Chapter 6:

Hydraulic & Pneumatic machines

5- Types of air compressors:

There are generally two basic types of compressors:

- Volumetric compressors (see: A, B and C).
- Dynamic compressors (see: Det E).

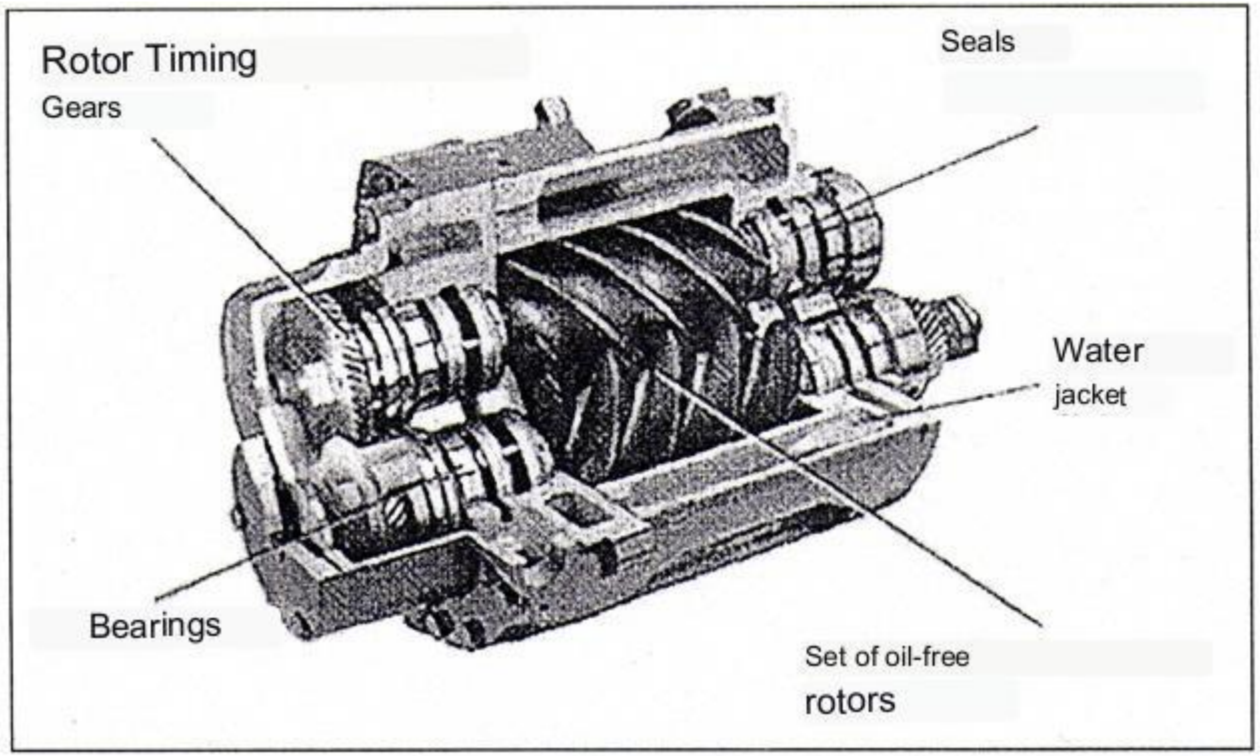
5.1)- Volumetric compressors:

In the volumetric type, a given amount of air is drawn into a compression chamber and then the volume the air occupies is decreased, resulting in a corresponding increase in its pressure before it is expelled. Rotary screw air compressors, vane compressors and reciprocating compressors are the three most common types of positive displacement compressors used in small and medium industries.

A-Rotary screw compressor:

They are the most common for powers between 5 and 900 HP (1 HP = 745.7 Watt). The most common type of rotary compressor is the screw compressor with two helical rotors.

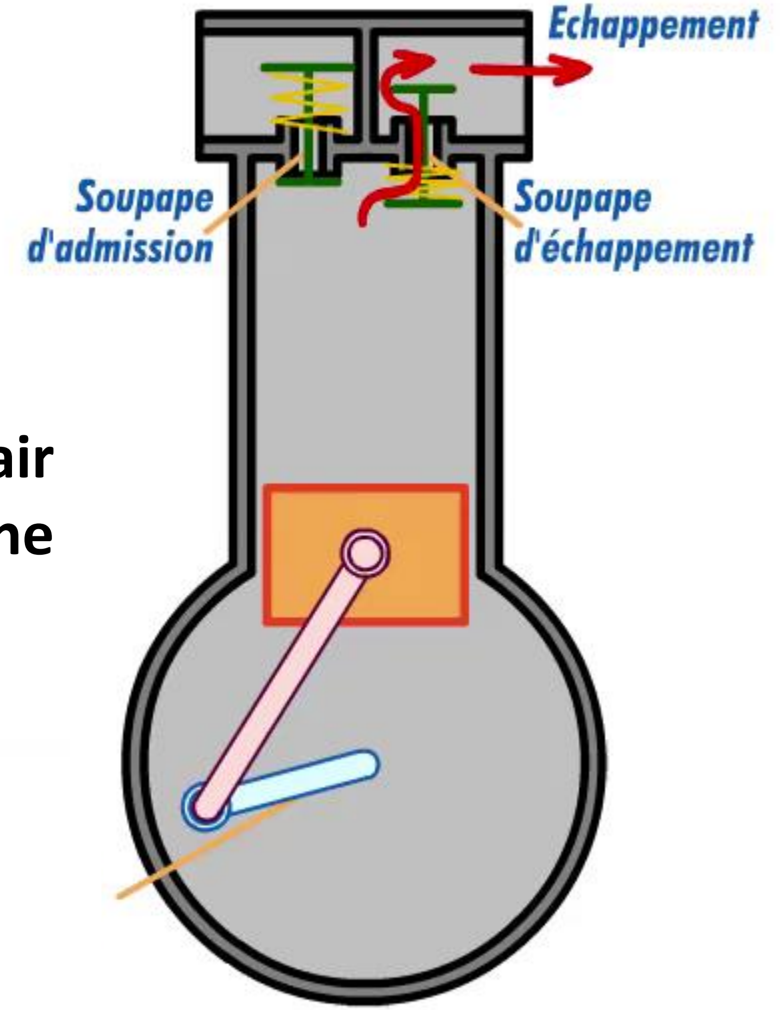
Two mated rotors are meshed together, trapping air and reducing its volume along the rotors. Depending on air purity requirements, rotary screw compressors are of the lubricated or dry (oil-free) type.



B. Reciprocating compressor:

Compressors of this type have a piston driven by a crankshaft and an electric motor. General purpose reciprocating compressors are available on the market in sizes ranging from less than 1 HP to around 30 HP. They are often used to supply air to control and automation devices in buildings.

In its downward stroke, the piston sucks in the outside air and in its upward stroke, it pushes it back to the tank. The pressure in the tank increases with each expulsion of air.



C. Rotary vane compressor

The rotor rotates in a cylindrical stator. During the rotation, the centrifugal force pushes the pallets out of their location: they then form individual compression cells. The rotation reduces the volume of the cell and thus increases the air pressure.

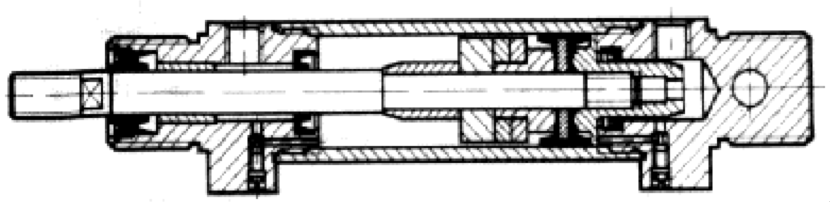
The heat generated by the compression is controlled thanks to an injection of pressurized oil.

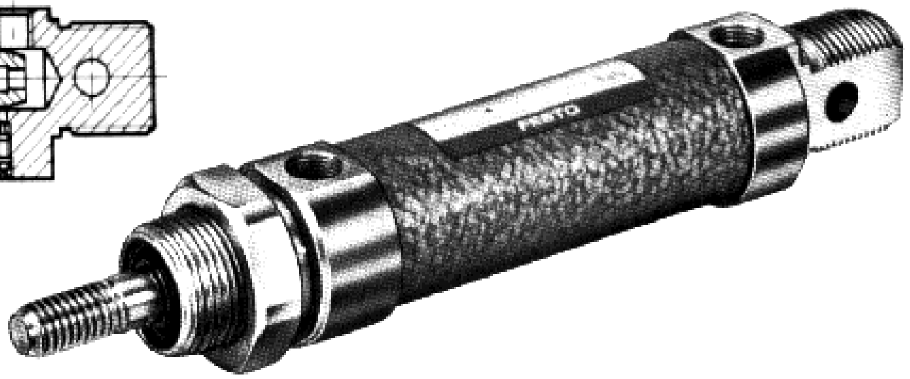
The high pressure air is exhausted through an outlet port and the remaining traces of oils are removed by the final oil separator.

5.2)- Dynamic compressors:

Ram air compressors, which include centrifugal and axial machines, are common in very large manufacturing facilities.

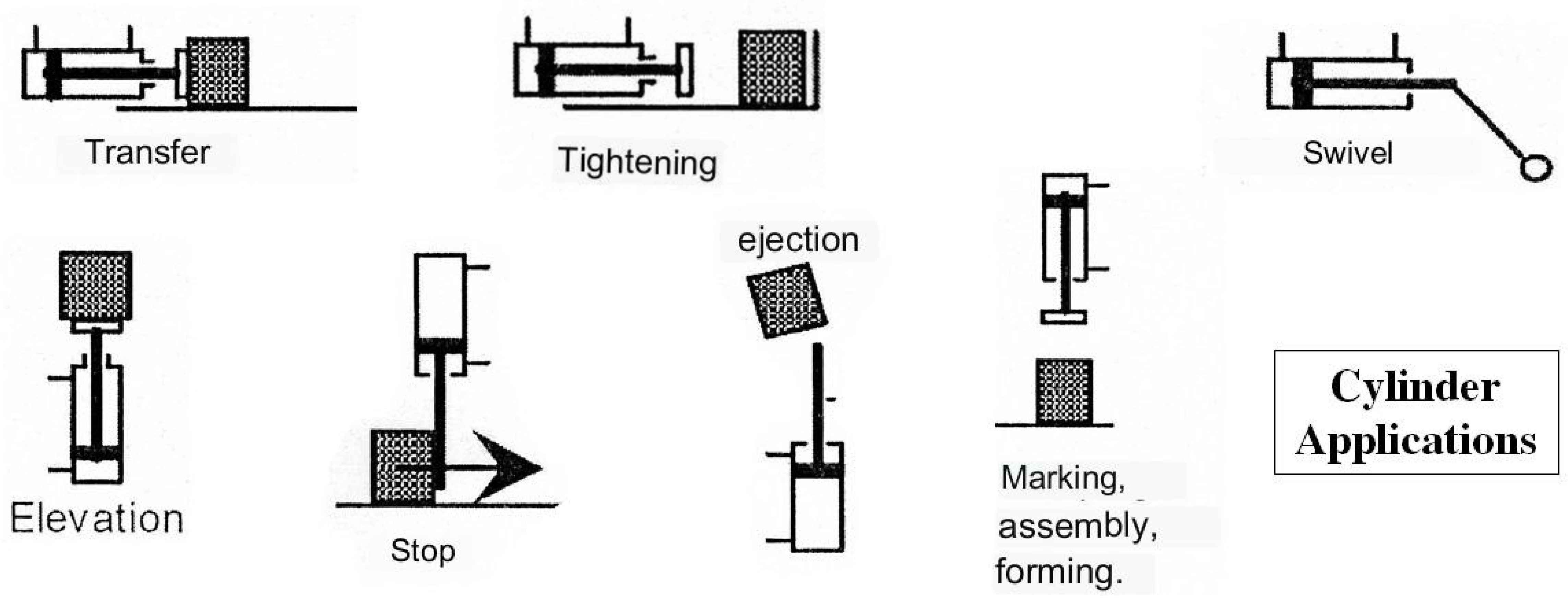
Cylinders





Cylinders convert the energy of a pressurized fluid into mechanical energy (movement with effort). They can: lift, push, pull, tighten, turn, block, hit, ...

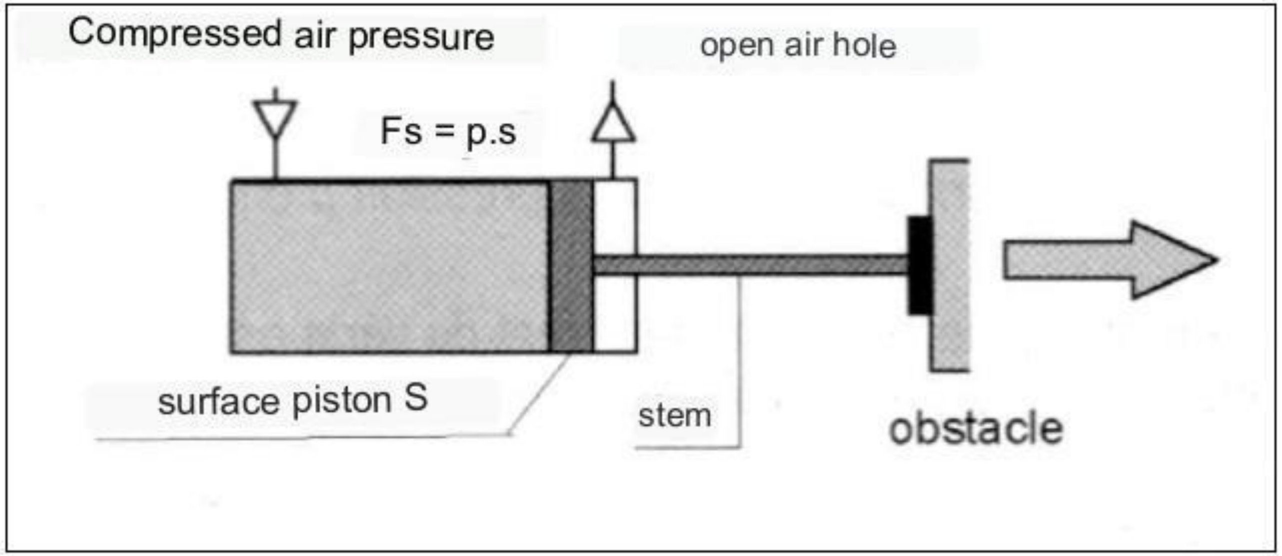
Pneumatic cylinders use compressed air, from 2 to 10 bars in common use. Their main characteristics are: running, strength and speed.



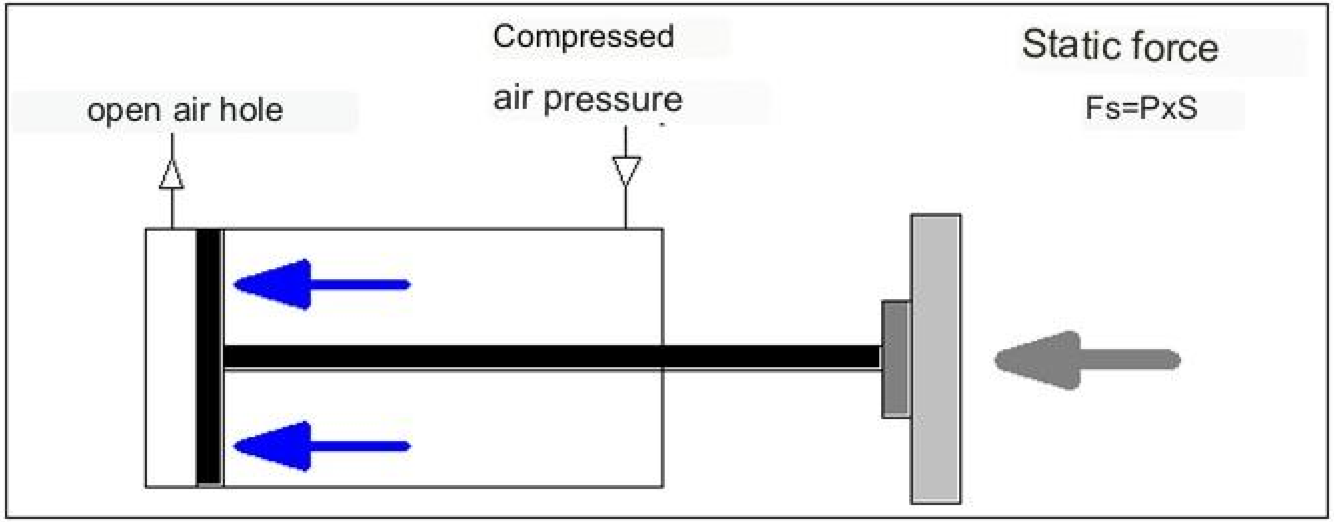
Forces available:

1. Static strength

By making the compressed air act on a stationary face, we obtain a static force F_s proportional to the pressure p and to its surface of action S :

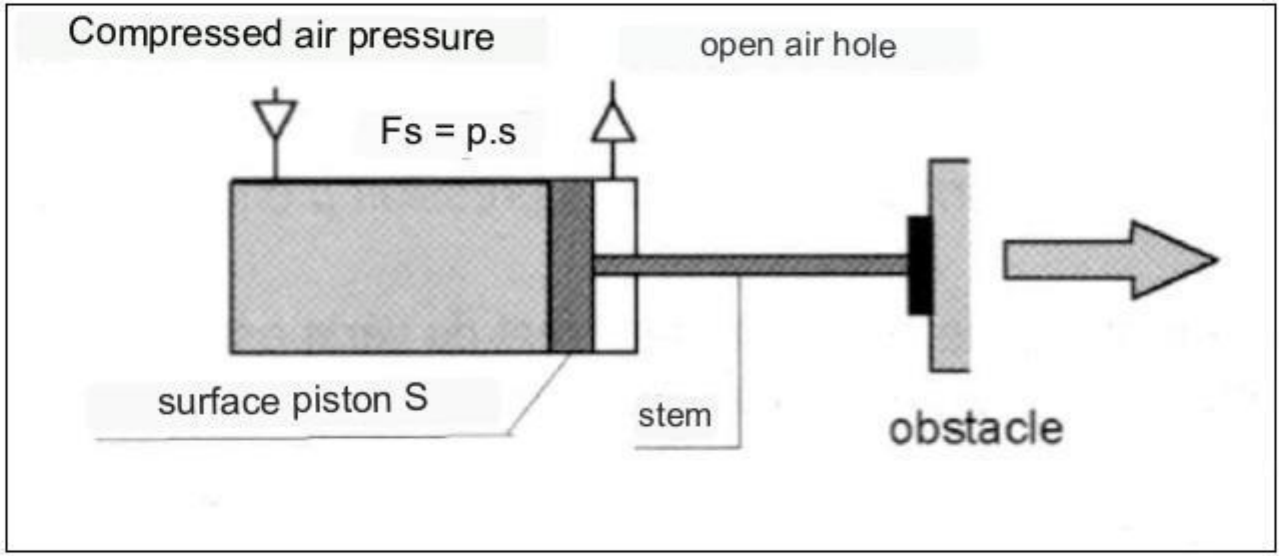


$$F_s = P \times S$$



Example :

Consider a double-acting cylinder with an **internal diameter of** 50 mm and a **rod diameter of** 20 mm, with a pressure of 6 bars.



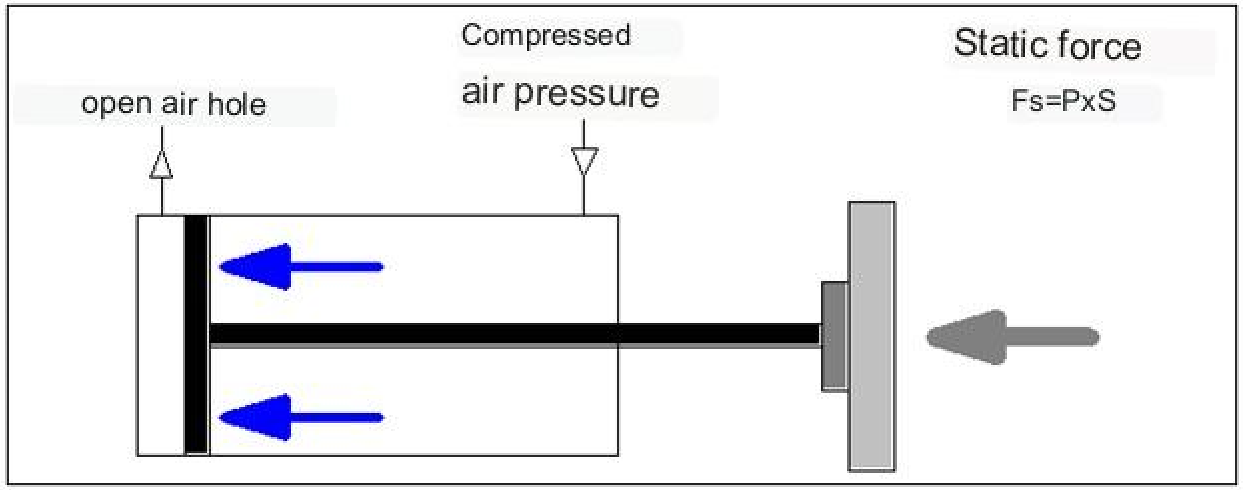
a) Extended rod:

The output rod static force is :

$$F_s = P \times S = P \times \pi \times \frac{D^2}{4} \approx 119{,}28\ daN$$

Example :

Consider a double-acting cylinder with an **internal diameter of** 50 mm and a **rod diameter of** 20 mm, with a pressure of 6 bars.



b) Entry rod:

When the rod retracts, the section is equal to ($S_{cylinder}$ - S_{rod}):

$$S = \frac{\pi}{4} \times \left(D^2_{vérin} - d^2_{tige}\right) = \frac{\pi}{4} \times \left(5^2 - 2^2\right) \approx 16{,}485\ cm^2$$

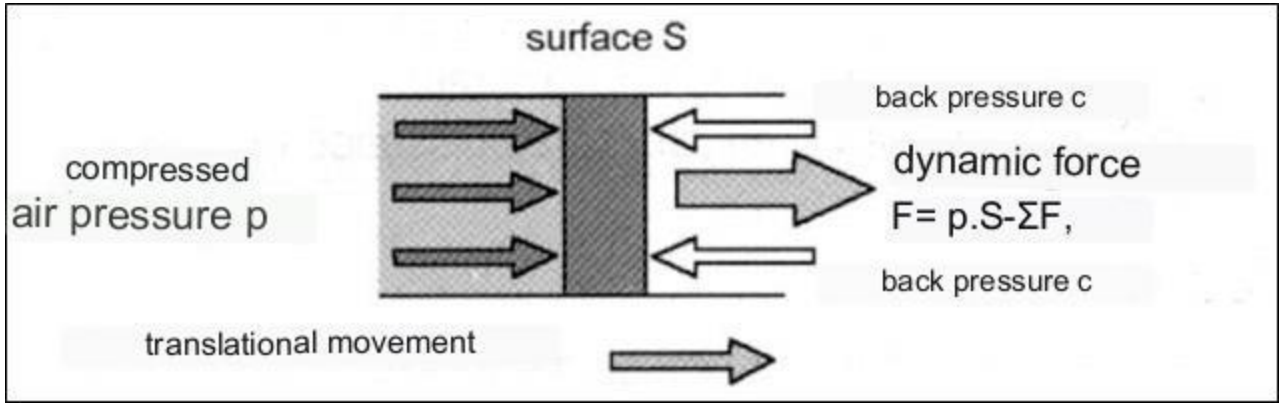
whence the static force with the rod retracted: $F_s = P \times S \approx 100{,}19\ daN$

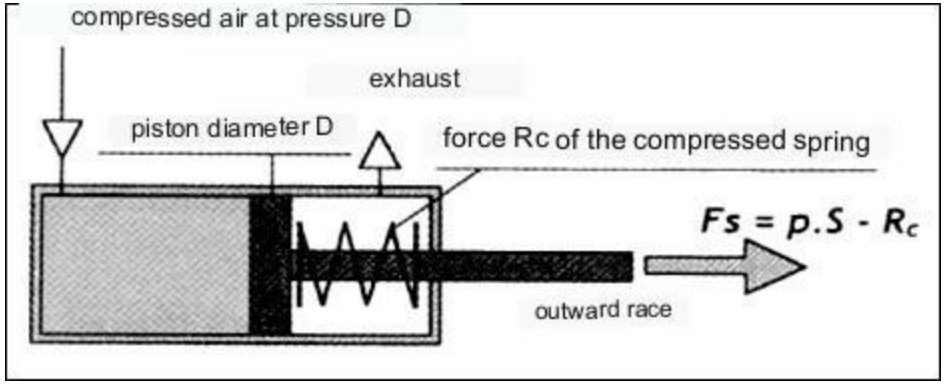
2. Dynamic strength

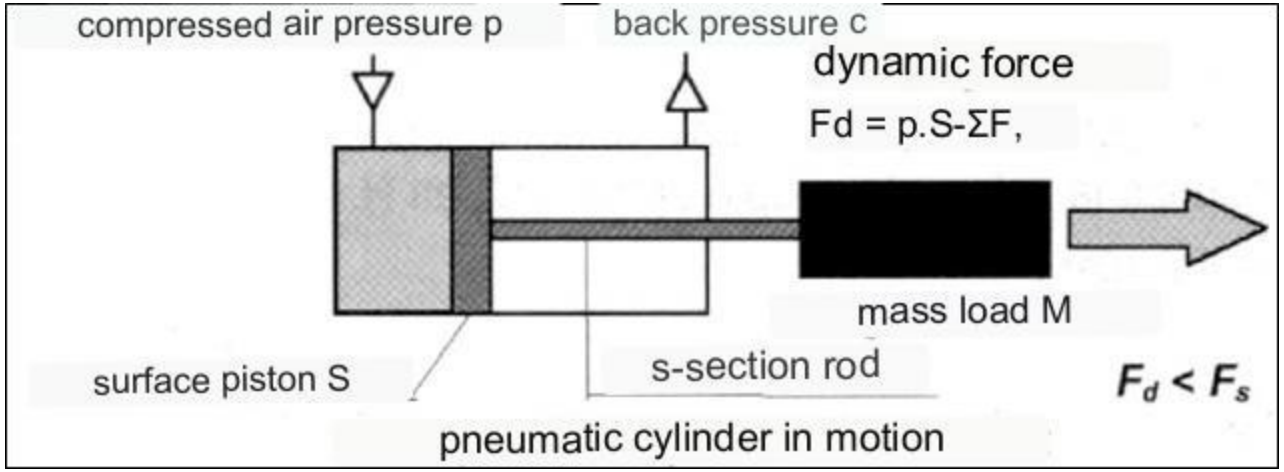
If the face is mobile in translation, the dynamic force F_d obtained during the movement is lower because it depends on the forces that oppose its movement: force related to the **opposite pressure (called counter-pressure), friction force, inertia force and the restoring force of the compressed spring** in VSE .

$$F_d = P \times S - \sum F_r$$

ΣF_r : Resistant Forces







Yield η

The measurements show that η is between **0.8 and 0.95** depending on the type of jack, its dimensions, the pressure and the dry or lubricated operation.

$$\eta = \frac{dynamic \;\; Force \;\; (F_d)}{static \, Force \;\; (F_s)}$$

Load rate *t* :

To be certain of using the jack in good conditions, the **load rate *t is defined*** . It is a parameter that takes into account both the effects of back pressure and internal friction.

$$\text{Load rate t} = \frac{F_{charge}}{F_s}$$

F ***load*** **:** Force to overcome to move the load;
Fs _ **:** Theoretical force ($F_s = PS$)

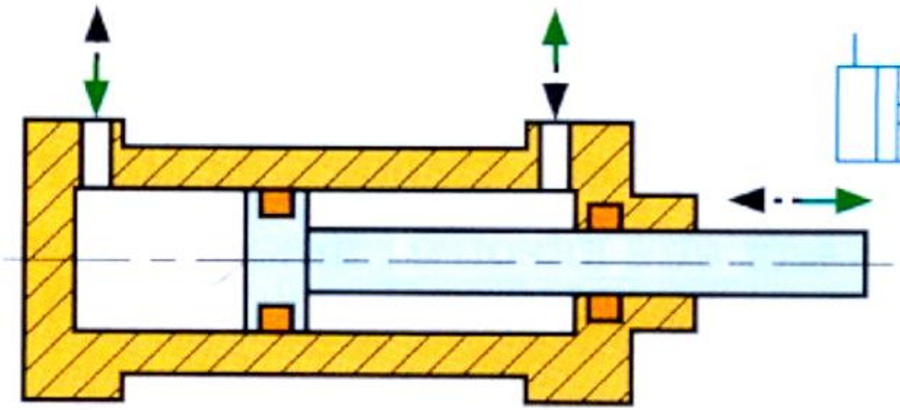
The essential ≤ **0.75**

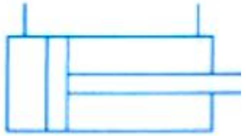
In practice : **0.5 ≤ loading rate *t* ≤ 0.75** .

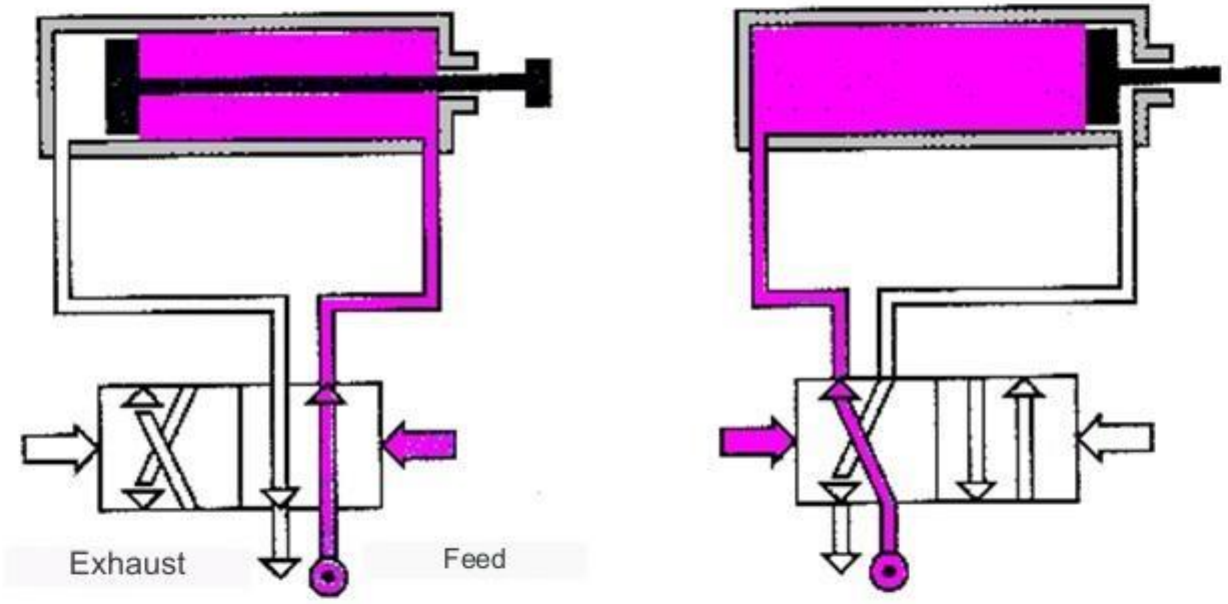
The usual load rate is 0.5, ie the cylinder will work at 50% of its capacity .

Cylinder types:

1. Double Acting Cylinders (VDE)

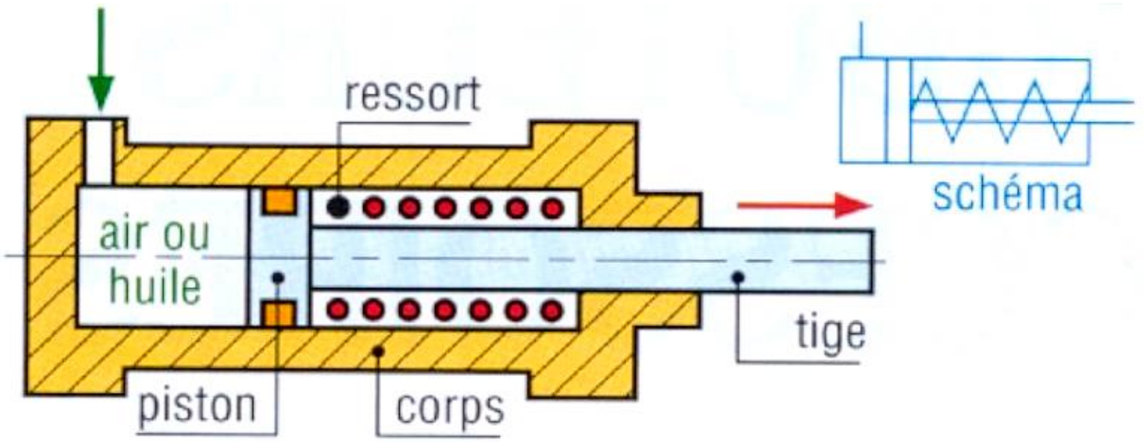






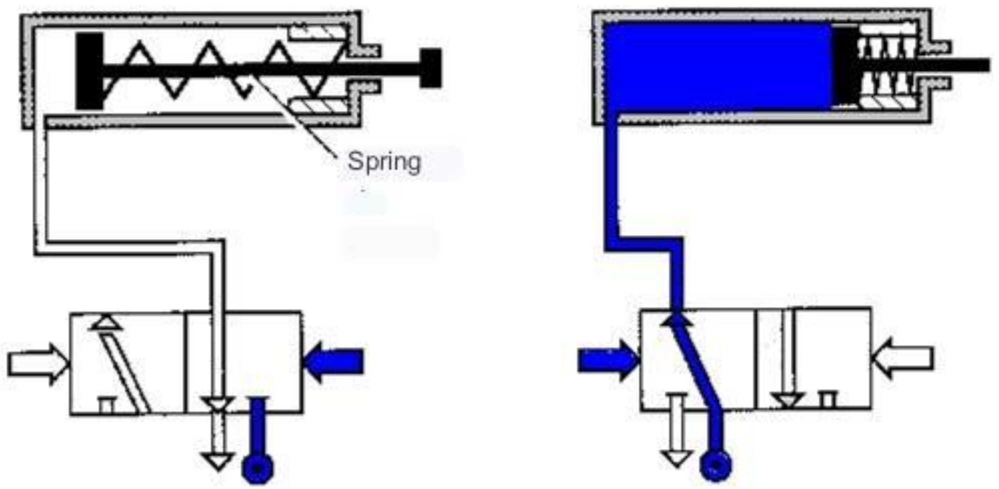
Cylinder types:

2. Single acting cylinders (VSE)

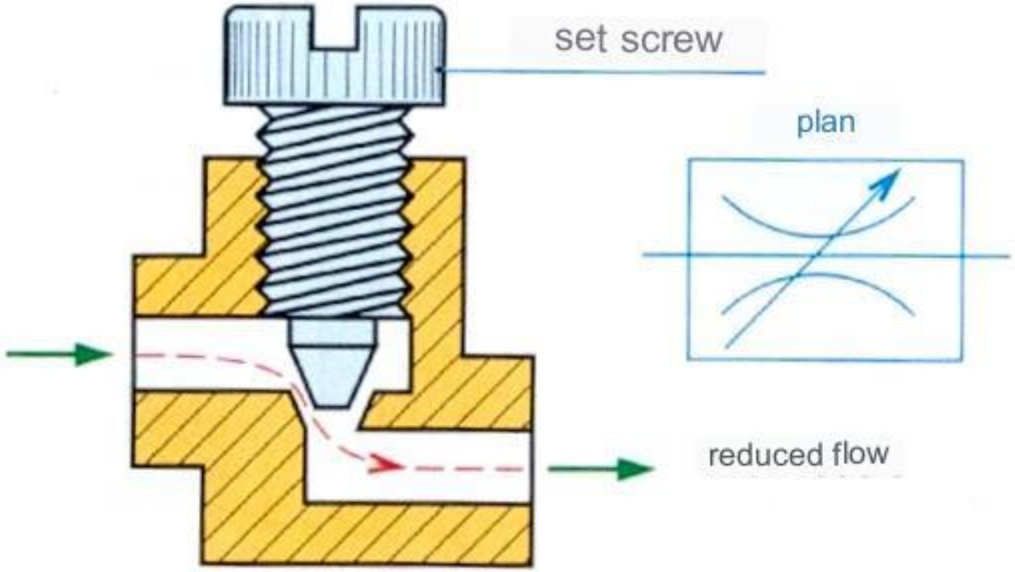


Developed static force : the force R_c of the compressed spring must be taken into account , hence:

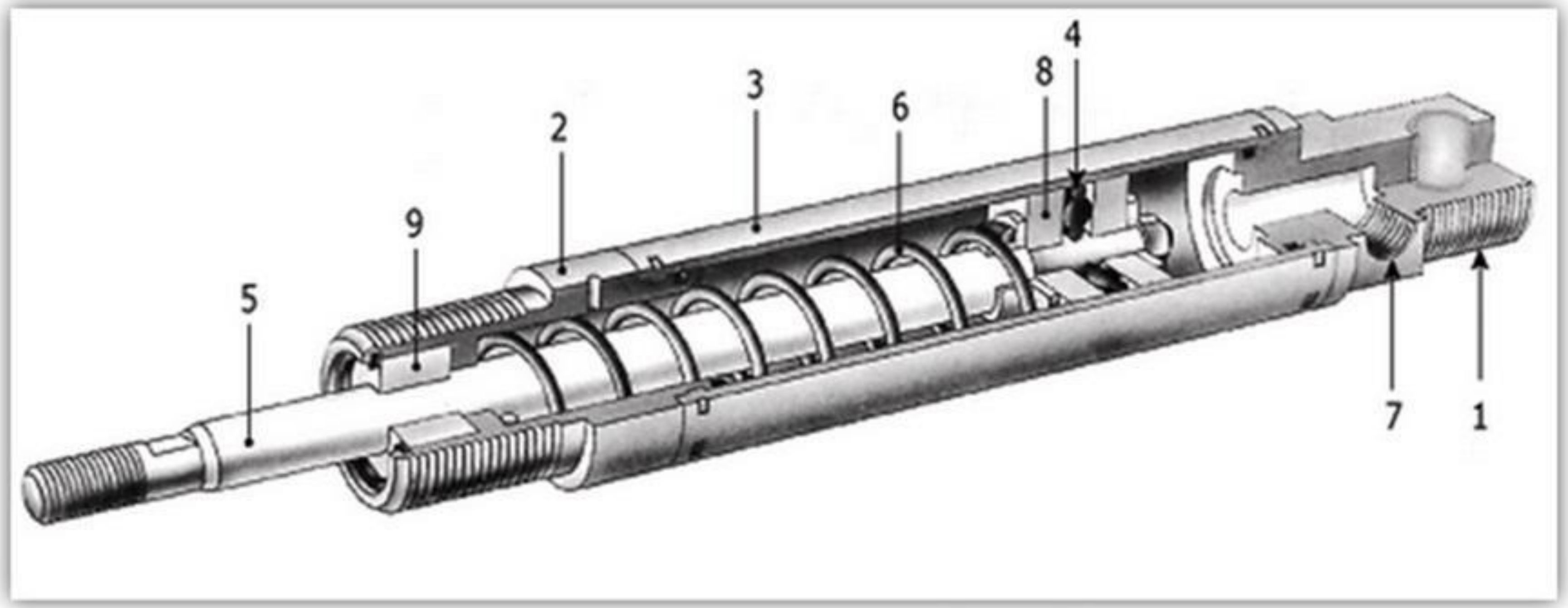
$$F_s = p \times S - R_c$$



Flow control principle



single acting



1. Rear flange or bottom (or bottom)

2. Front flange or bottom (or nose)

3. Tube

4. Piston seal

5. Stem

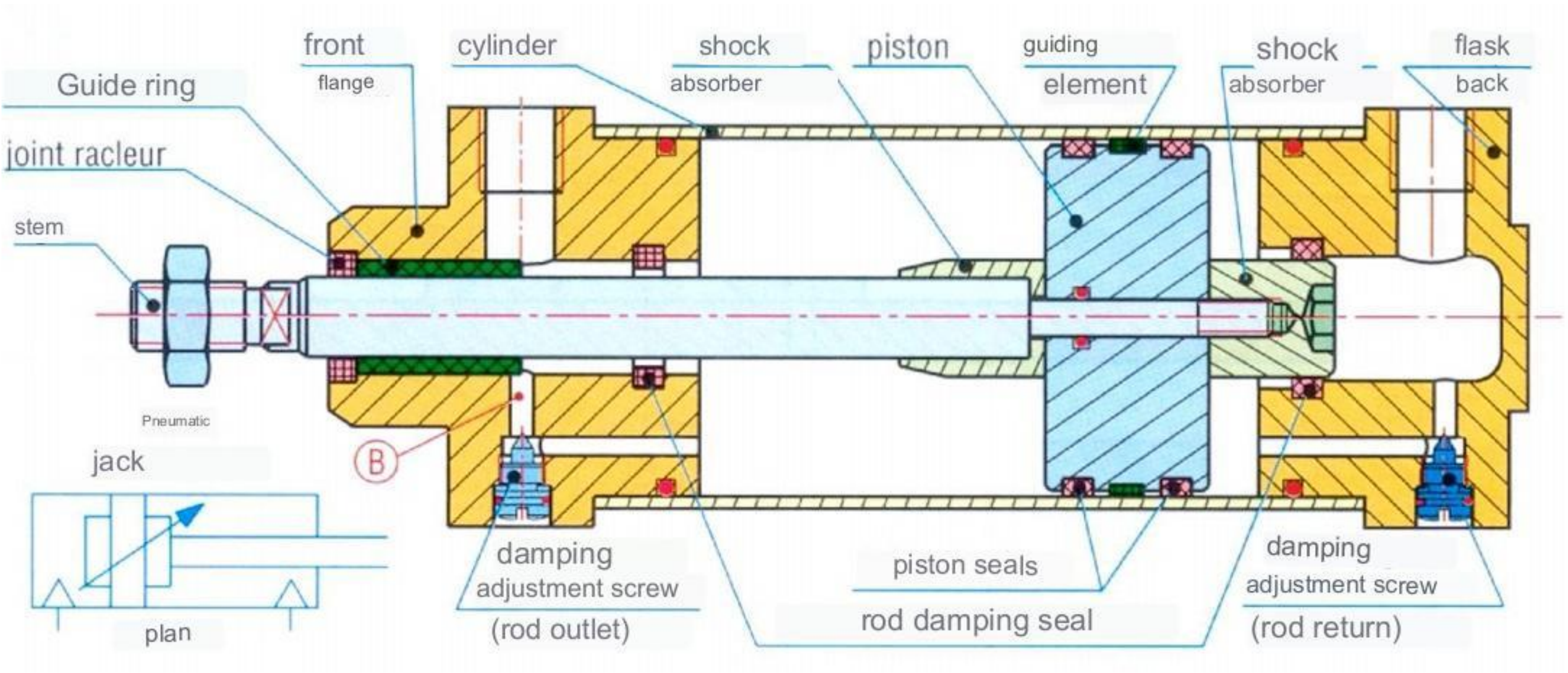
6. Return spring

7. Air inlet

8. Piston

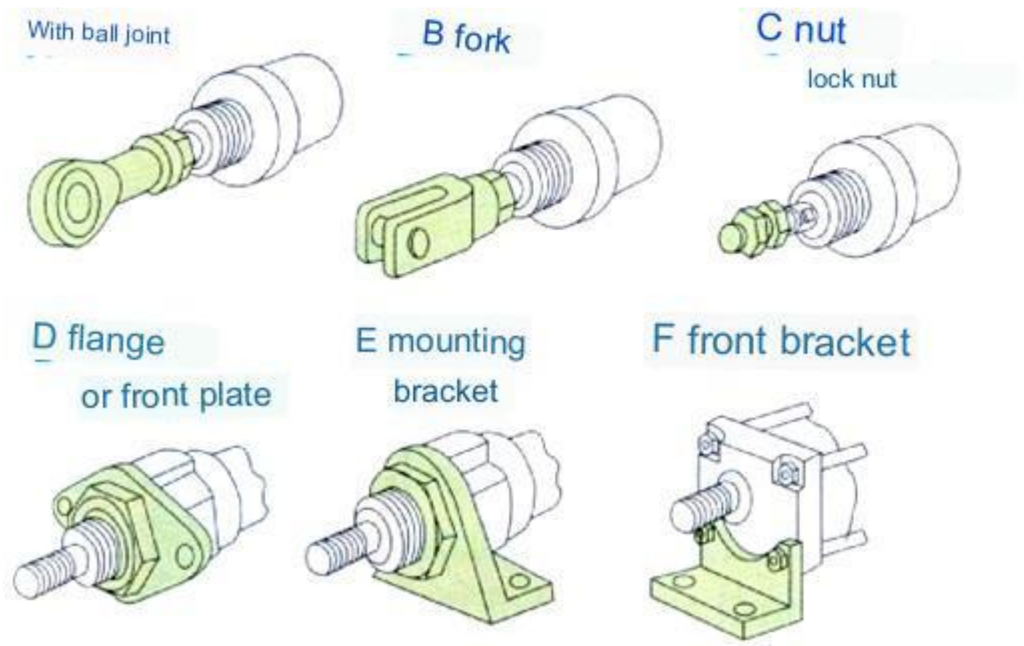
9. Socket

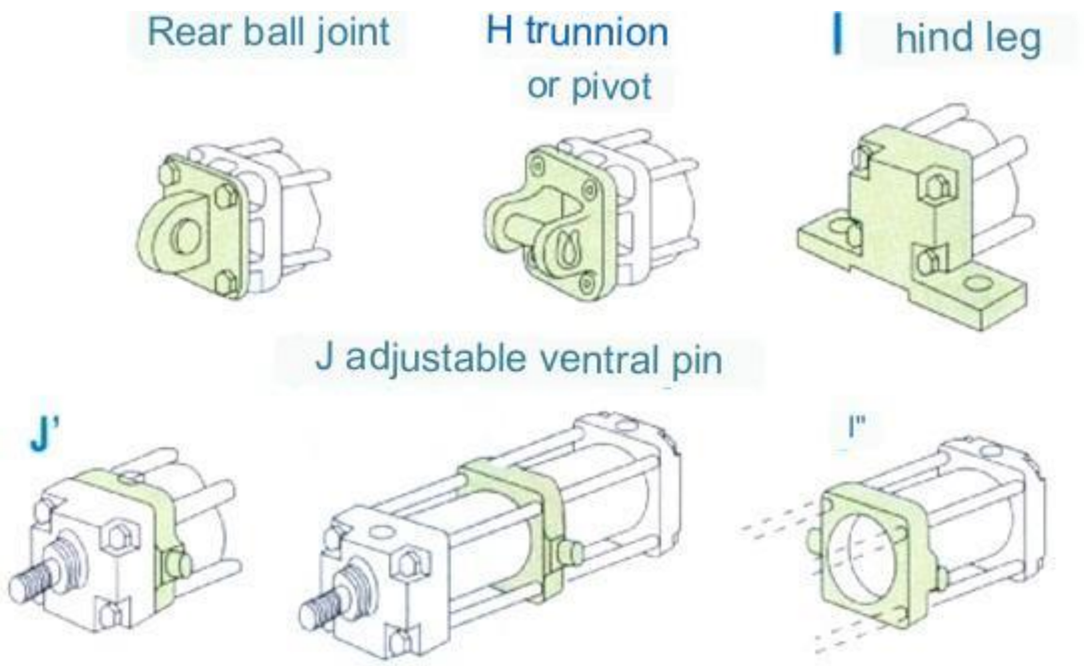
acting

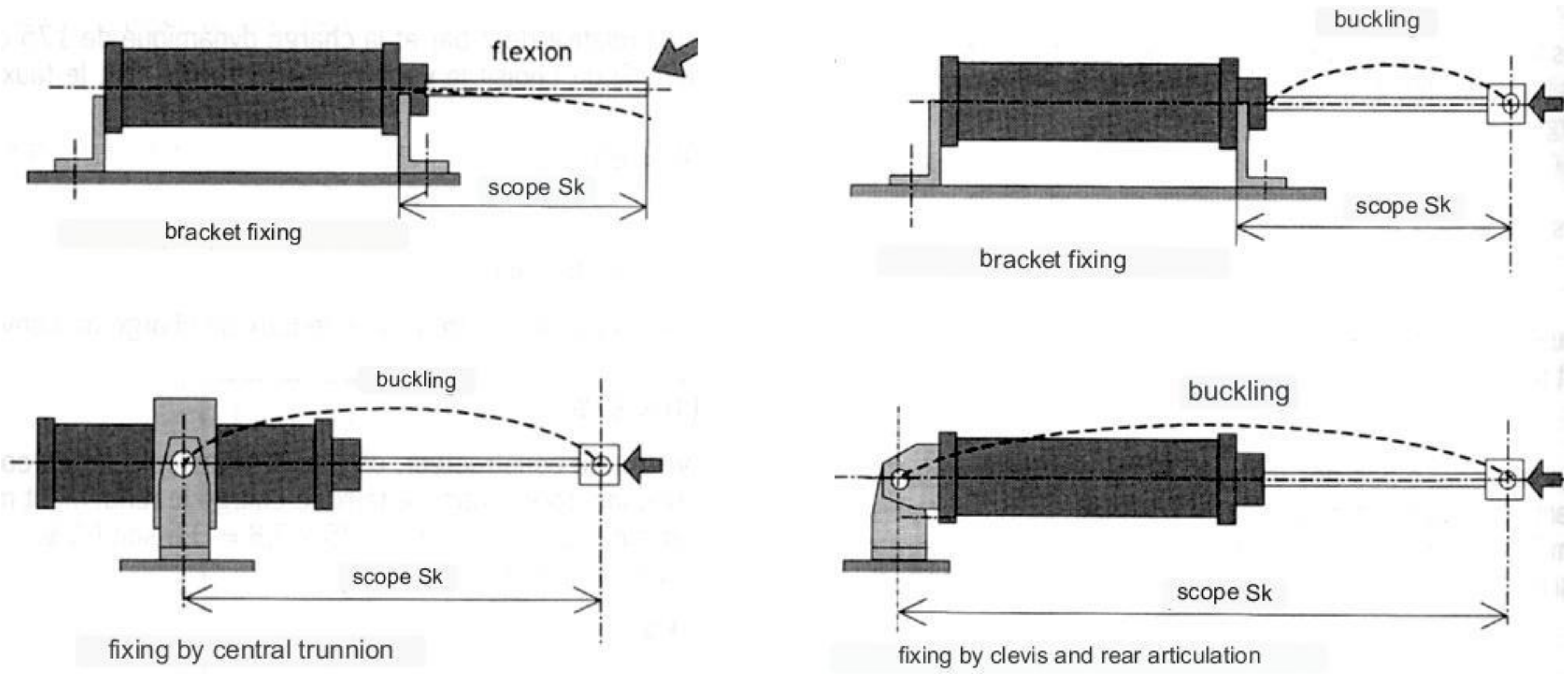


front
flange
cylinder
shock
absorber
piston
guiding
element
shock
absorber
flask
back
Guide ring
joint racleur
stem
Pneumatic
jack
plan
B
damping
adjustment screw
(rod outlet)
piston seals
rod damping seal
damping
adjustment screw
(rod return)

Fixings and assembly of cylinders







Cylinder rods subjected to bending and buckling forces

Determination of a jack

We always start our study with a loading rate of 0.5 (usual case):

1- Job pressure,

2- Load force (Fd) and the static force (Fs) **At the exit of the rod,**

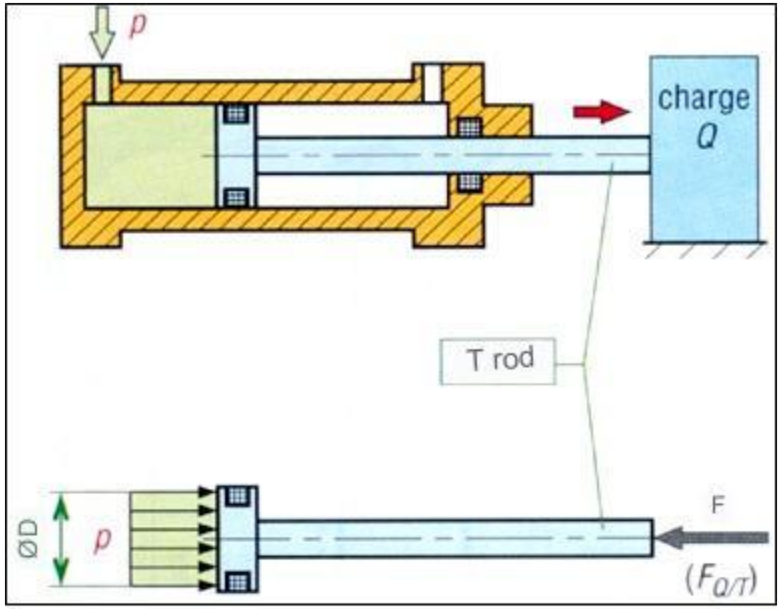
3- Calculate the diameter of the cylinder (D) then choose the diameter of the standardized cylinder (D) from two methods,

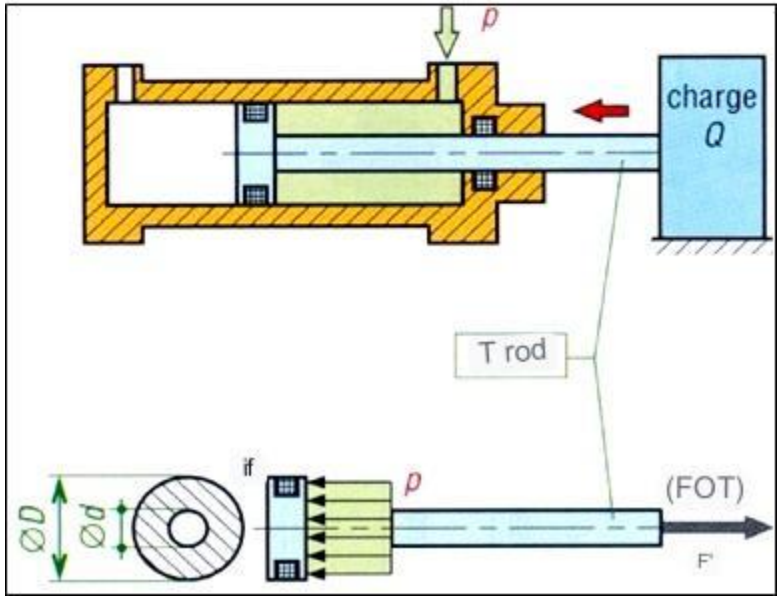
4- Draw the diameter of the rod (d),

5- Actual load rate,

6- Load force (Fd) and static force (Fs) **At the stem entrance,**

7- Cylinder stroke from speed and time,



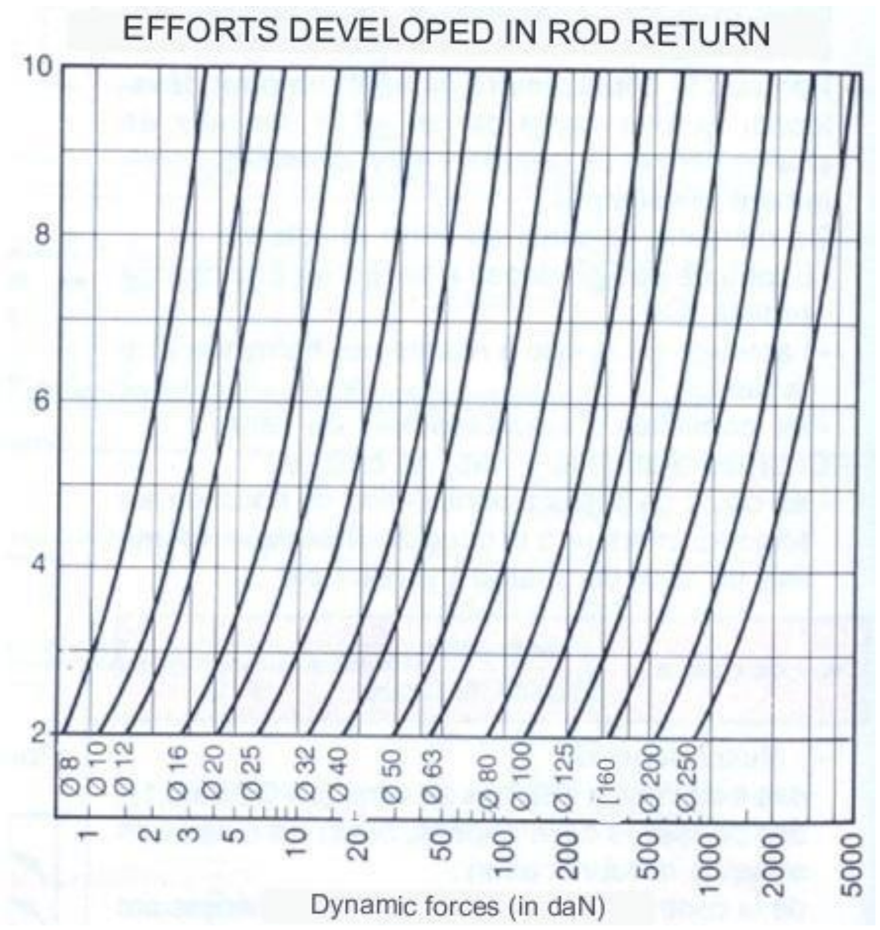


Standard cylinder diameters

2)

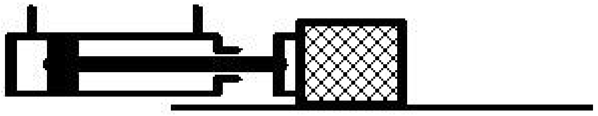
D Cylinder (mm)	8	10	12	16	20	25	32	40
d Stem (mm)	4	4	6	6	10	12	12	18
D Cylinder (mm)	50	63	80	100	125	160	200	250
d Stem (mm)	18	22	22	30	30	40	40	50

1)



Example 1:

Consider a cylinder used to transfer parts, under a pressure of 6 bars. At the end of the static and dynamic calculations, the force that the actuator must develop is **118 daN** when pushing.



Transfer

Determination of a jack

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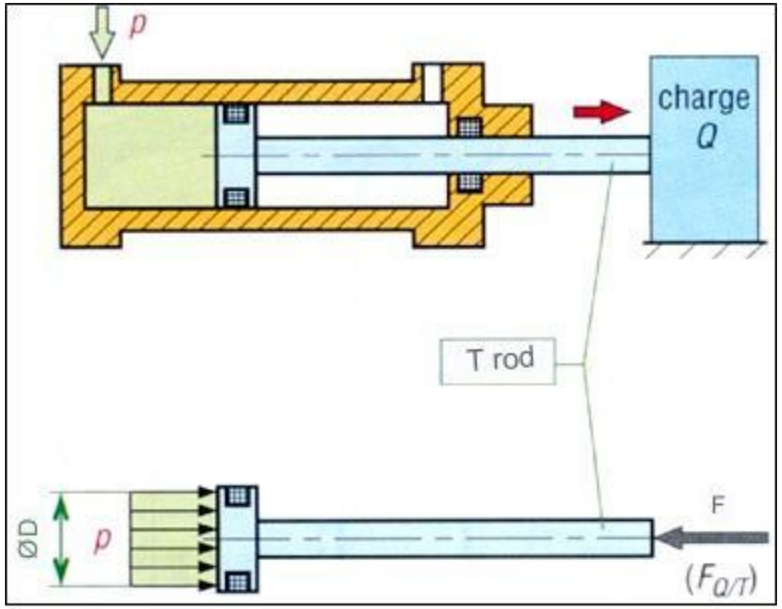
5- Actual load rate,

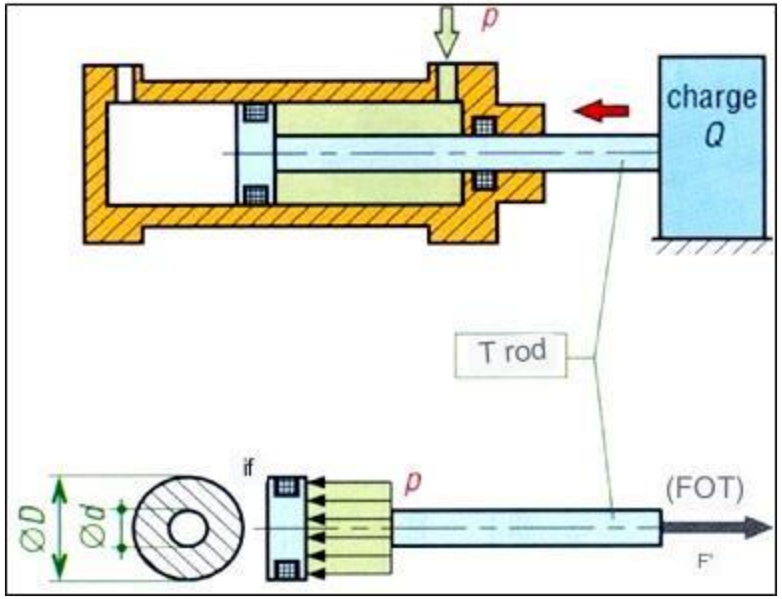
6- Load force (Fd) and static force (Fs) **At the stem entrance,**

7- Cylinder stroke from speed and time,

Example 1:

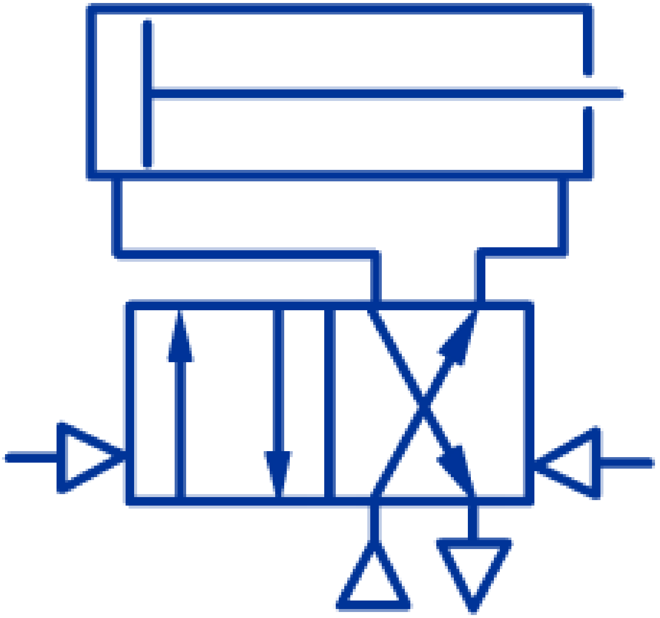
Consider a cylinder used to transfer parts, under a pressure of 6 bars. At the end of the static and dynamic calculations, the force that must develop the ram is **118 daN** when pushing.



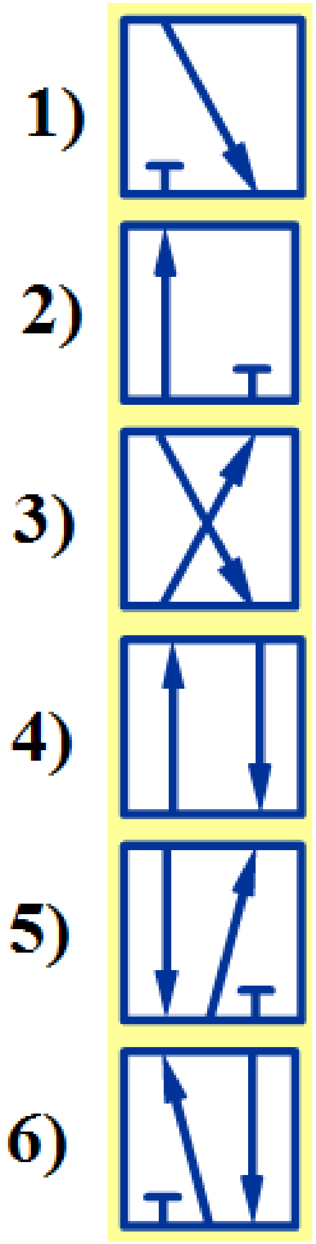


Apps

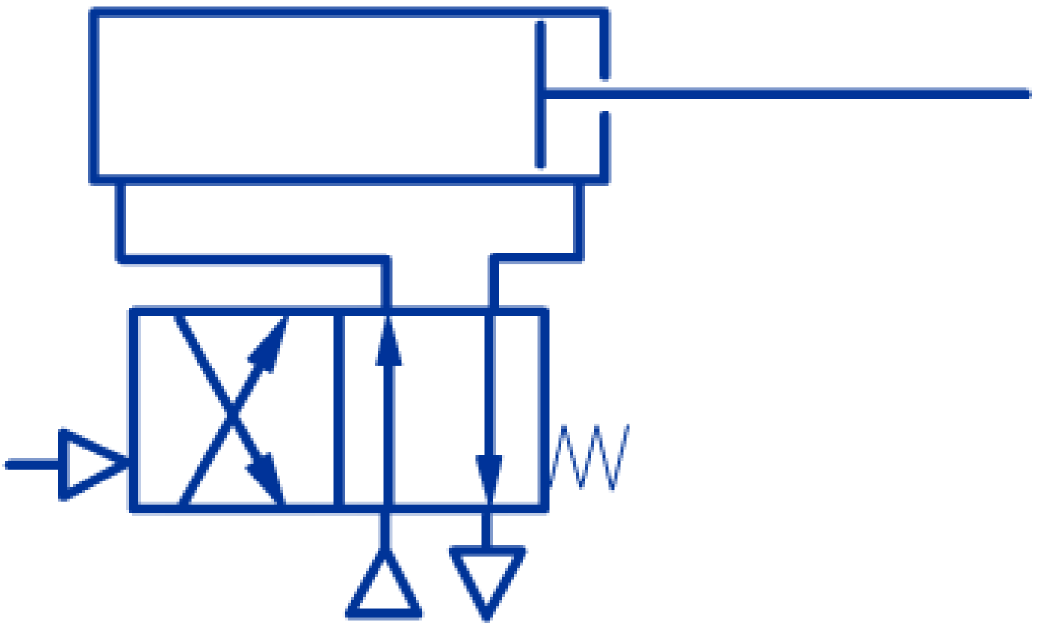
App 01

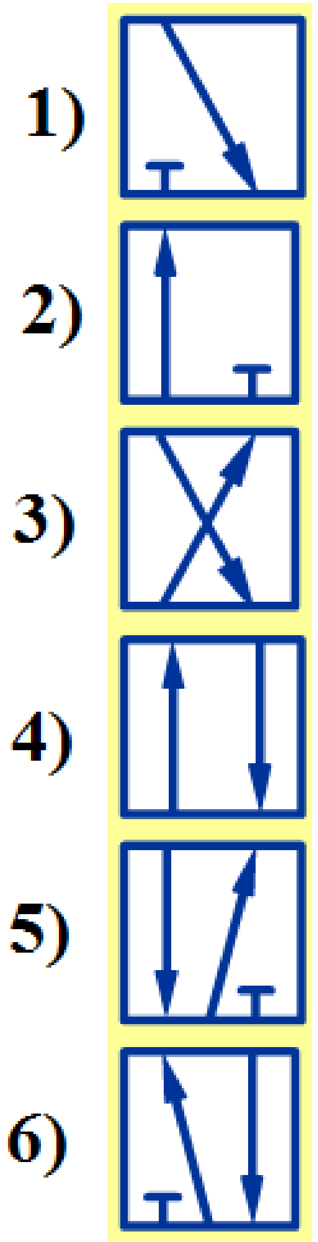


4/2 valve, Bistable, with pneumatic piloting



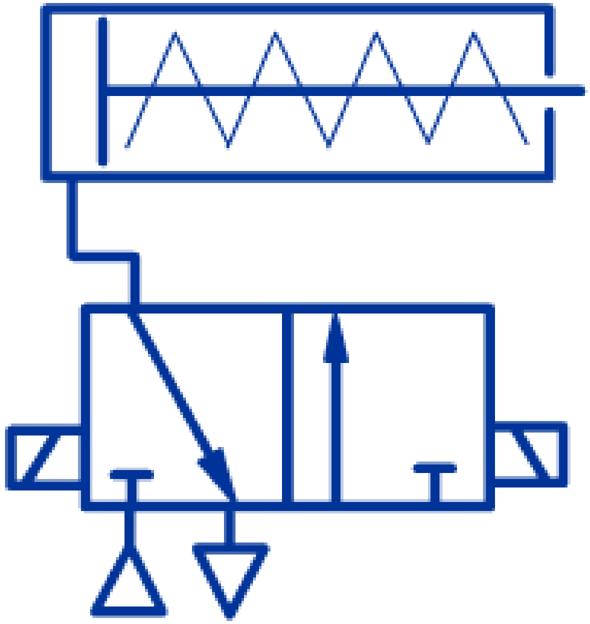
App 02



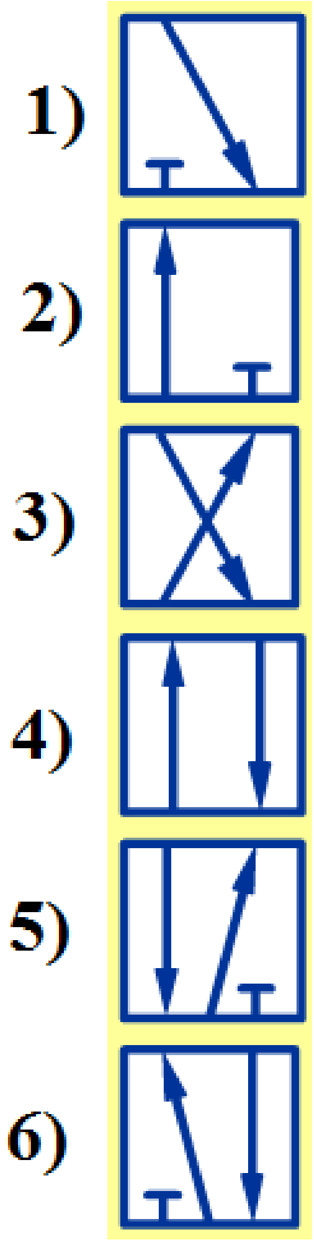


4/2 valve, Monostable, with pneumatic piloting

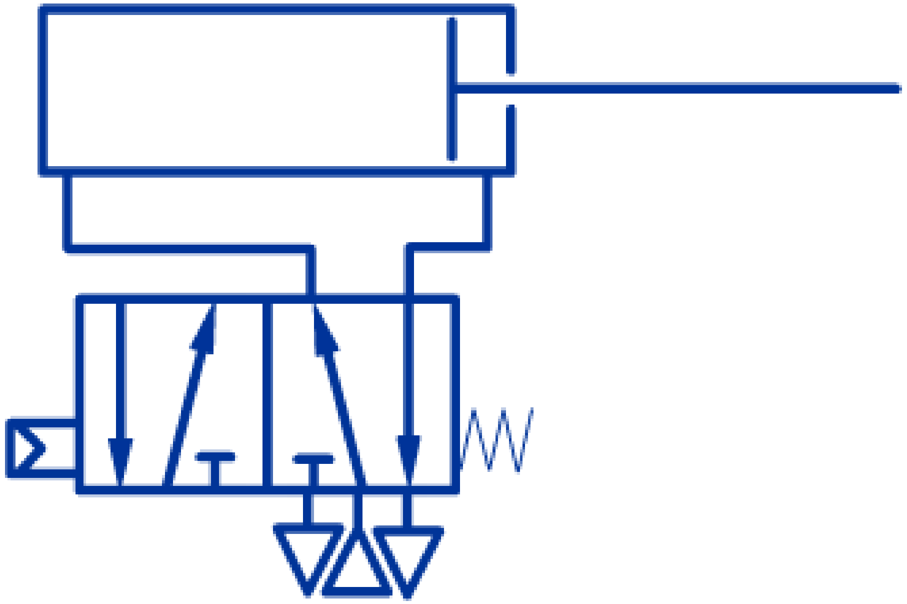
App 03

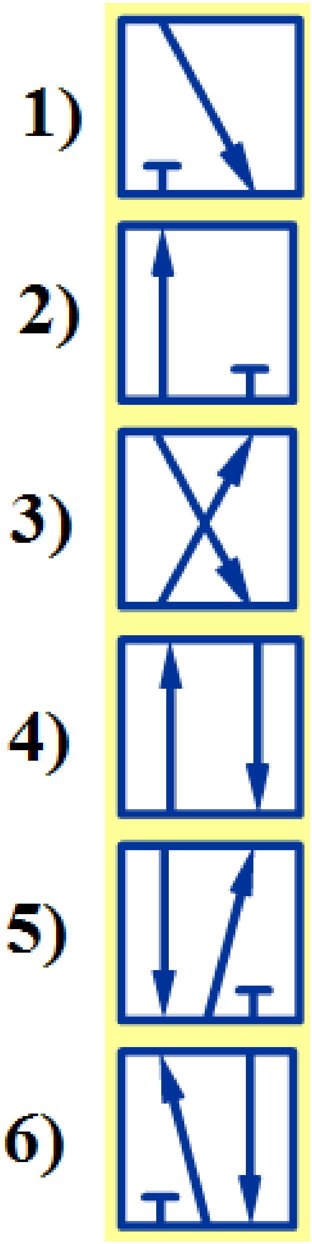


3/2 valve, Bistable, with electrical piloting



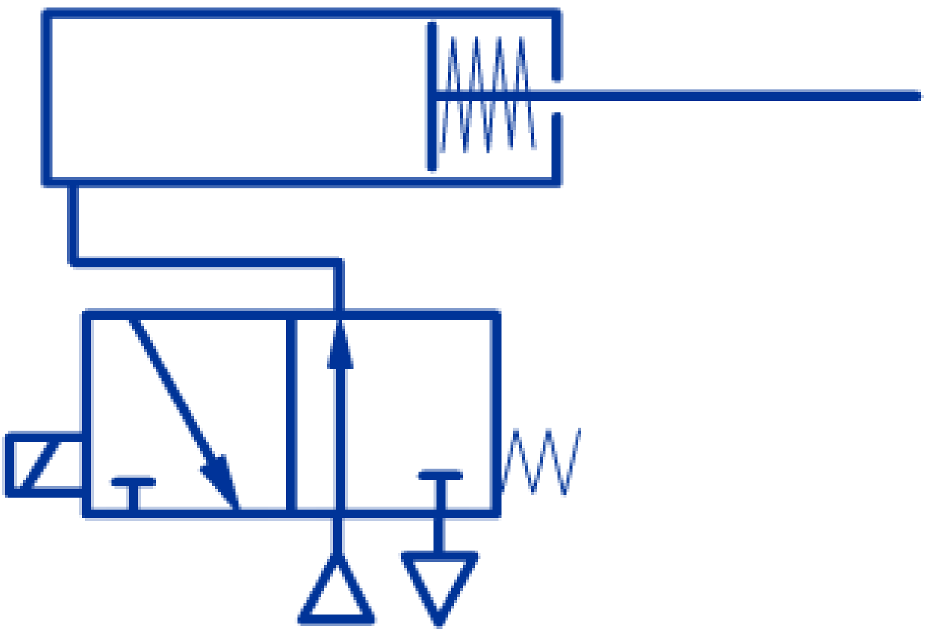
App 04

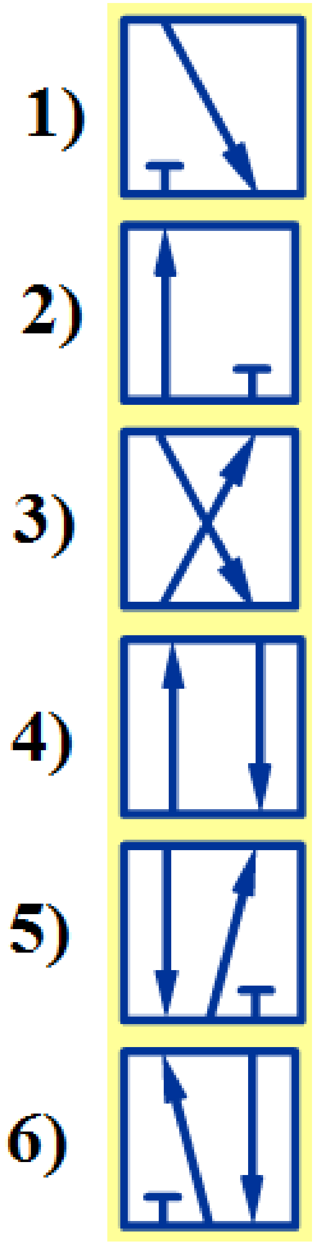




5/2 valve, Monostable, with pneumatic piloting

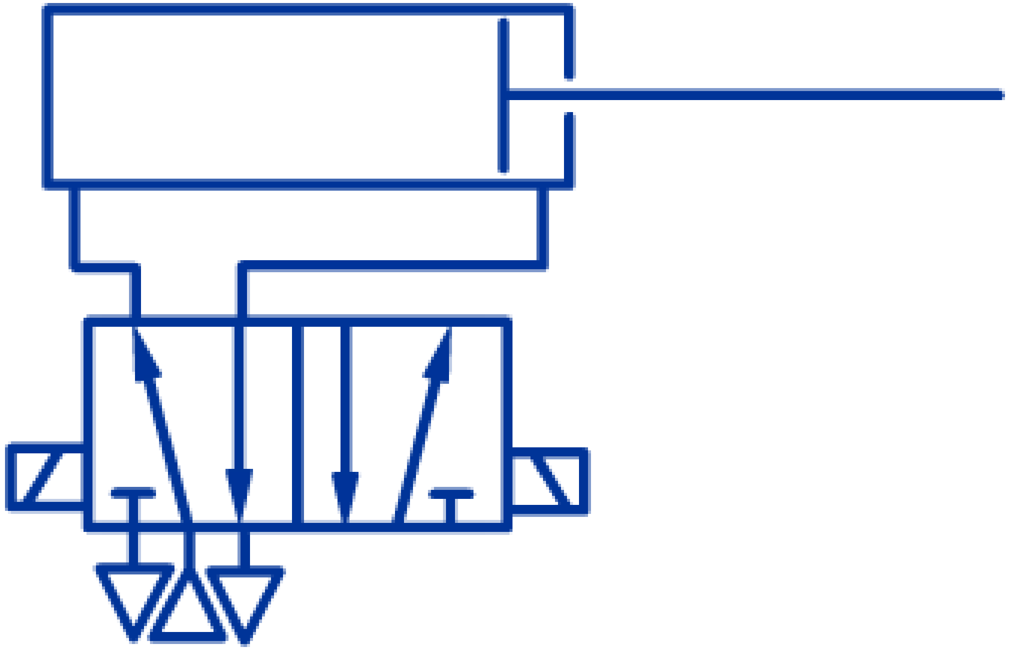
App 05

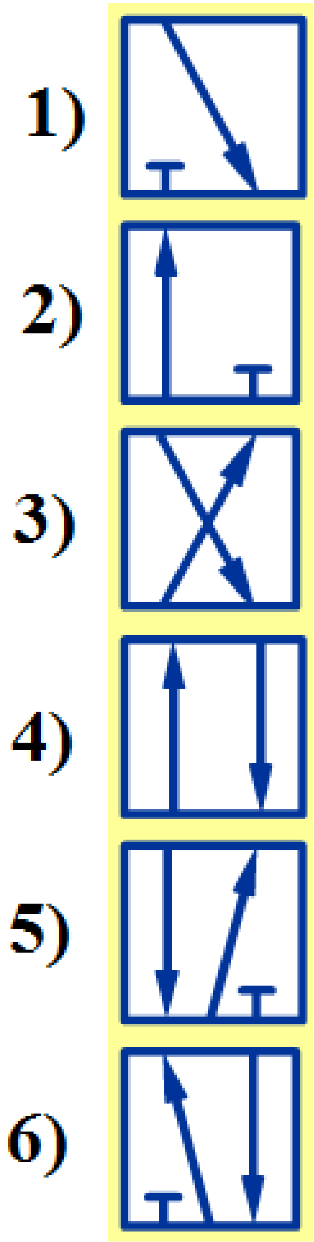




3/2 valve, Monostable, with electric piloting

App 06





5/2 valve, Bistable, with electric piloting

Determination of a jack

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