P there will be a proportional position S



Impact cylinders

Impact cylinders

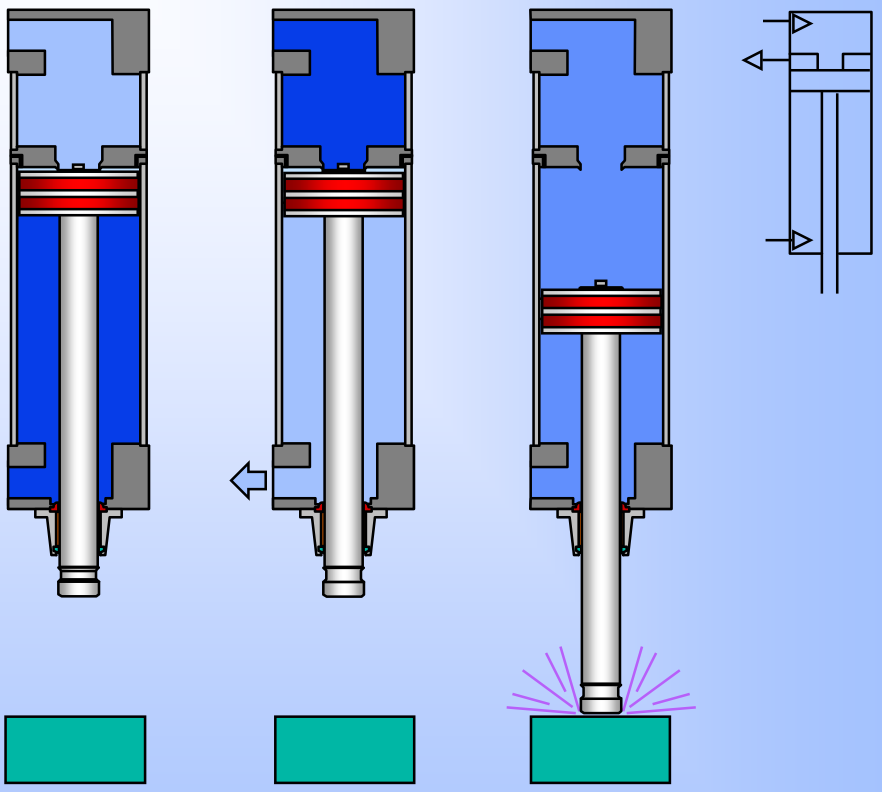
- The piston and rod accelerate very rapidly to deliver a hammer blow.
- By fitting suitable tooling to the piston rod, the impact cylinder can carry out certain types of presswork that would otherwise require larger and more costly presses.
- Bore sizes range from 2" to 6" diameter which can give an average equivalent thrust of 25 KN to 253 KN, when working through material of 1.0 mm thickness, at 5.5 bar working pressure.
- Impact cylinders are given energy ratings in Nm.
  - 2 inch bore = 25 Nm.
  - 3 inch bore = 63 Nm.
  - 4 inch bore = 126 Nm.
  - 6 inch bore = 253 Nm.

Impact cylinders

- The piston acts as a poppet valve creating an initial 9 to 1 area differential across it. This causes the cylinder to virtually pre-exhaust before moving, then the full area is suddenly exposed to the stored pressure and it fires.
- Applications that require the energy to be dissipated through a short working distance are best suited to impact cylinders.
- They include shearing, blanking, punching, piercing, coining, cold forming, embossing, stamping, staking, marking, riveting, swaging, bending, nailing, flattening, cropping, hot forming, crimping, and flying shear.

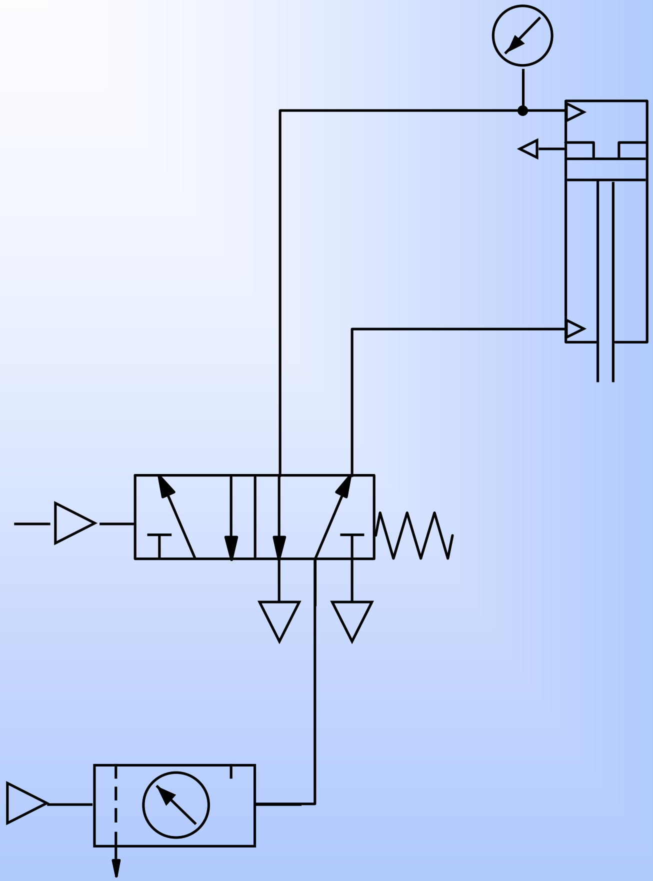
Impact cylinders

- Three stages of operation
- 1. Piston is held in the instroked position.
- 2. Reservoir above the piston at pressure but force under piston is still higher due to larger area. Air still venting
- 3. Pressure under piston fallen just enough to cause movement allowing the stored pressure to act over the full area and cause rapid acceleration.



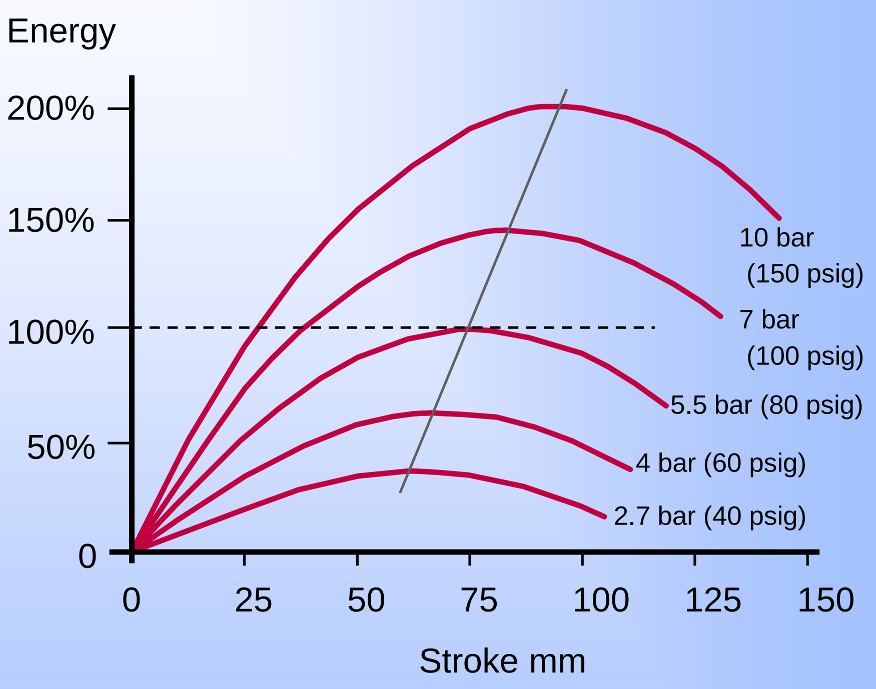
Control circuit

- Valve shown in the normal position holding the cylinder instroked.
- When the control valve is operated the chamber on top of the piston is pressurised and the volume under the piston is vented.
- Full top pressure is quickly reached but the venting pressure must fall to less than 1/9 of this before the cylinder fires.



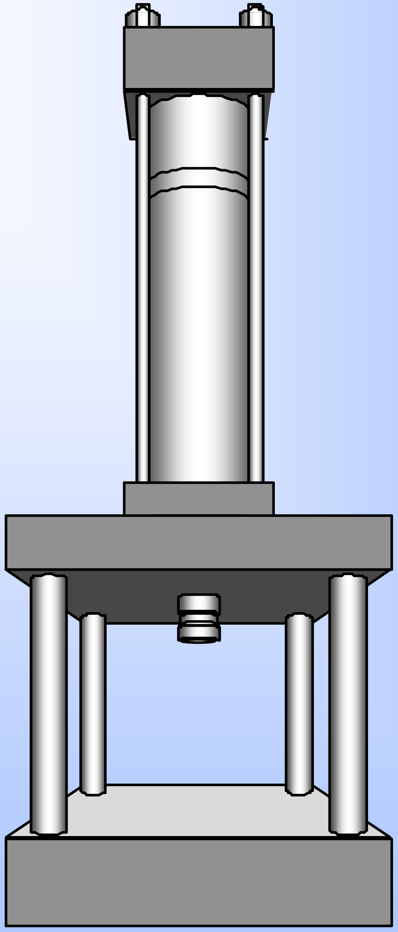
Energy graph

- Typical kinetic energy characteristics of the piston and rod are shown against stroke at varying line pressures.
- The maximum energy is developed at approximately 75mm of stroke which should be the point of impact
- 100% energy represents the published rating for the chosen impact cylinder.



Installation

- Impact vertically up or vertically down.
- At the point of impact the piston rod and tooling can be considered to be in free flight
- The frame must be stiff enough to take the recoil force at the instant of firing.
- Four pillar frames are simple to construct. A thick top plate will resist flexing when the cylinder is fired and add mass to the cylinder body.



Impact cylinders

- **Warning.** **There will be a pause before an impact cylinder fires. Also it is possible to hold an impact cylinder in balance at the point of firing, then vibration, extra load, a very slight change in the pressure balance or other disturbance will set it off. The working area should be guarded at all times and tubing branched to an indicator to warn when the top reservoir is charged.**

End

- Click here to go back to Main Contents Page

Help

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