Sistem Hidrolik dan Pneumatik

Mekatronika

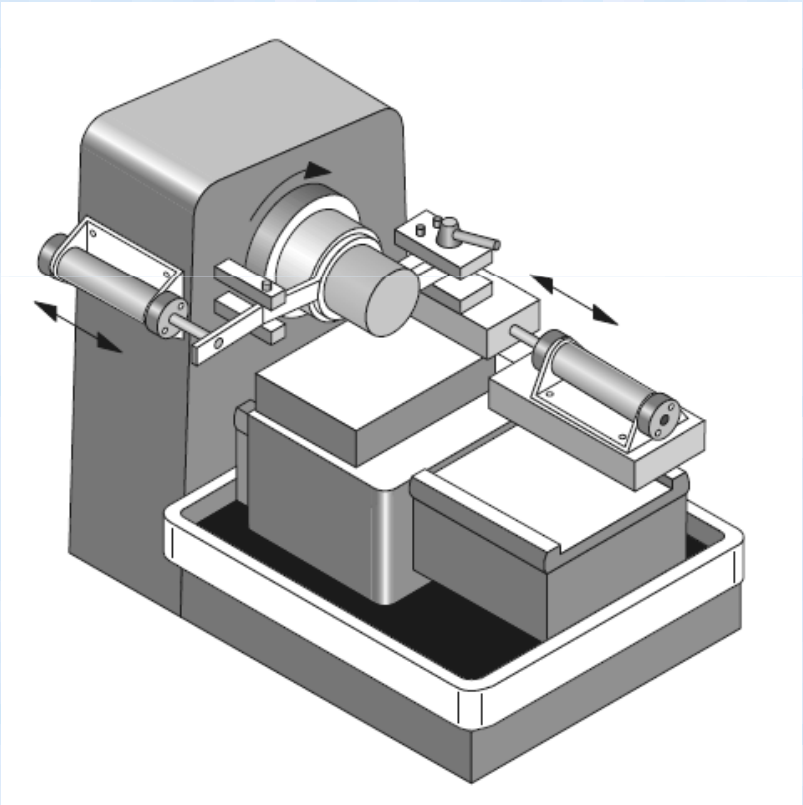
STT Mandala

Hidrolik

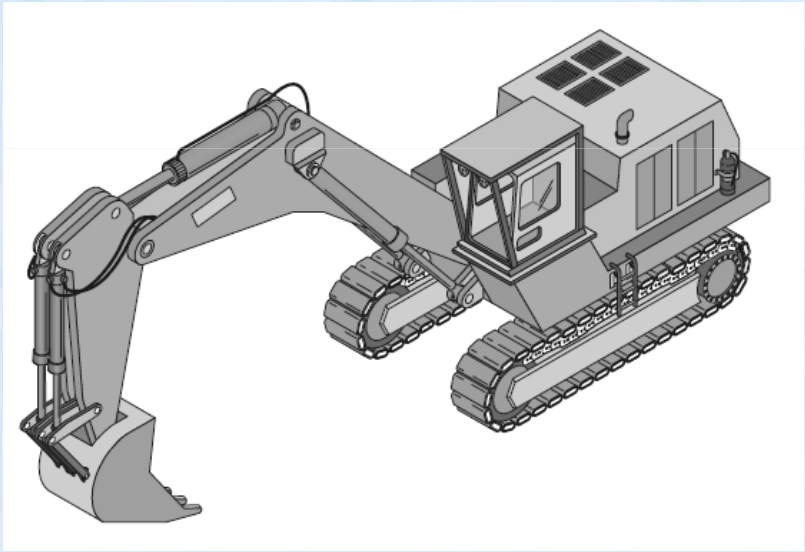
- Hidrolik: menghasilkan gaya dan gerak dengan menggunakan fluida hidrolik sebagai medium transmisi daya
- Aplikasi hidrolik:
  - Stationary (industri: proses, manufaktur)
  - Mobile (bergerak di atas roda/track: construction)
  - Marine, mining, aircraft

Stationary Hydraulics

- Mesin produksi dan assembly
- Jalur transfer
- Alat angkat dan angkut
- Mesin press
- Mesin injection moulding
- Lift



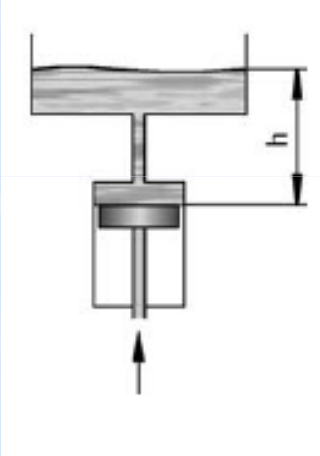
Mobile Hydraulics



- Mesin konstruksi
- Excavator, platform pengangkat
- Alat angkat dan angkut
- Mesin pertanian

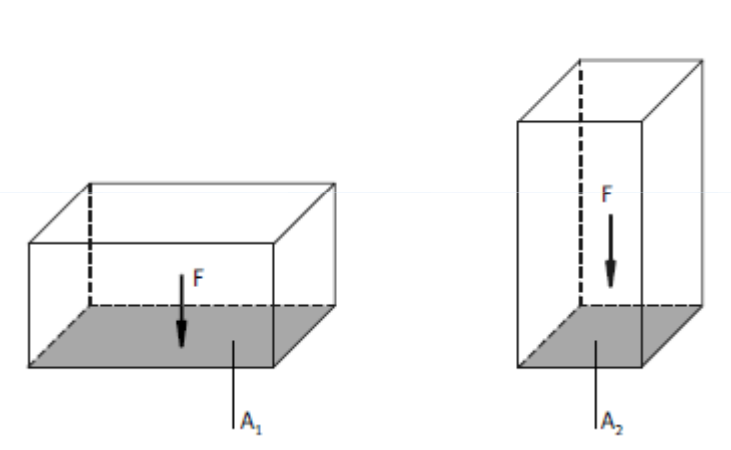
Prinsip dasar hidrolik

- Tekanan hidrostatik



$$p_s = h \cdot \rho \cdot g$$

- Gaya, luas permukaan



$$p = \frac{F}{A}$$

Ilustrasi

- Sebuah silinder piston diberikan tekanan sebesar *100* bar, permukaan piston efektif adalah *7,85*cm^2. Tentukan gaya maksimum yg diperoleh

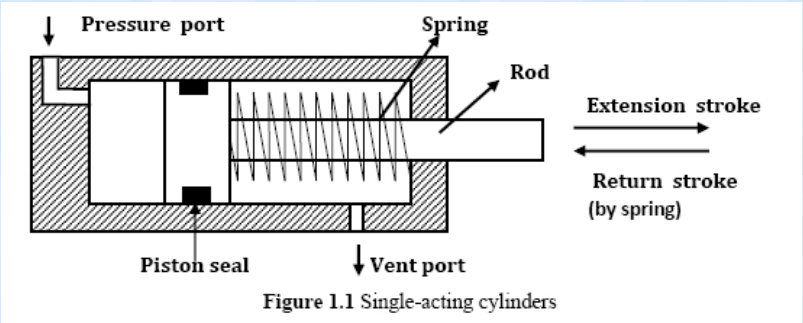


Figure 1.1 Single-acting cylinders

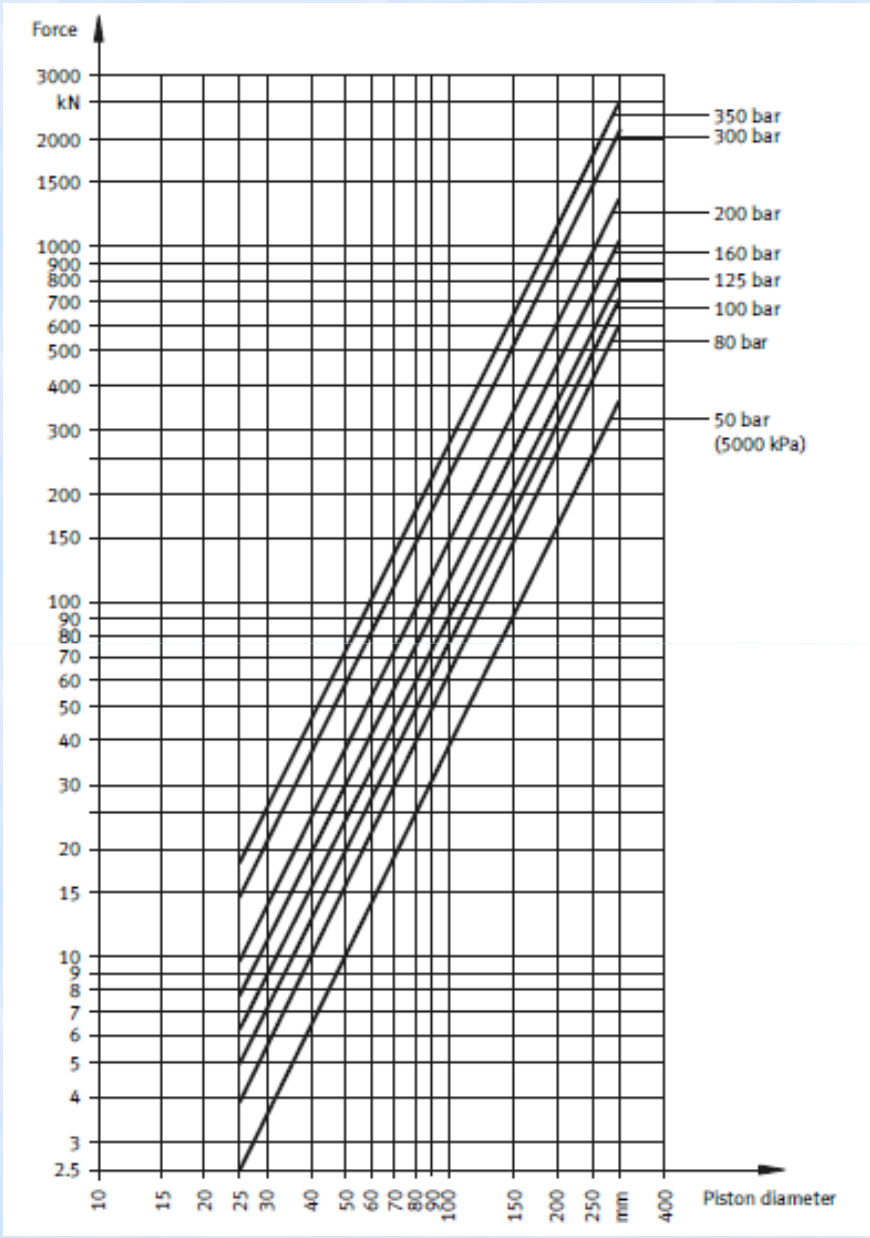
Solusi

$p = 100\ \text{bar} = 1000\ \text{N/cm}^2$

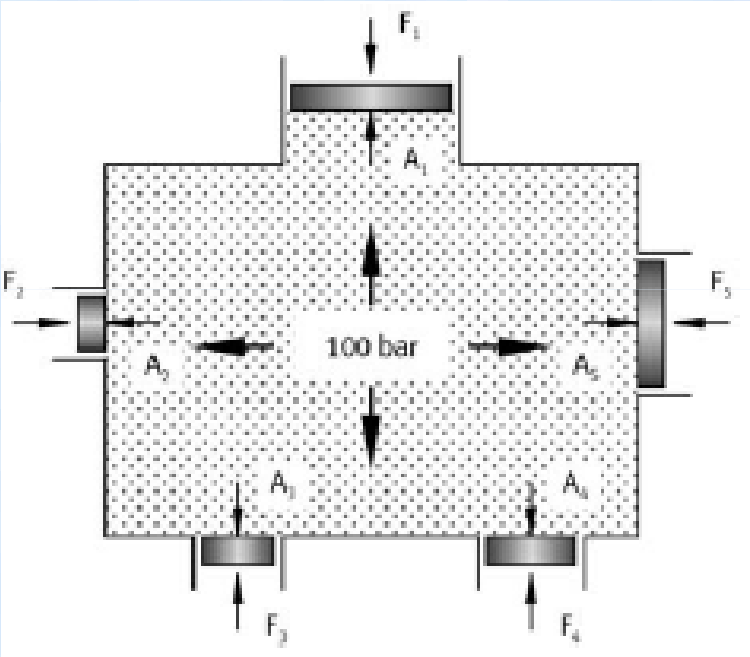
$A = 7.85\ \text{cm}^2$

$$F = p \cdot A = \frac{1000\text{N} \cdot 7.85\,\text{cm}^2}{\text{cm}^2} = 7850\ \text{N}$$

Diameter piston, gaya dan tekanan



Transmisi tekanan



- Jika gaya F1 beraksi melalui luas penampang A1 pada cairan dalam ruang tertutup, tekanan p yg dihasilkan akan diteruskan ke seluruh cairan (hukum Pascal)

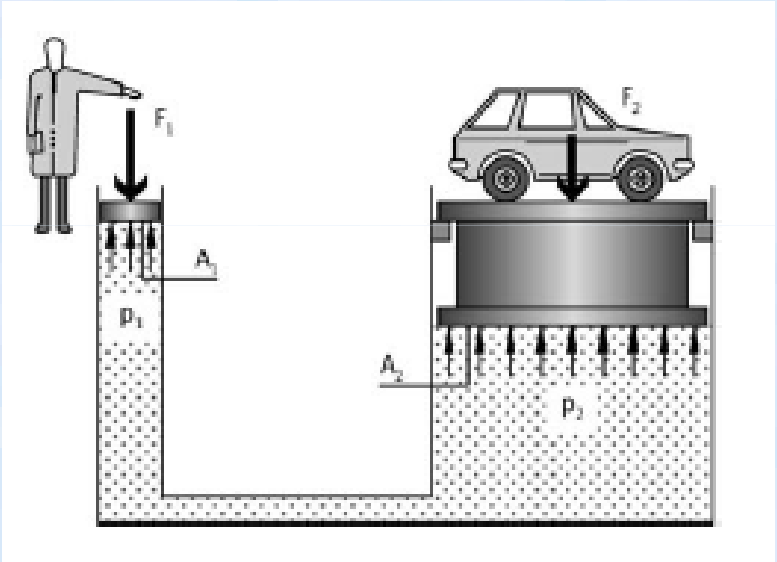
Transmisi daya

$$p_1 = \frac{F_1}{A_1}$$

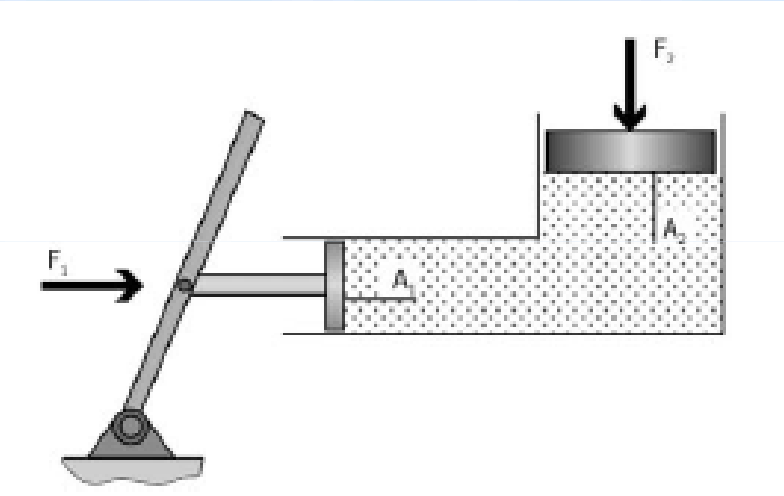
$$p_2 = \frac{F_2}{A_2}$$

$$p_1 = p_2$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$



Ilustrasi



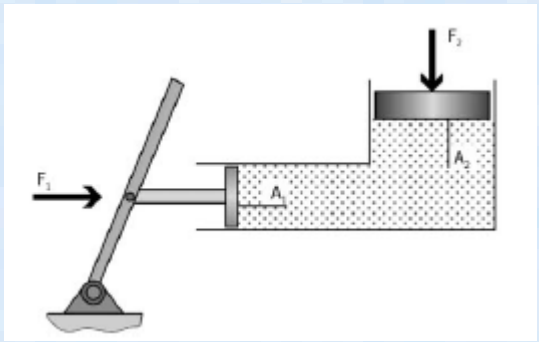
$A_1 = 40\ cm^2 = 0.004\ m^2$

$A_2 = 1200\ cm^2 = 0.12\ m^2$

- Sebuah kendaraan akan diangkat dengan dongkrak hidrolik. Massa kendraan 1500kg. Berapakah gaya yg diperlukan pada piston?

Solusi

- m=1500kg
- F_2=m.g=1500.9.81=14715N
- p_1=p_2
- F_1=A_1.F_2/A_2=490,5 N



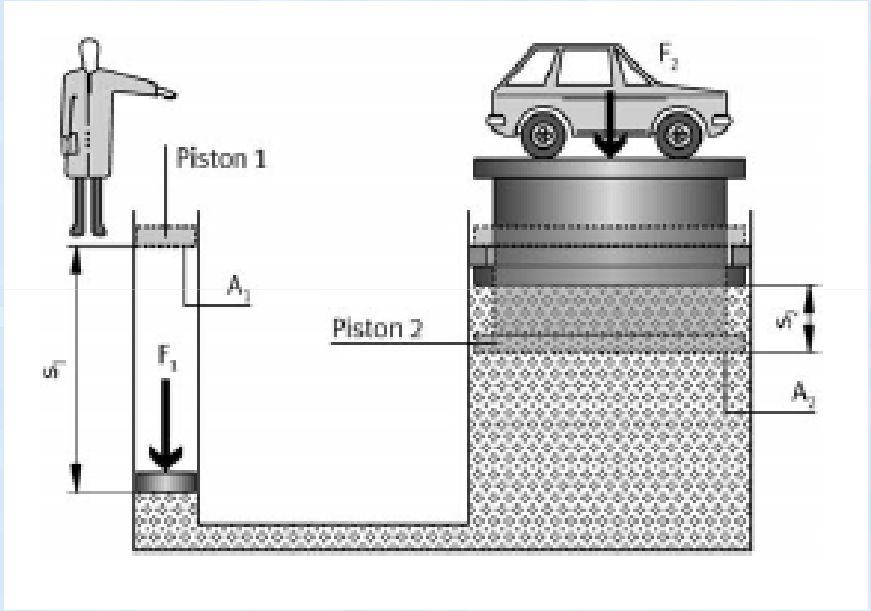
Transmisi perpindahan

$V_1 = s_1 \cdot A_1$

$V_2 = s_2 \cdot A_2$

Volume yg dipindahkan sama

$s_1 \cdot A_1 = s_2 \cdot A_2$

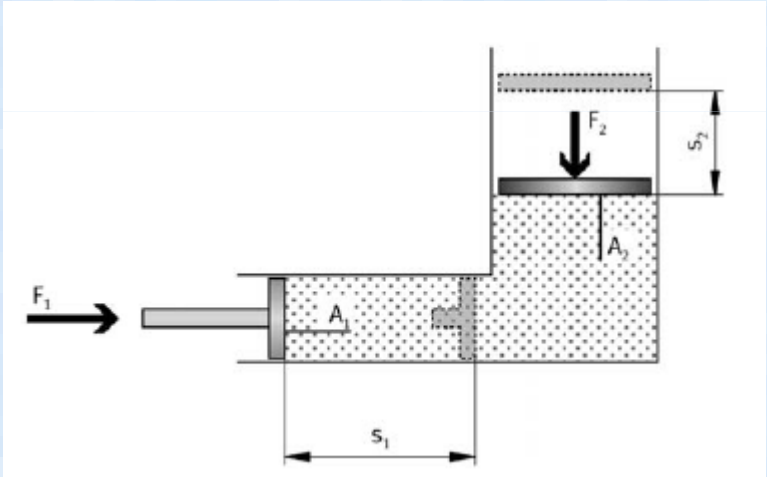


Ilustrasi

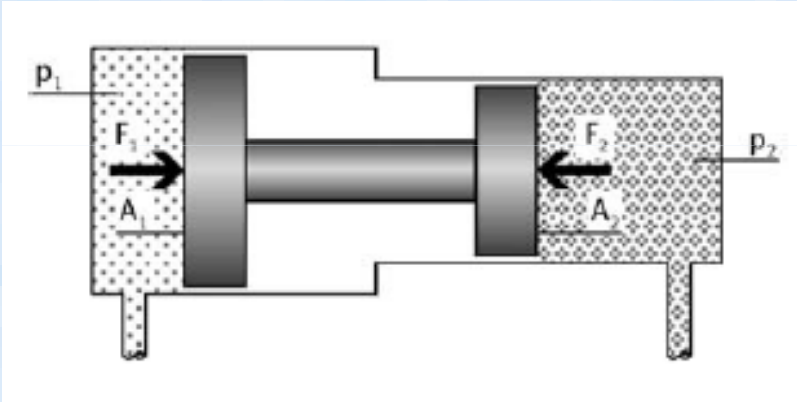
- Jika diketahui:
  - A_1=40cm^2
  - A_2=1200cm^2
  - s_1=15cm

  $s_2=s_1.A_1/A_2$

  $=15.40/1200=0.5$cm

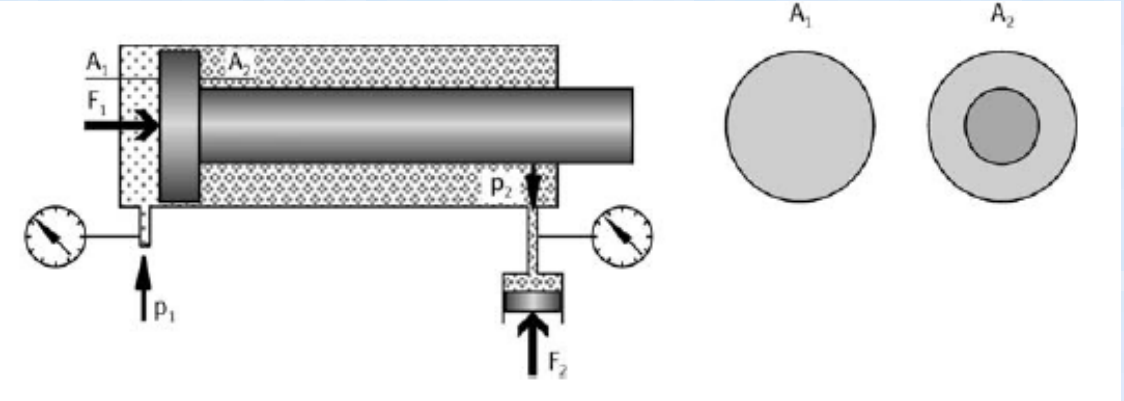


Transmisi tekanan



- Tekanan p_1 memberikan gaya F_1 pada luas penampang A_1 yg kemudian diteruskan melalui batang piston ke piston yg lebih kecil. Maka gaya F_2 beraksi pada luas penampang A_2 dan menghasilkan tekanan p_2. Karena luas penampang piston A_2 lebih kecil dari luas penampang A_1 maka tekanan p_2 lebih besar dari p_2
- $F_1=p_1.A_1=F_2=p_2A_2$
- $P_2=p_1.A_1/A_2$

Ilustrasi



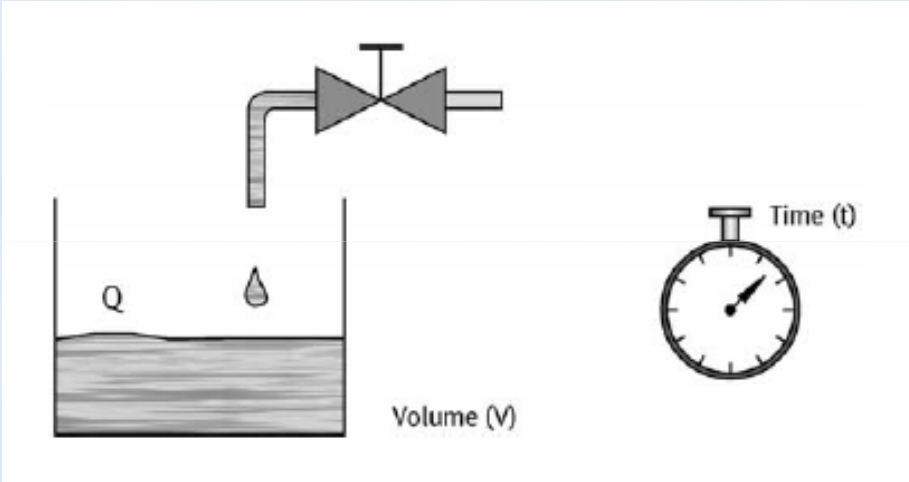
- Jika diketahui:

$P_1 = 10 \cdot 10^5$ Pa
$A_1 = 8\ cm^2 = 0.0008\ m^2$
$A_2 = 4.2\ cm^2 = 0.00042\ m^2$

$$p_2 = \frac{p_1 \cdot A_1}{A_2} = \frac{10 \cdot 10^5 \cdot 0.0008}{0.00042} \frac{N \cdot m^2}{m^2 \cdot m^2} = 19 \cdot 10^5\ Pa\ (19\ bar)$$

Laju aliran

- Laju aliran: volume cairan yg mengalir melalui pipa pada periode wak
- Laju aliran Q=V/t
  - V=volume (m3)
  - t = waktu (s)



Persamaan kontinyutas

- Laju aliran: volume cairan yg mengalir melalui pipa pada periode wak
- Laju aliran Q=V/t
  - V=volume (m3)
  - t = waktu (s)
- t=s/v
- V=A.s
- Maka Q=V/t=A.v
  - Q=laju aliran
  - v=kecepatan aliran
  - A=luas penampang pipa

Daya hidrolik

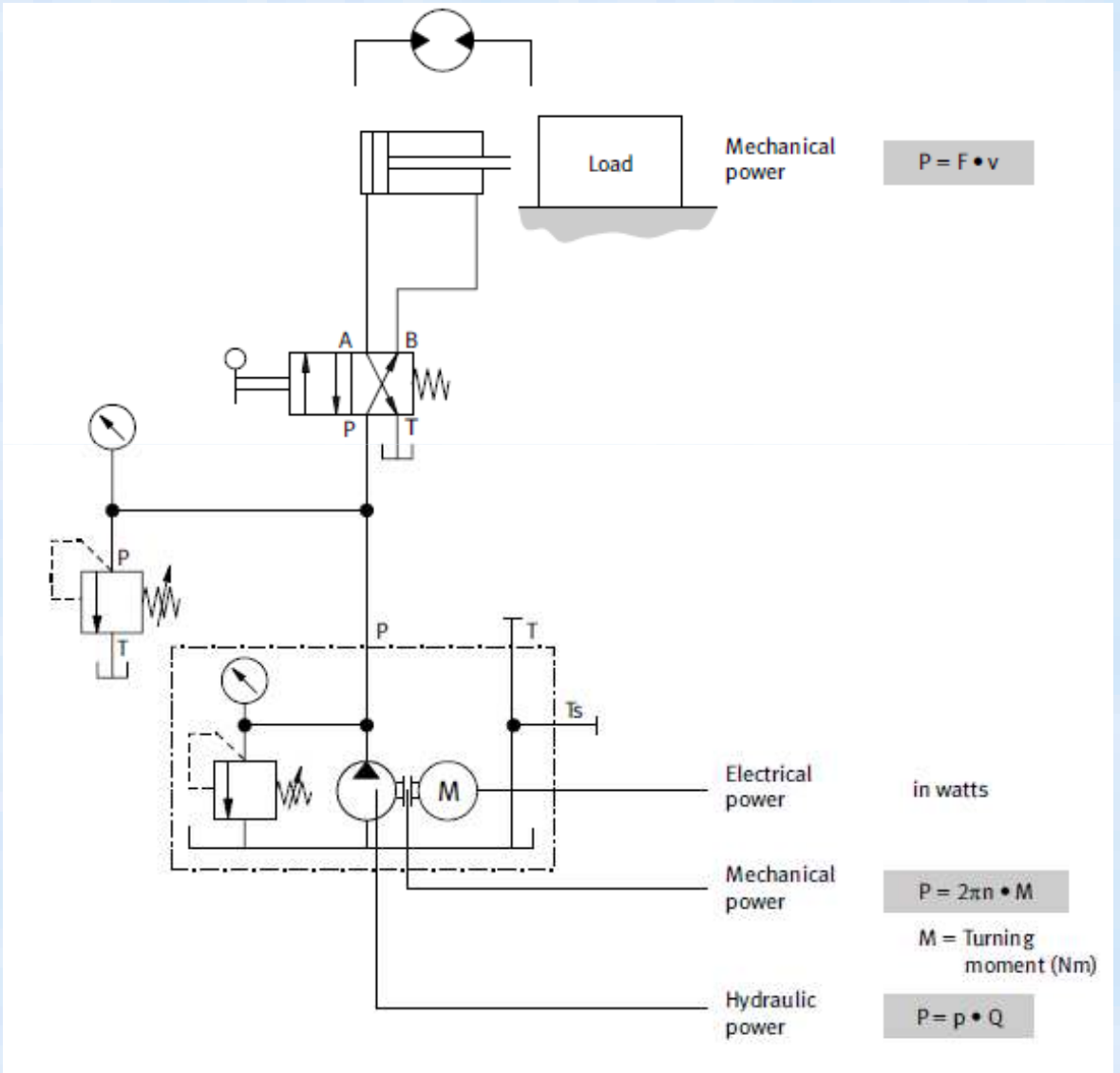
- Daya hidrolik:

  P=p.Q

  P=Daya (W)

  p=tekanan (Pa)

  Q=laju aliran (m^3/s)



Ilustrasi

- Jika diketahui:

$$p = 60 \cdot 10^5\ \text{Pa}$$

$$Q = 4{,}2\,\text{l/min} = 4{,}2 \cdot 10^{-3}\,\text{m}^3/\text{min} = \frac{4{,}2}{60} \cdot 10^{-3}\,\text{m}^3/\text{s} = 0{,}07 \cdot 10^{-3}\,\text{m}^3/\text{s}$$

$$P = p \cdot Q = 60 \cdot 10^5\,\text{Pa} \cdot 0{,}07 \cdot 10^{-3}\,\text{m}^3/\text{s} = 4{,}2 \cdot 10^2\,\frac{\text{Nm}^3}{\text{m}^2\text{s}} = 420\ \text{W}$$

Karena adanya kerugian hidrolik (katup, gesekan, panas) maka efisiensi sistem hidrolik sekitar 70%-75%

Komponen2 sistem hidrolik

- Supply Daya (*Power Supply Unit*)
- Fluida Hidrolik
- Katup : pengatur arah, pengatur tekanan, pengatur aliran
- Silinder (aktuator linier: single acting, double acting, telescopic)
- Motor hidrolik (rotary actuator)

Power Supply Unit (Power Pack)

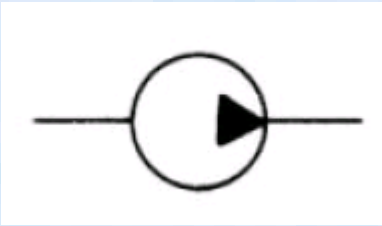
- Memberikan daya hidrolik yg diperlukan dengan mengkonversi daya mekanik dari motor penggerak
- *Pompa hidrolik-filter oli-pendingin/pemanas oli-reservoir*

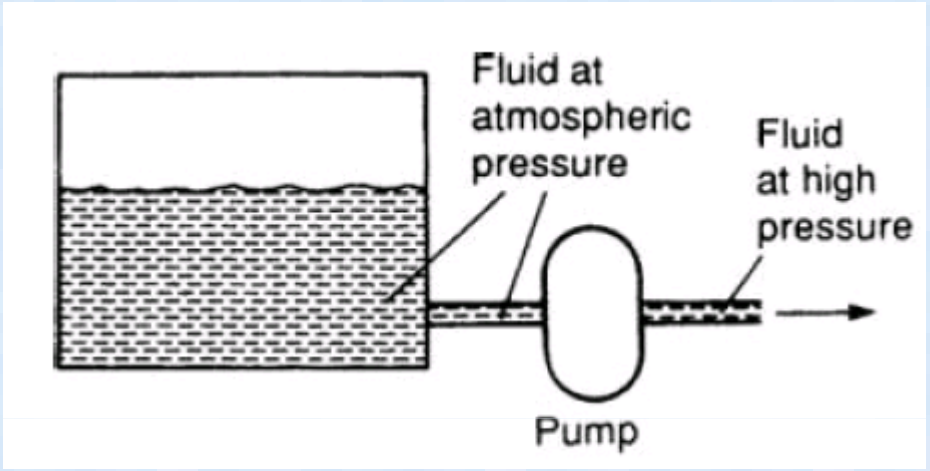
Power Pack
AC motor, pompa, reservoir
Relief valve

Penggerak Mula

- Stationary hydraulic: motor listrik
- *Mobile hydraulics: motor bakar*

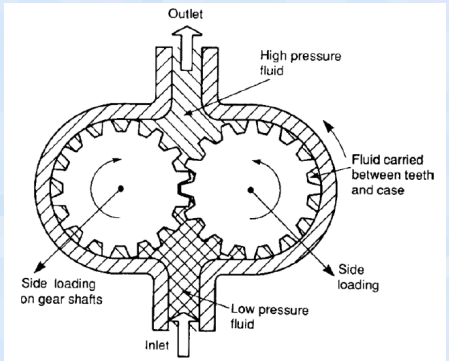
Pompa Hidrolik



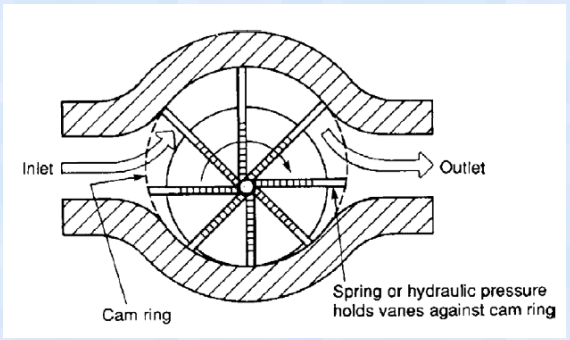


Mengubah energi dari penggerak menjadi energi hidrolik

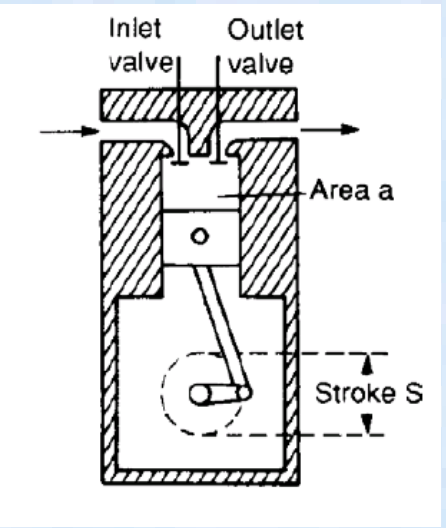
Gear Pump



Vane Pump



Piston Pump



Pompa Hidrolik

Volume yg dipindahkan/perpindahan volumetrik/volume kerja adalah ukuran dari sebuah pompa yaitu volume cairan yg diberikan oleh pompa untuk setiap putaran pompa

$$Q=n \times V$$

Q: laju aliran volumetrik (volume/menit)
n= putaran pompa (rpm)
V=volume kerja

Fluida Hidrolik

- Media kerja yang mentransfer energi dari power supply unit untuk menngerakkan silinder atau motor hidrolik
- Biasanya menggunakan mineral oil based (hydraulic oils)

Ilustrasi

- Putaran pompa n=1450 rpm
- Volume kerja=2,8cm^3 (per putaran)
- Berapakah laju aliran volumetrik pompa?
- Q=n x V=1450rpm x 2,8cm^3

  =4060cm^3/min=4,06dm^3/min

  =4,06 liter/min

Katup

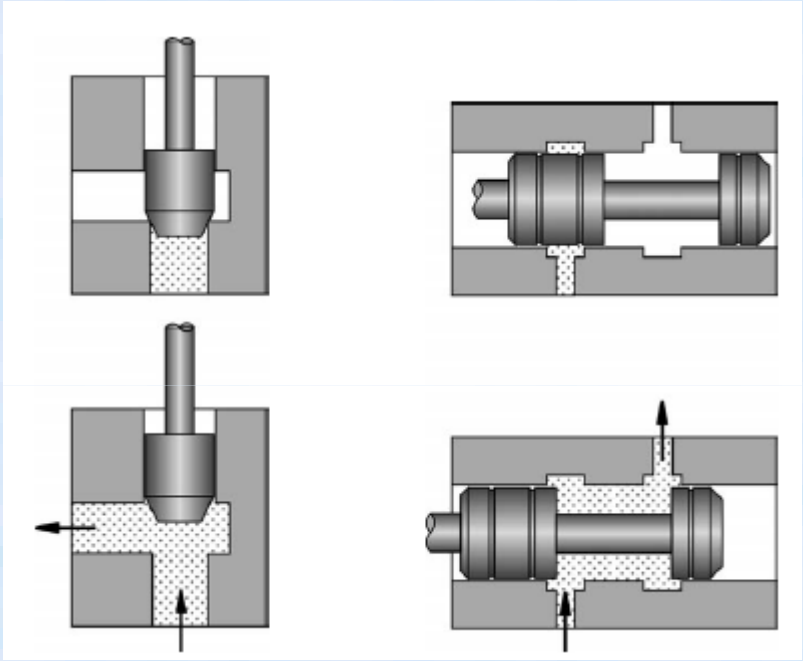
Pengatur arah

Pengatur tekanan

Pengatur aliran

Non-return valve

Desain Katup

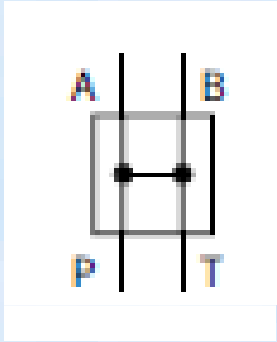


Poppet

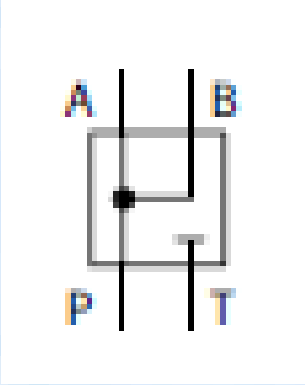
Spool/Slide

Penamaan port katup

- Port diberi label dengan huruf P,T,A,B
- Katup memiliki beberapa posisi switch:
  - Garis horizontal antara huruf2 nama port (misalnya: P-A berarti port2 tsb saling berhubungan
  - Huruf tunggal yg dipisahkan dengan koma (contoh: P-A,T) menandakan bahwa port tsb (T) diblok



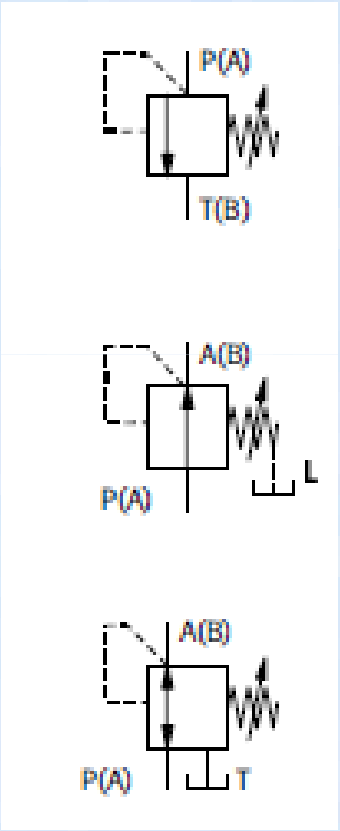
P-A-B-T



P-A-B,T

Katup pengatur tekanan

- Mengatur dan membatasi tekanan dalam sistem hidrolik
- Pressure relief valve (PRV): tekanan dalam sistem dibatasi. Tekanan diukur pada input katup
- Pressure regulator: mengurangi tekanan output jika terdapat tekanan input yg berlebih. Tekanan diukur di output katup



Pressure Relief Valve

2-way pressure regulator

3-way pressure regulator

Pressure relief valve

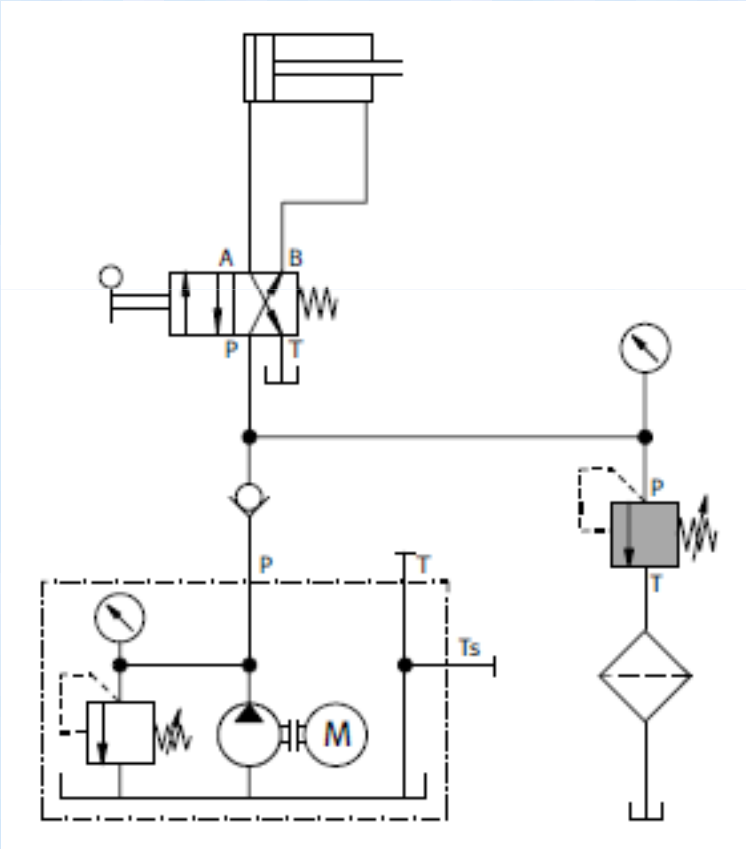


Diagram Rangkaian

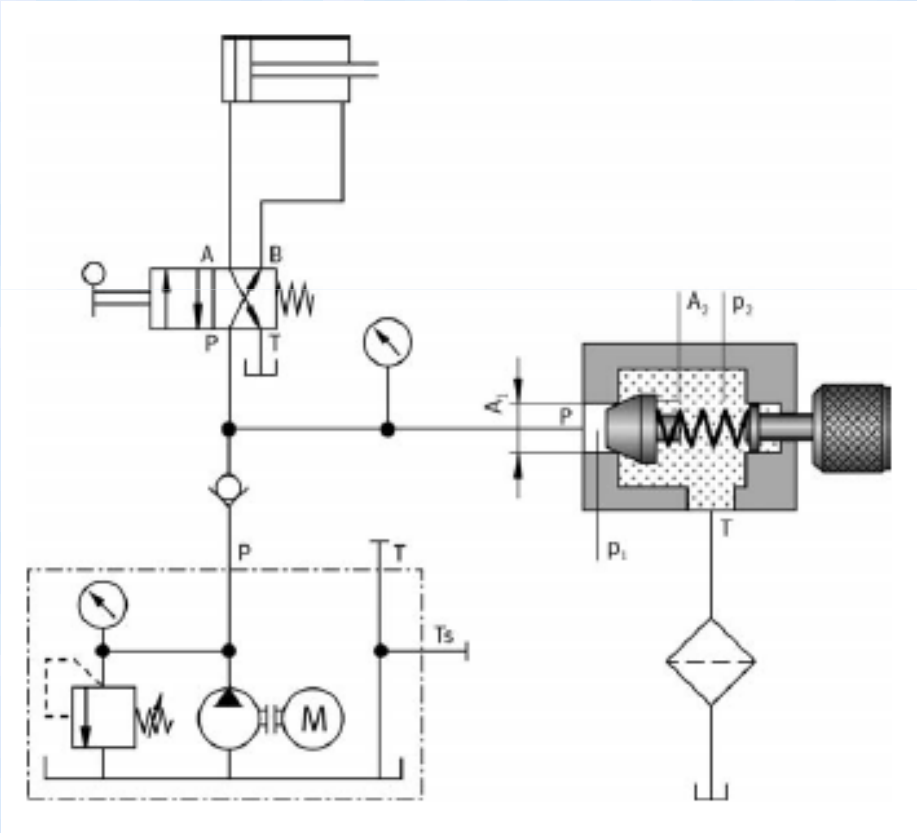


Diagram Bagian Katup

Pressure Regulator

- Mengurangi tekanan input ke tekanan input tertentu
- Digunakan jika diperlukan beberapa besar tekanan yg berbeda dalam sistem

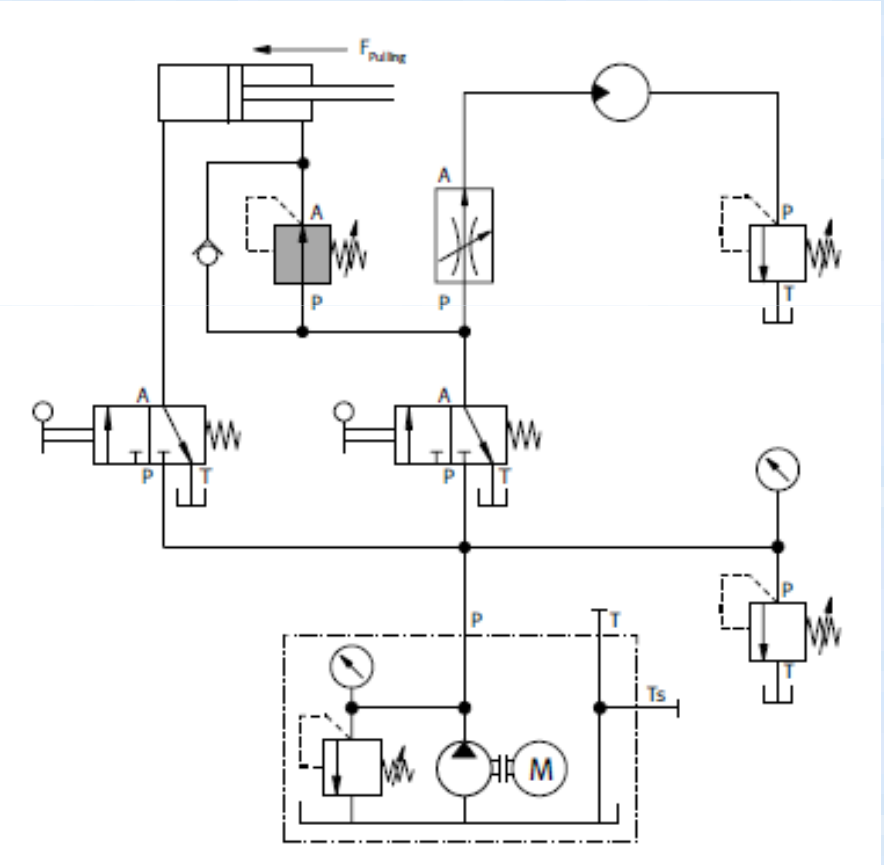
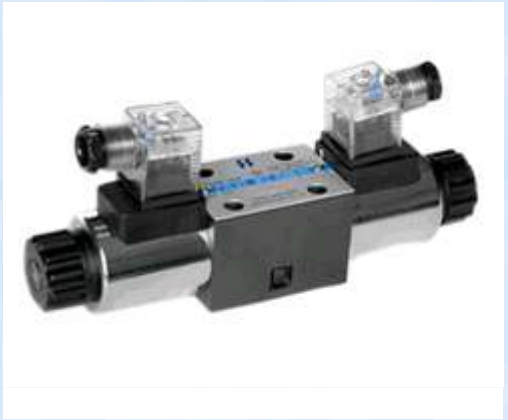


Diagram Rangkaian

Diagram Bagian Katup

Katup pengatur arah

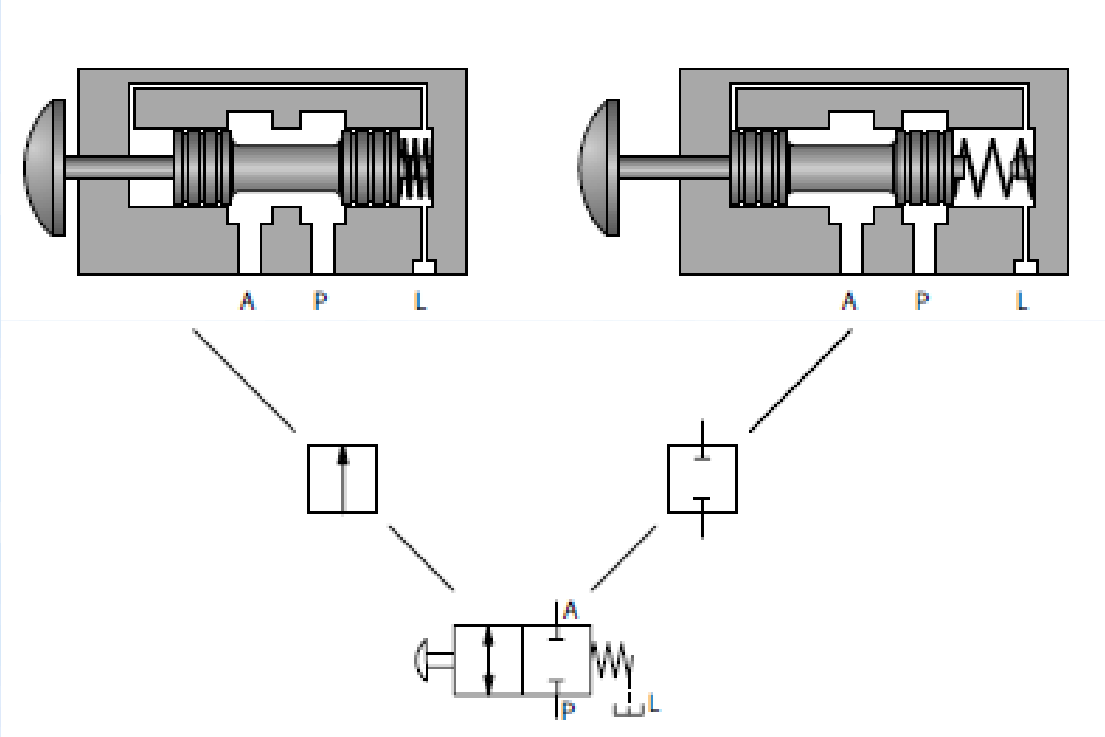


Solenoid operated

Lever operated

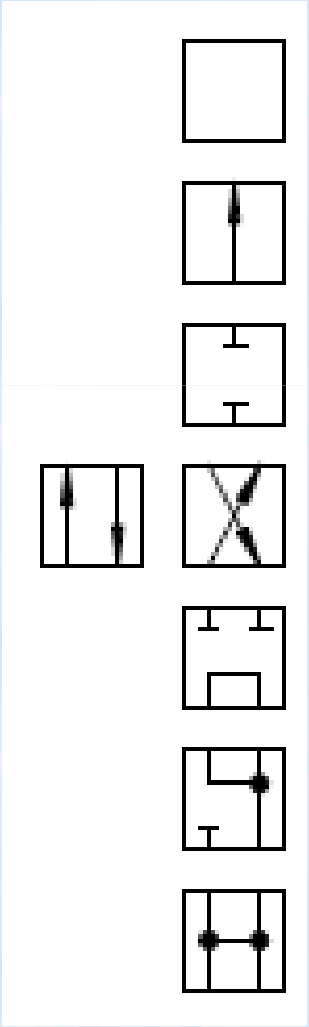
Pilot operated

Katup pengatur arah



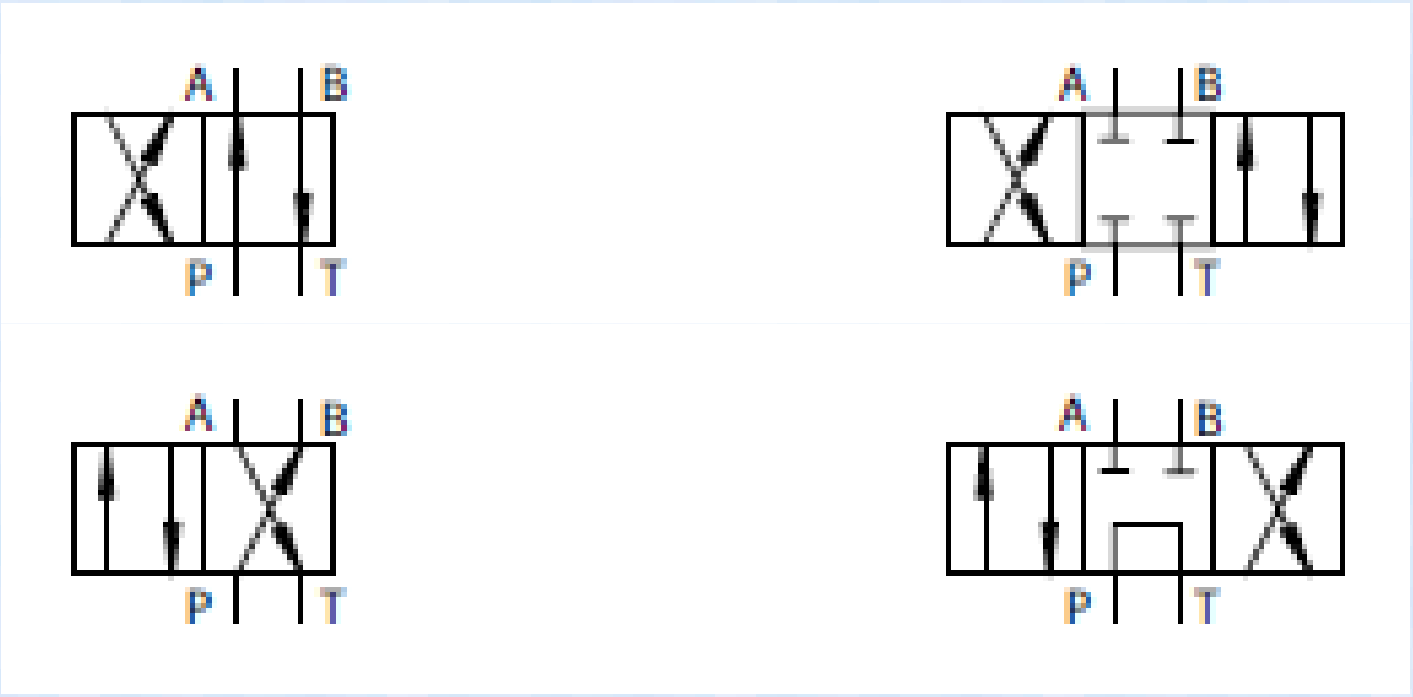
- Mengubah, membuka atau menutup jalur aliran pada sistem hidrolik

Simbol Katup Pengatur Arah



- Posisi switch
- Jalur aliran dengan simbol anak panah
- Posisi tertutup
- Jalur aliran dua arah
- Dua port terhubung, dua port tertutup
- Tiga port terhubung, satu port tertutup
- Semua port terhubung

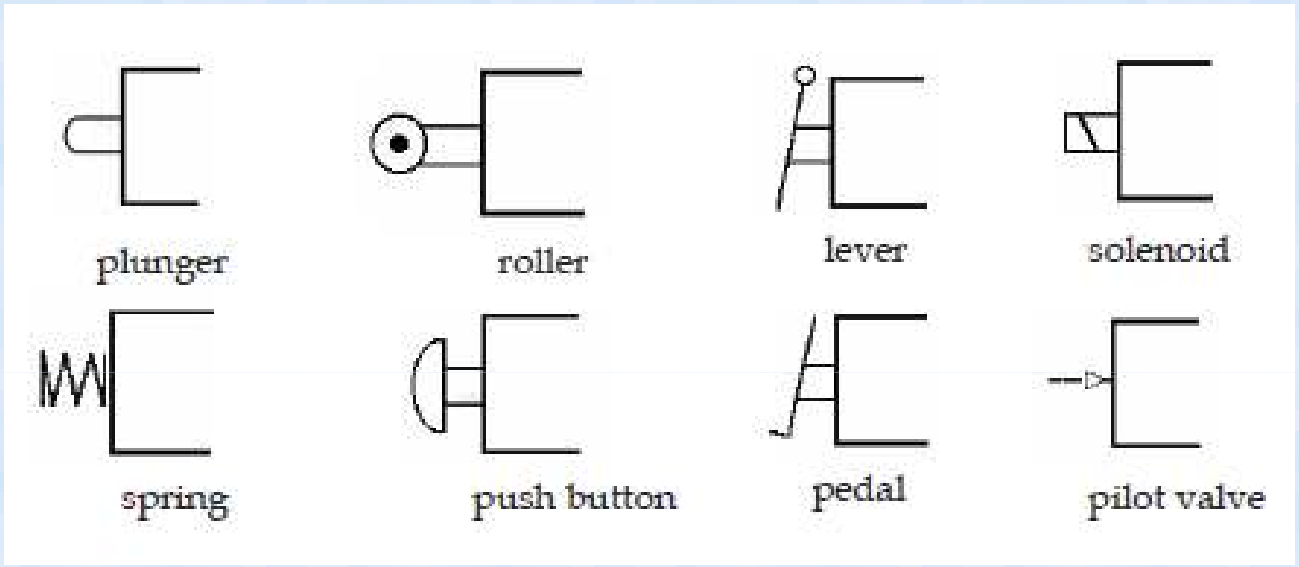
Posisi switch

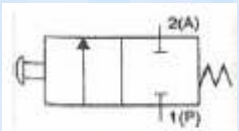


4/2 way valve

4/3 way valve

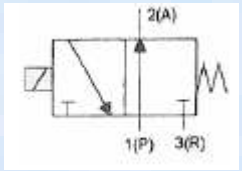
Simbol aktuasi katup



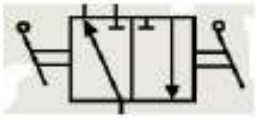


2/2 valve

Push button operated spring return valve

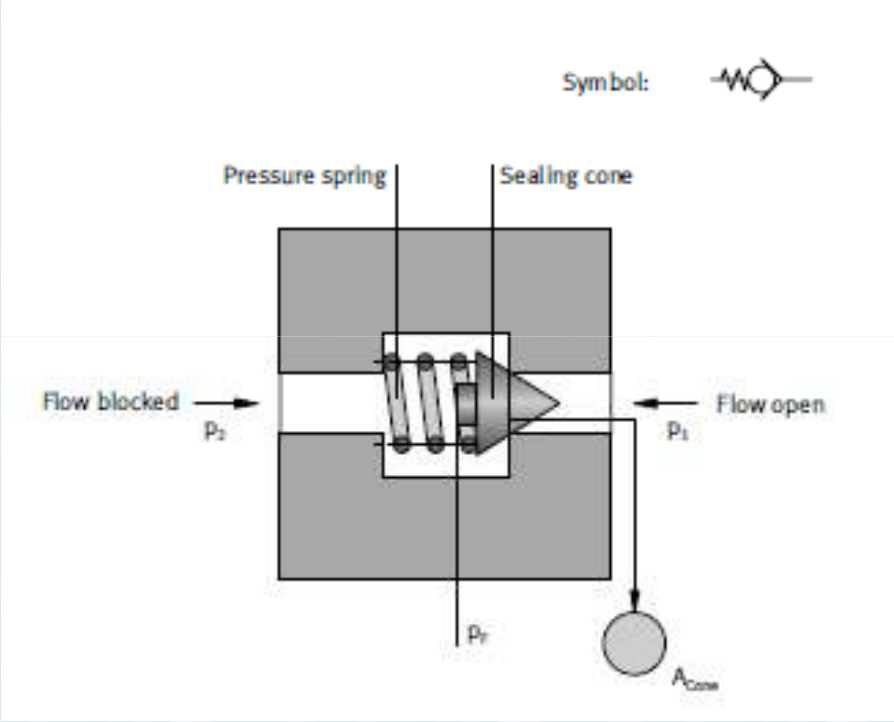


Solenoid operated spring return 3/2 valve

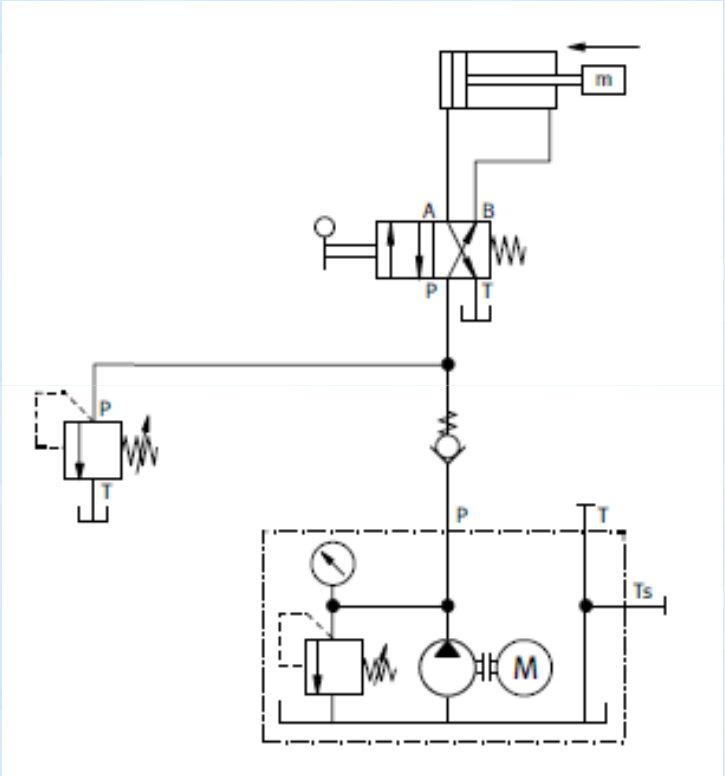


lever operated 3/2 valve

Non-return valve



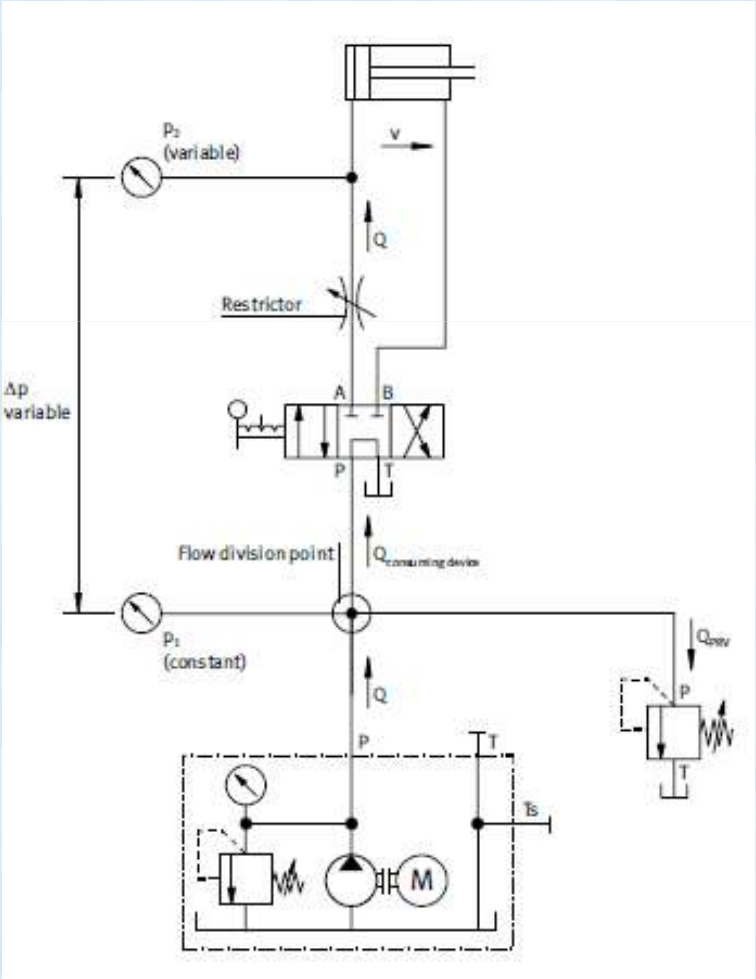
Skema potongan



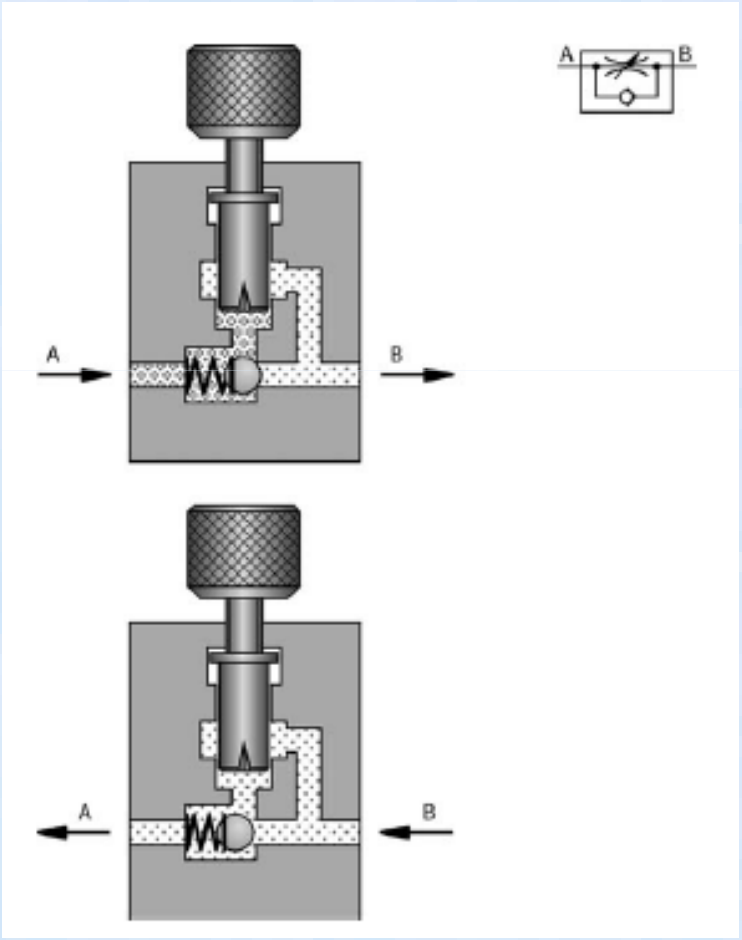
Aplikasi

Katup pengatur aliran

- Mengurangi kecepatan silinder atau rpm dari motor hidrolik yg tergantung dari laju aliran
- Bekerja berdasarkan pengurangan luas penampang katup yg menyebabkan peningkatan tekanan
- Peningkatan tekanan akan dikurangi oleh PRV dengan mengalirkan fluida hidrolik kembali ke reservoir

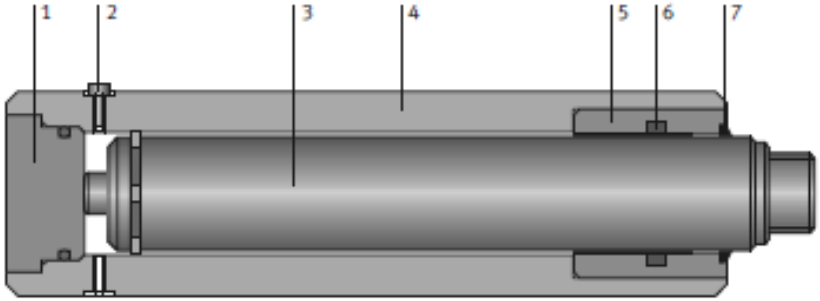


Katup pengatur aliran satu arah



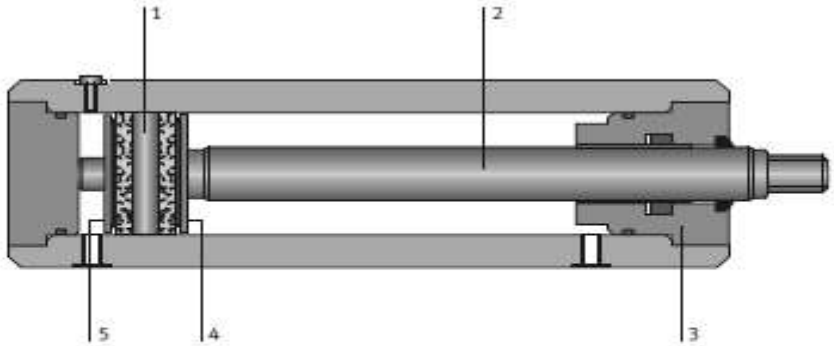
- Pembatasan aliran hanya berlaku di satu arah saja
- Kombinasi antara katup pengatur aliran dan non-return valve

Silinder hidrolik



1 Mounting screw
2 Vent screw
3 Piston rod
4 Cylinder barrel
5 Piston rod bearing
6 Piston rod seal
7 Wiper

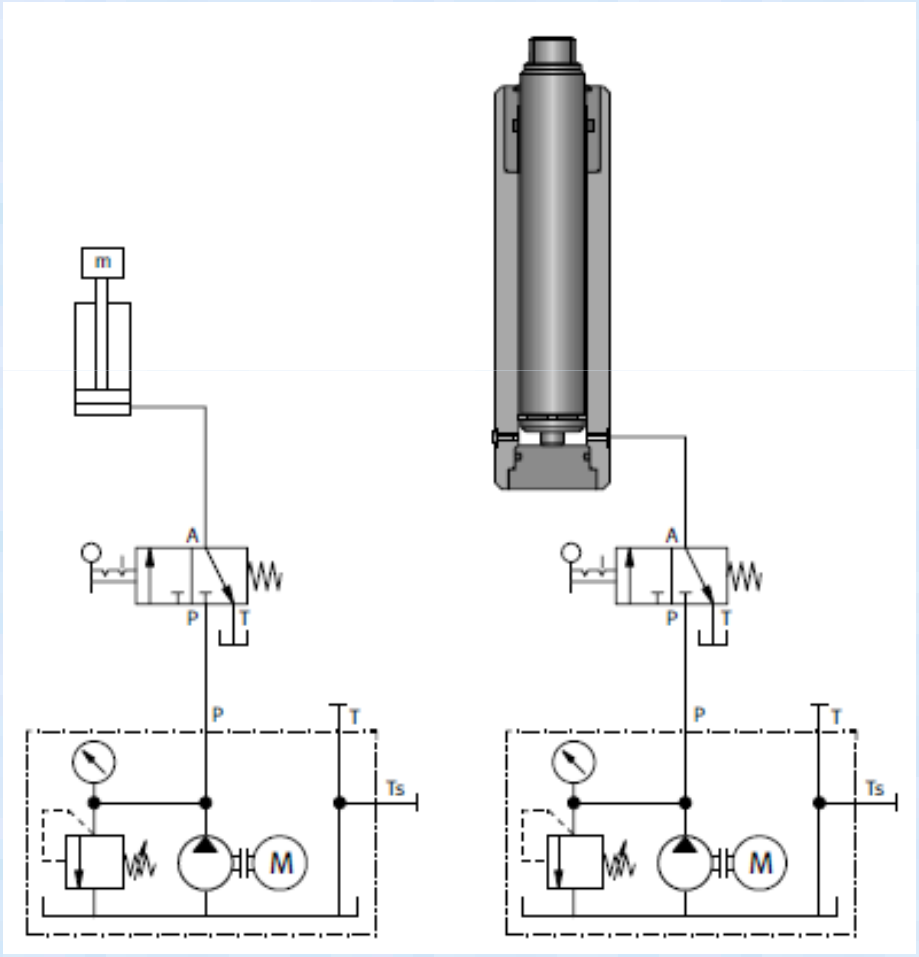
- Single acting



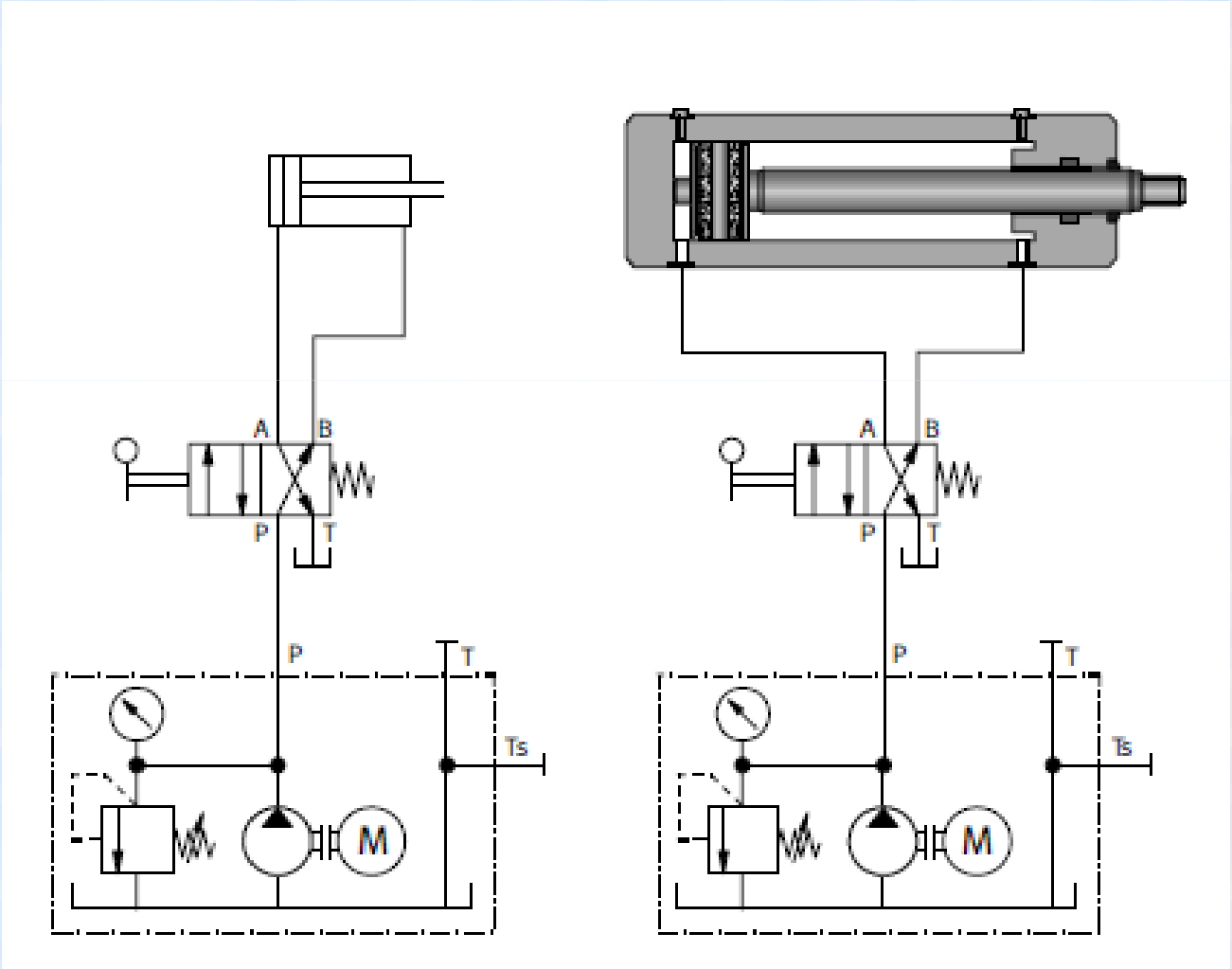
1 Piston
2 Piston rod
3 Piston rod bearing
4 Annular piston surface
5 Piston surface

- Double acting

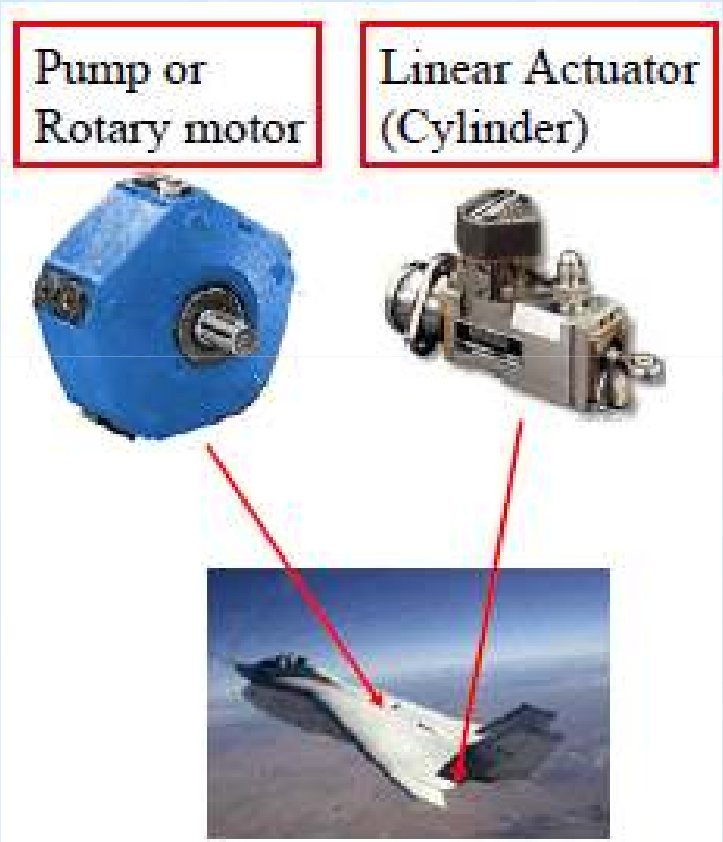
Single Acting Cylinder



Double Acting Cylinder



Aktuator Hidrolik



Ilustrasi

Sebuah silinder hidrolik akan digunakan untuk memindahkan lomponen dengan jarak 50 mm dalam waktu 10s. Gaya sebesar 10kN diperlukan untuk memindahkan component tersebut. Tentukan tekanan kerja serta laju aliran cairan hidrolik jika silinder dari piston berdiameter 100 mm.

Solusi

Diketahui :

s=50mm=0,05m

t=10s

F=10kN=10000N

dpiston=100mm=0,1m

Ditanyakan

P=?

Q=?

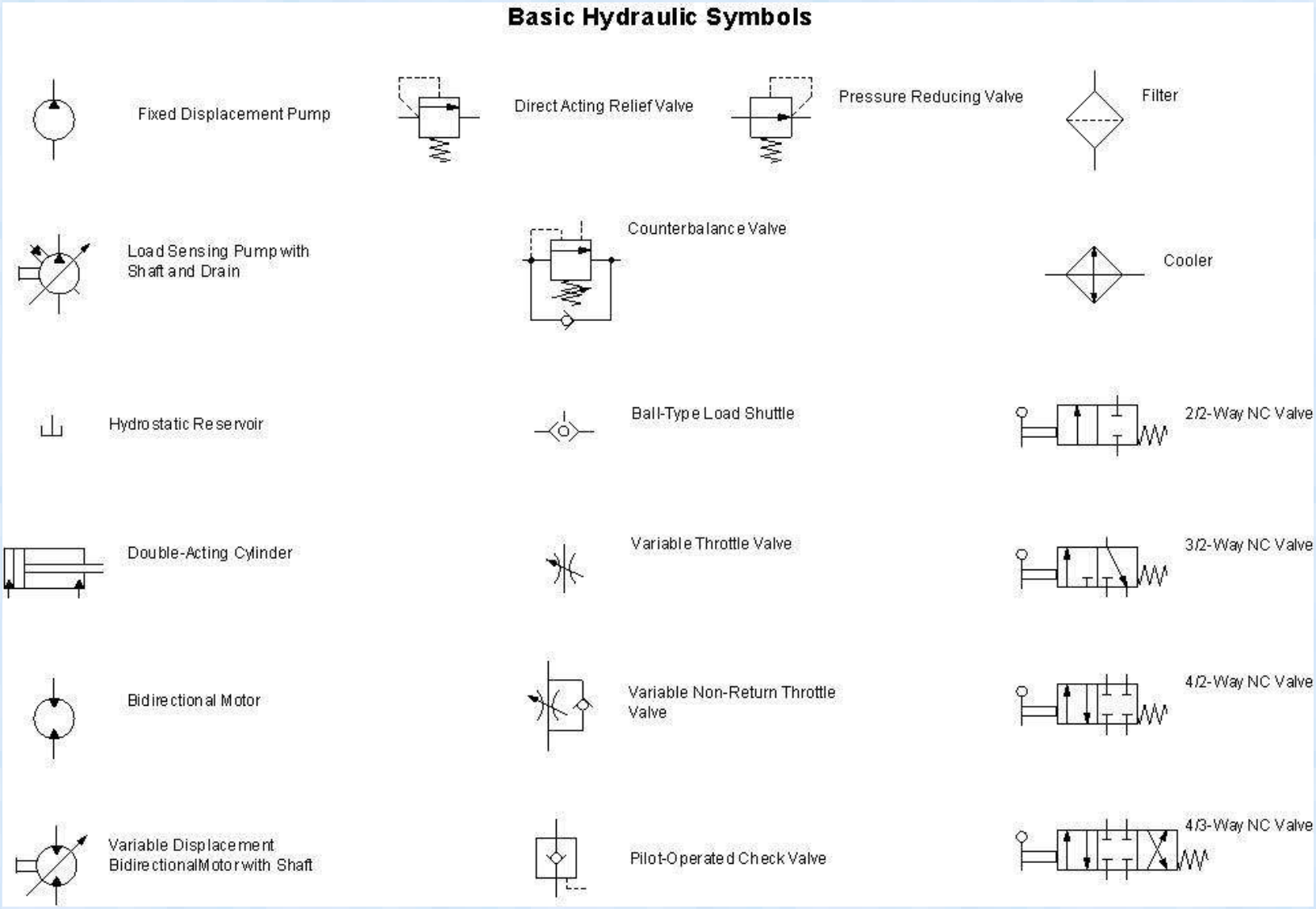
Solusi:

$v=s/t=0,05/10=0,005m/s$

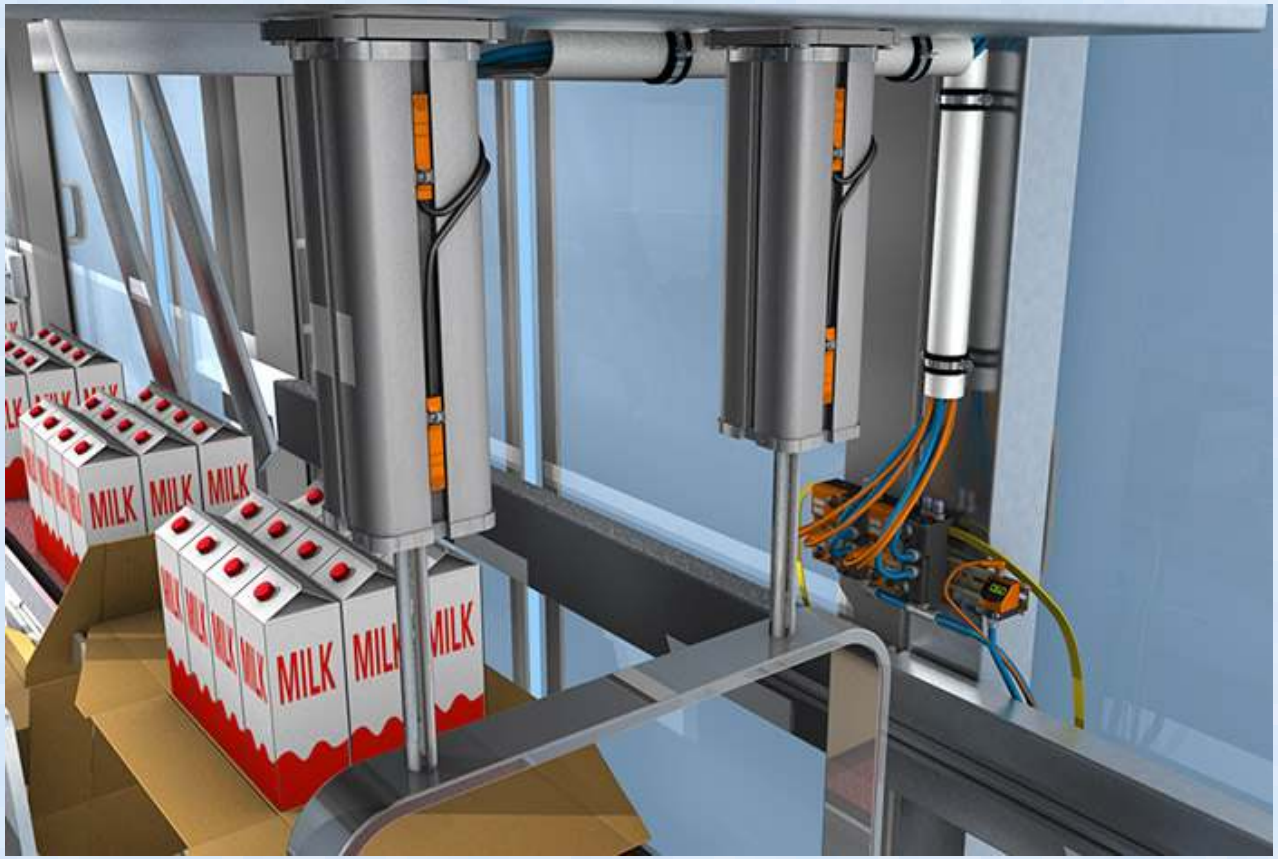
$P=F/A=10000/(\pi/4)*0,1^2=1,2732.10^6=12,73$ bar

$Q=v*A=0,005m/s \times (\pi/4)*0,1^2=3,9273.10\text{-}5$ m3/s=2,36 l/min

Simbol Hidrolik



Pneumatik



Sistem Pneumatik?

- Kamus: dioperasikan oleh udara atau oleh tekanan udara atau pembuangan udara
  http://dictionary.reference.com/browse/pneumatic
- Aktuator pneumatik: transducer yang mengkonversi energi dari udara yang dikompress menjadi gerak
  - Linier
  - Ayun
  - Rotasi

Silinder Pneumatik

- Diameter : 2,5 hingga 320mm
- Panjang langkah : 1 sampai 2000mm
- Gaya tersedia : 2 hingga 45000N pada tekanan 6 bar
- Kecepatan piston: 0,1 sampai 1,5m/s

Aplikasi Pneumatik

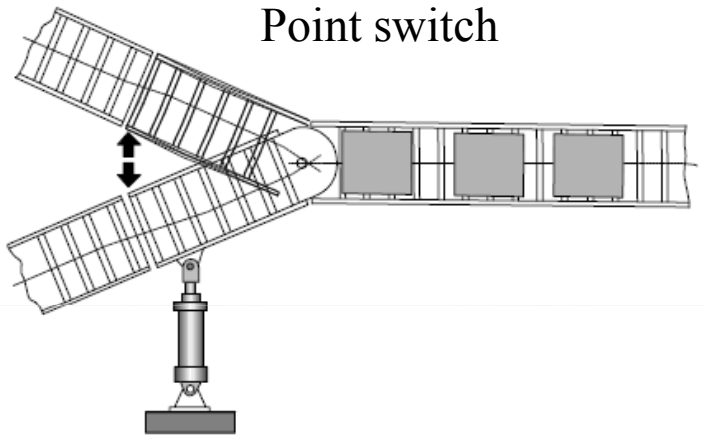
Material Handling

- Clamping
- Shifting
- Positioning

Aplikasi Umum

- Packaging
- Filling
- Metering

Point switch



Pneumatic cutter

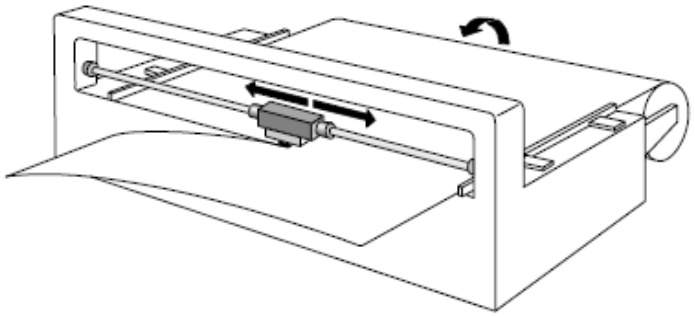
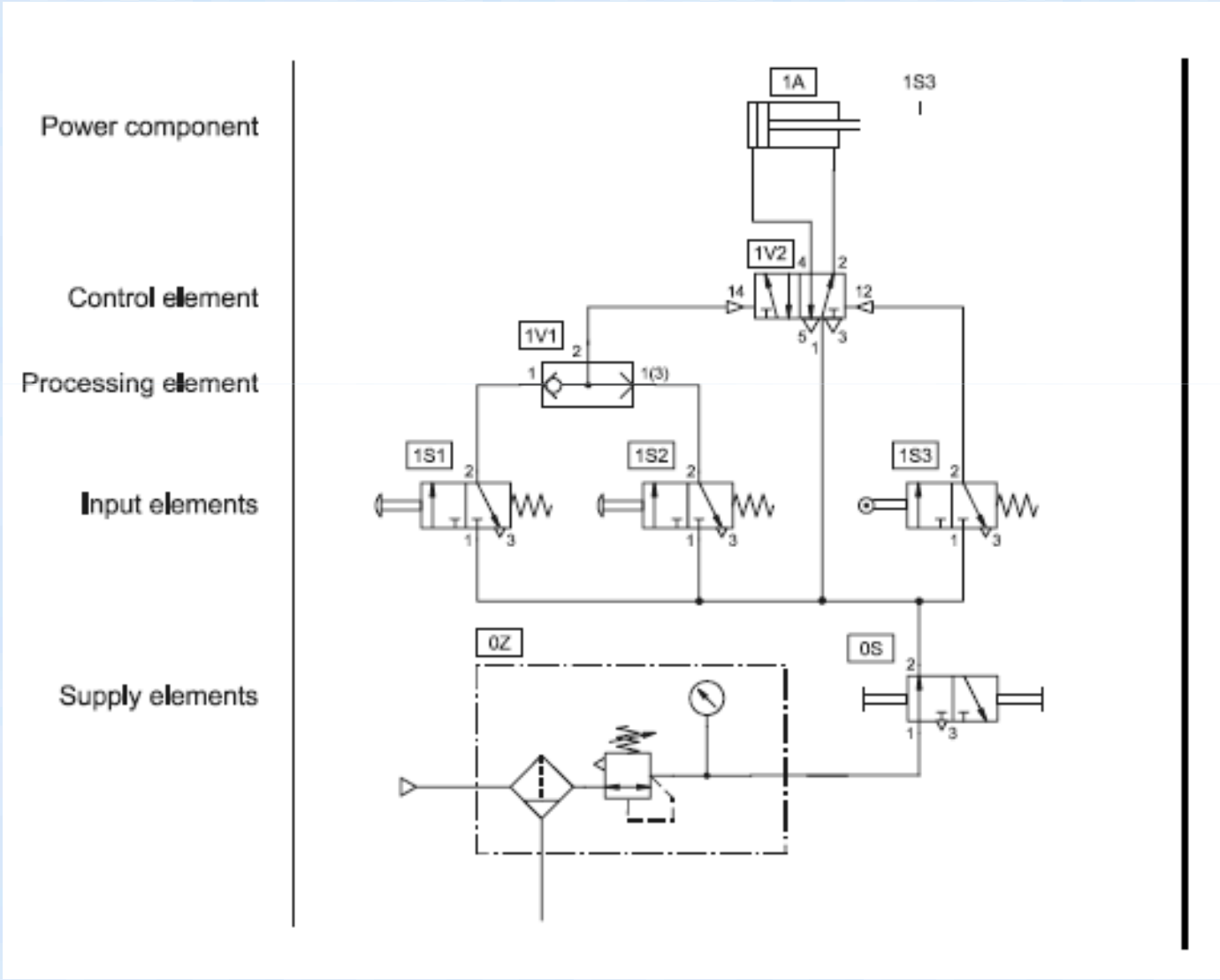


Diagram Rangkaian Pneumatik



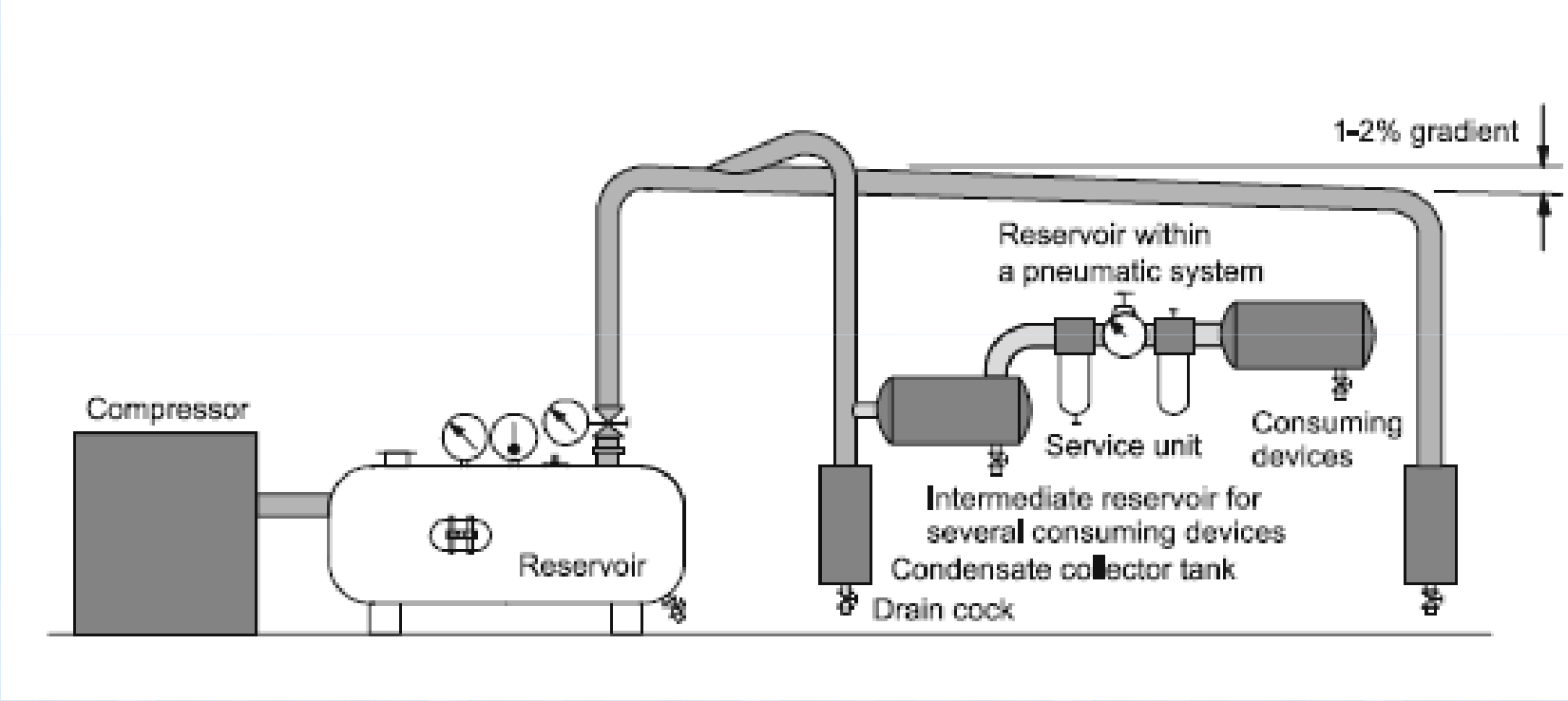
Komponen Sistem Pneumatik

- Penyediaan dan pendistribusian udara
- Katup
- Elemen pemroses
- Komponen daya

Penyediaan dan pendistribusian udara

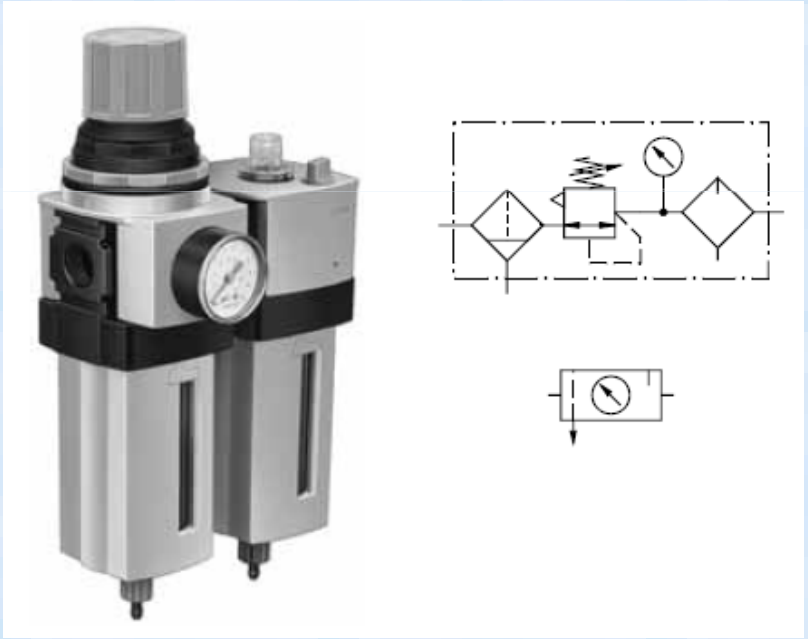
- Udara dikompres oleh kompresor udara dan dikirim ke sistem pendistribusian udara
- Komponen pneumatik dirancang untuk beroperasi pada tekanan maksimum 8-10 bar (dalam praktek 5-6 bar)
- Kompresor harus menyediakan tekanan 6,5-7 bar karena terjadi kehilangan tekanan dalam sistem pendistribusian udara
- Reservoir/receiver digunakan untuk mengurangi fluktuasi udara
- Kompresor mengisi receiver sebagai tanki penyimpan

Sistem pendistribusian udara



Air Service Unit

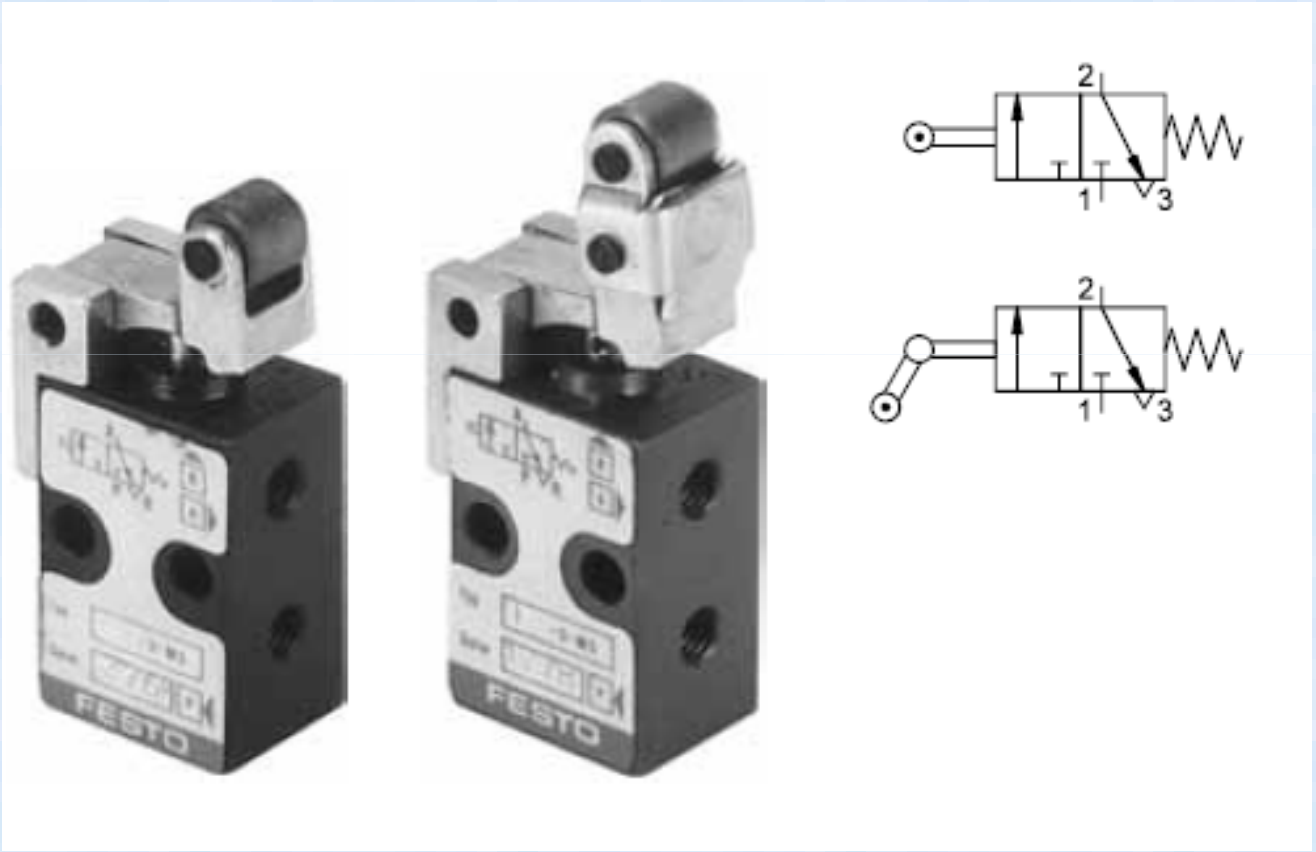
- Filter udara bertekanan: menghilangkan semua kotoran di udara bertekanan sekaligus air yg terkondensasi
- Regulator udara bertekanan: menjaga tekanan operasi sistem konstan walaupun terjadi fluktuasi tekanan di jalur distribusi dan konsumsi
- Pelumas udara bertekanan: meberikan kabut oli ke sistem pendistribusian udara jika diperlukan



Katup

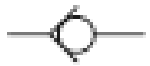
- Serupa dengan sistem hidrolik, katup berfungsi untuk mengatur tekanan atau laju aliran udara
  - Katup pengatur arah
  - Non-return valve
  - Katup pengatur tekanan
  - Shut-off valves

Katup pengatur arah

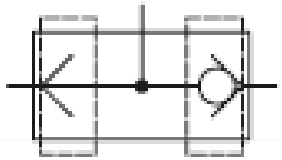


Non-return valve

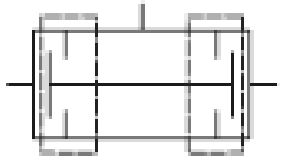
Check valve



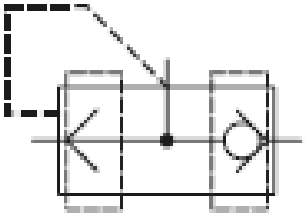
Shuttle valve



Dual-pressure valve



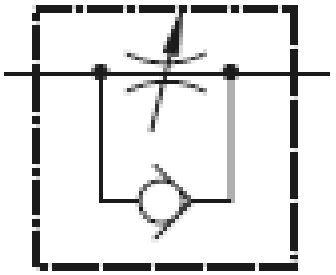
Quick exhaust valve



Katup pengatur aliran

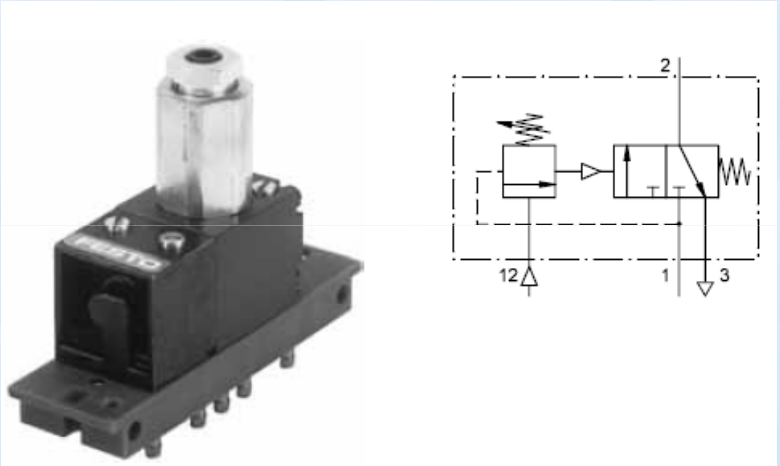
Flow control valve, adjustable

One-way flow control valve



Katup pengatur tekanan

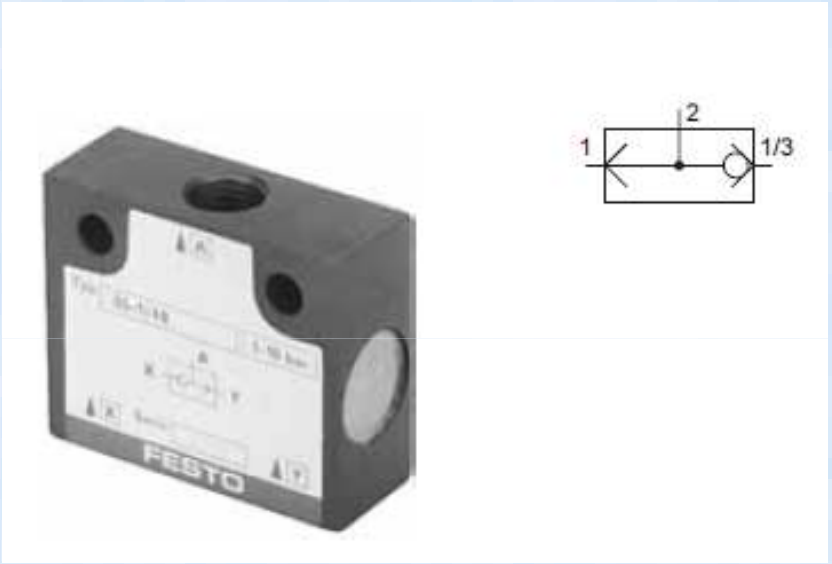
- Pressure limiting valves: membatasi tekanan di receiver dan menjaga suplai tekanan ke sistem pada tekanan yg tepat
- Pressure regulating valves: menjaga tekanan tetap konstan walaupun terjadi fluktuasi tekanan pada sistem
- Pressure sequence valves: digunakan jika sinyal yg tergantung tekanan diperlukan



Pressure sequence valve

Elemen pemroses

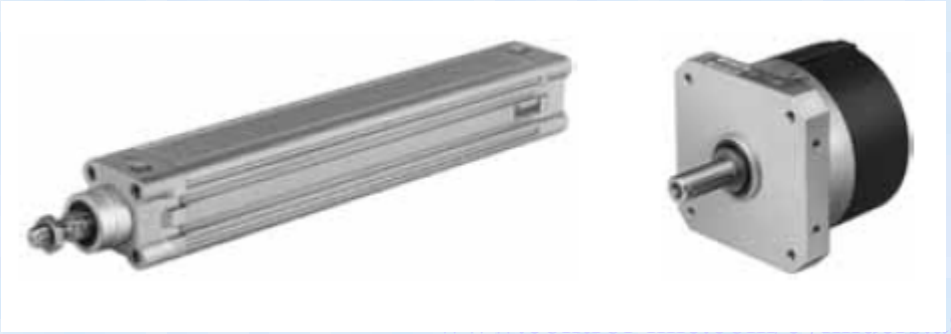
- Dual pressure valve (fungsi AND)
- Shuttle valve (fungsi OR)



Shuttle valve

Komponen Daya

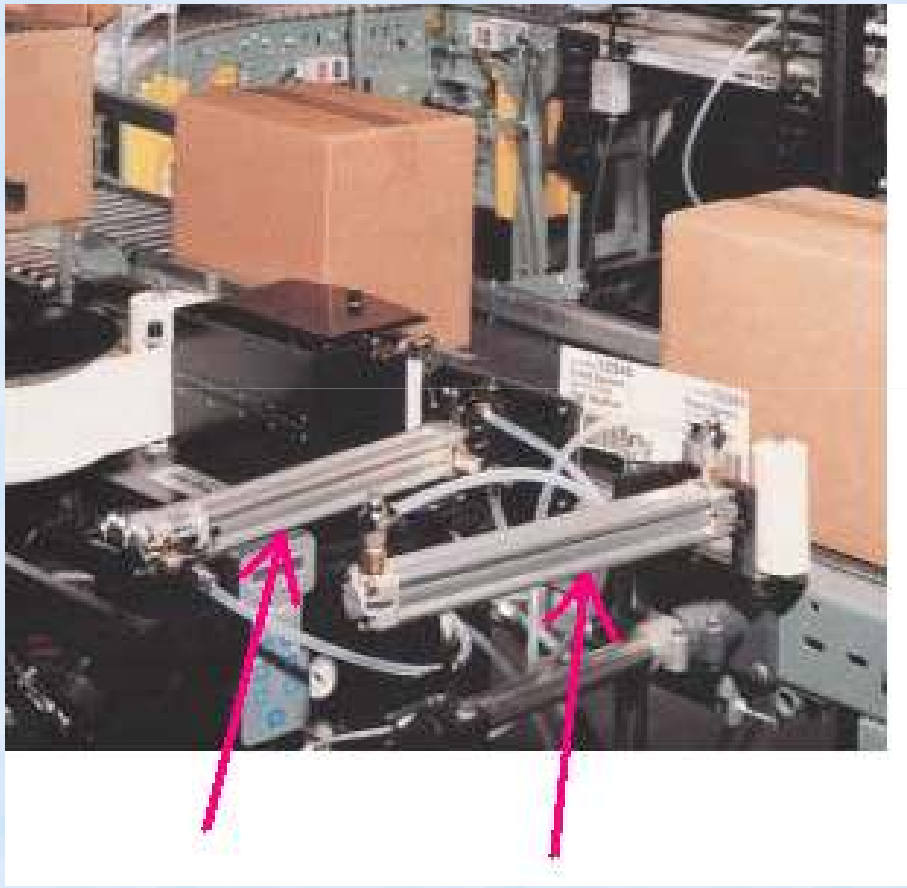
Aktuator dengan elemen pengatur



Aktuator linier dan rotary

Aplikasi Tie Rod Cylinder

Dua silinder ini memberi label pada kotak dengan lebih cepat



Aplikasi Rotary Actuator

- Rotary actuator digunakan dalam permesinan
- Power Tools

Pneumatic Gripper

- Mencakup gerak linier dan berputar
- Digunakan untuk : "mengambil dan menempatkan" benda
- Fully open dan fully closed

www.eu-nited-robotics.net/node/152

Aplikasi Pneumatic Gripper

Digunakan dalam aplikasi robotika

http://www.strobotics.com/r17.htm

Supply

– Compressor with fixed capacity

– Air reservoir with T junction

– Pressure source

Service equipment

– Filter — Separation and filtration of particles

– Water separator, — Manually operated

– Water separator, automatic

– Lubricator — Metered quantities of oil passed to the air stream

– Pressure regulator — Relieving type – vent hole for excess upstream pressure – adjustable

Combined symbols

– Air service unit — Filter, Regulator, Gauge, Lubricator

Simplified air service unit

Simplified air service unit without lubricator

Simbol-simbol Pneumatik

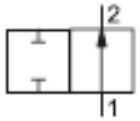
penyediaan dan pembangkitan udara

Simbol-simbol Pneumatik

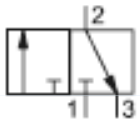
Katup pengatur arah

Number of ports
Number of positions

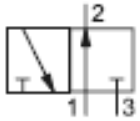
2/2 – Way directional control valve, normally open



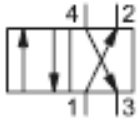
3/2 – Way directional control valve, normally closed



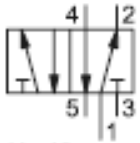
3/2 – Way directional control valve, normally open



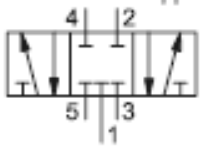
4/2 – Way directional control valve
Flow from 1 → 2 and from 4 → 3



5/2 – Way directional control valve
Flow from 1 → 2 and von 4 → 5

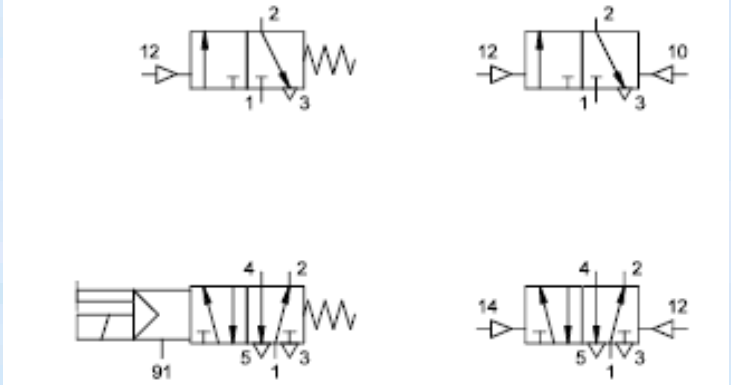


5/3 – Way directional control valve
Mid position closed



Sistem Penomoran Port Katup

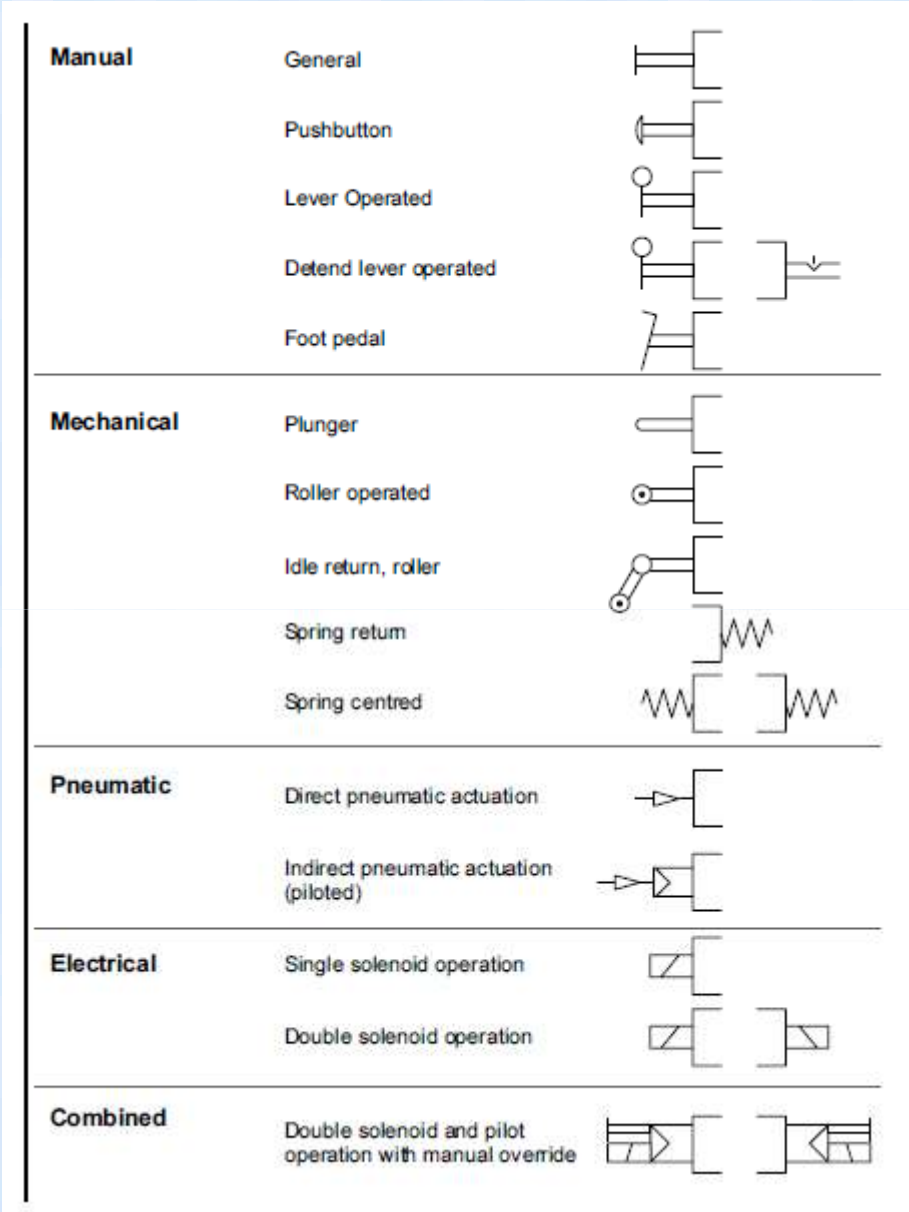
	ISO 5599-3	Lettering System	Port or Connection
Working lines	1	P	Pressure port
	2, 4	A, B	Working lines
	3, 5	R, S	Exhaust ports
Pilot lines	10	Z	Applied signal inhibits flow from port 1 to port 2
	12	Y, Z	Applied signal connects port 1 to port 2
	14	Z	Applied signal connects port 1 to port 4
	81, 91	Pz	Auxiliary pilot air



Contoh penomoran port

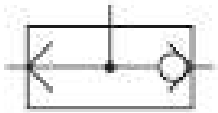
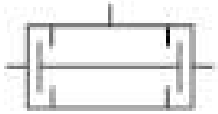
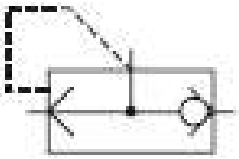
Simbol-simbol Pneumatik

Metode Aktuasi Katup



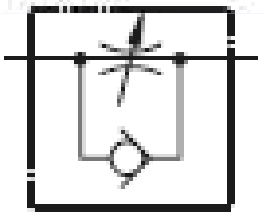
Simbol-simbol Pneumatik

Non-return Valve

Check valve	
Spring-loaded check valve	
Shuttle valve	
Dual-pressure valve	
Quick exhaust valve	

Simbol-simbol Pneumatik

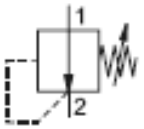
Katup pengatur aliran

Flow control valve, adjustable	
One-way flow control valve	

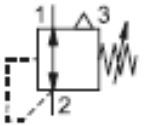
Simbol-simbol Pneumatik

Katup pengatur tekanan

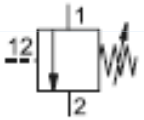
Adjustable pressure regulating valve, non - relieving type



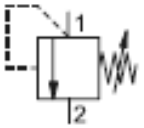
Adjustable pressure regulating valve,relieving type



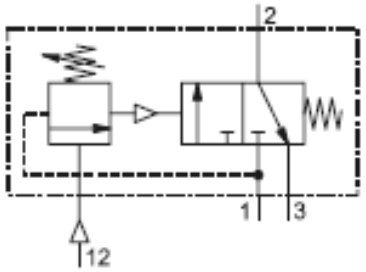
Sequence valve external source



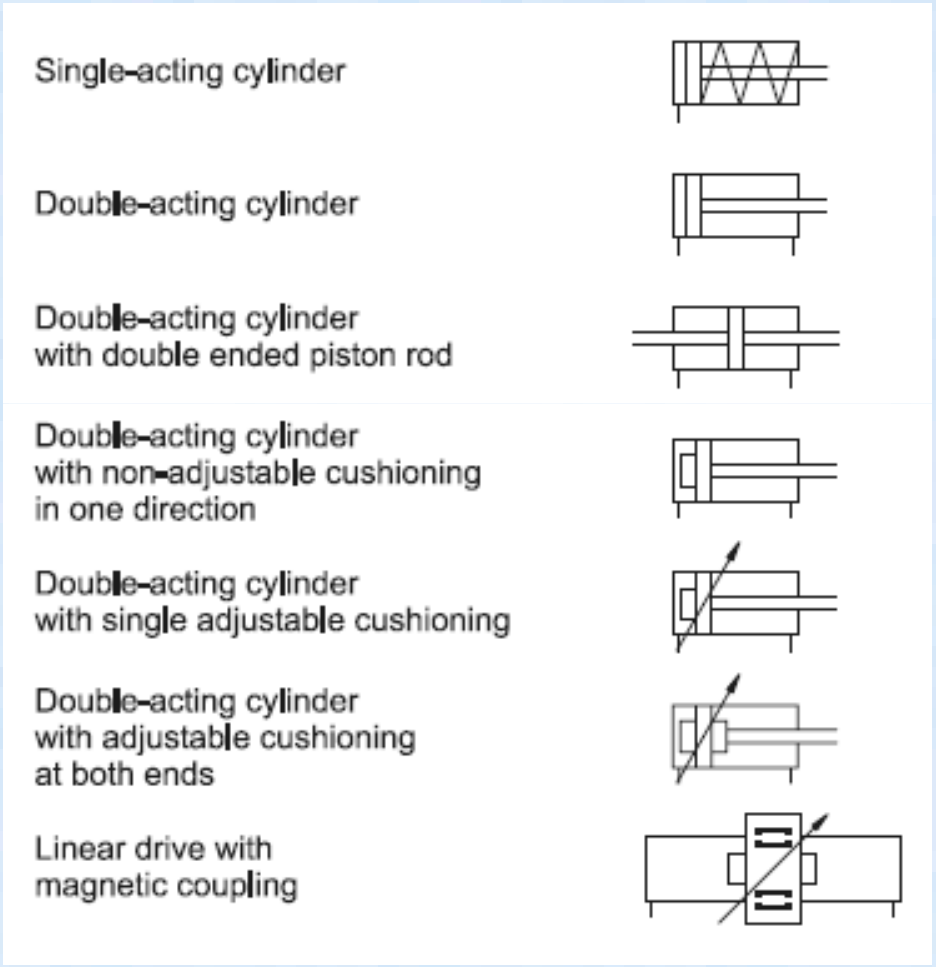
Sequence valve in - line



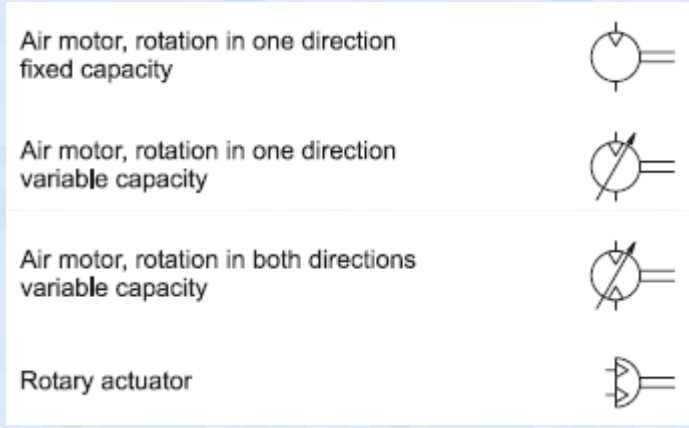
Sequence valve combination



Simbol-simbol Pneumatik



Aktuator linier



Aktuator rotary

Simbol-simbol Pneumatik

Peralatan tambahan

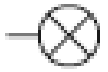
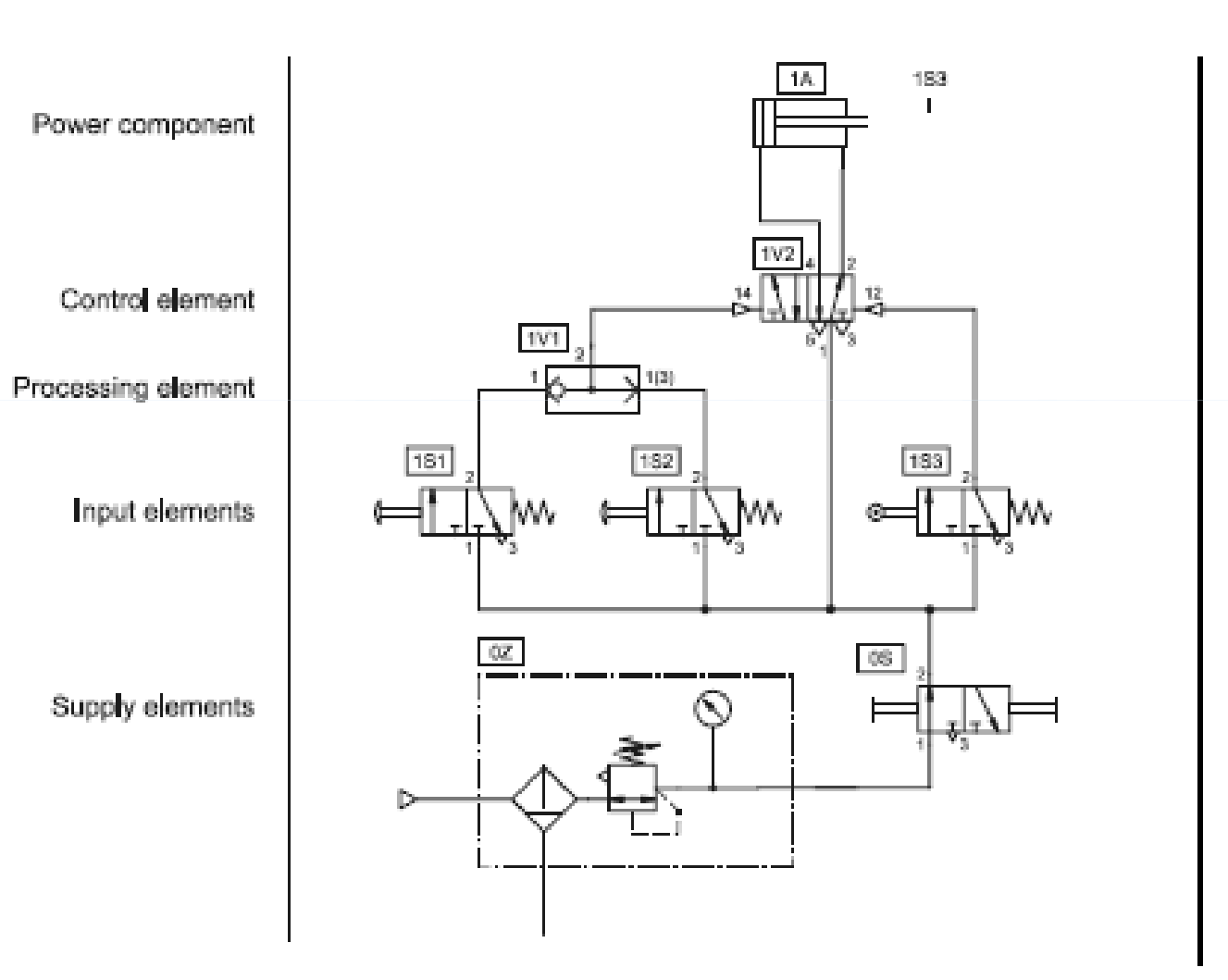
Exhaust port without fixture for connection	
Exhaust port with threaded connection	
Silencer	
Line connection	
Crossing lines	
Pressure gauge	
Visual indicator	

Diagram Rangkaian



Penamaan Komponen dalam Diagram Rangkaian

T 4.1
Designation by numbers

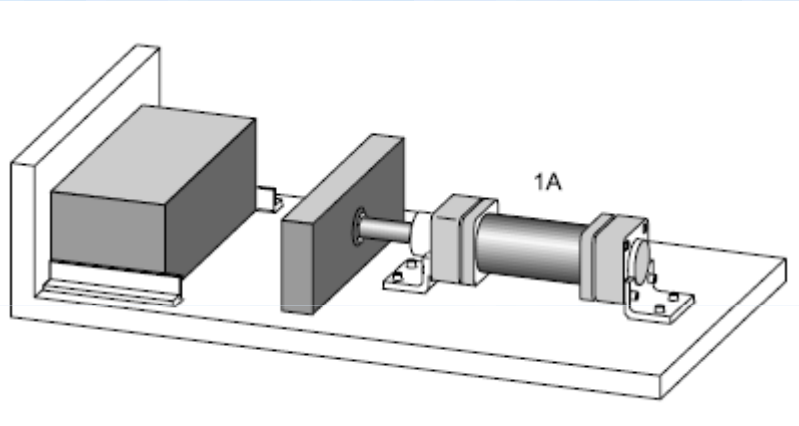
0Z1, 0Z2 etc.	Energy supply unit
1A, 2A, etc.	Power components
1V1, 1V2, etc.	Control elements
1S1, 1S2, etc.	Input elements (manually and mechanically actuated valves)

T 4.2
Designation by letters

1A, 2A, etc.	Power components
1S1, 2S1, etc.	Limit switches, activated in the retracted end position of cylinders 1A, 2A
1S2, 2S2, etc.	Limit switches, activated in the forward end position of cylinders 1A, 2A

Ilustrasi:

kontrol single acting cylinder



- Sebuah silinder single acting berdiameter 25 mm digunakan untuk menekan sebuah komponen jika sebuah *push button* ditekan. Selama *push button* diaktivasi, silinder tetap dalam posisi menekan. Jika *push button* dilepas, penekanan dilepas

Diagram Rangkaian

kontrol single acting cylinder

- Katup pengatur arah untuk silinder single adalah katup 3/2-way
- Karena silinder berkapasitas kecil, operasi dapat dikontrol langsung oleh katup pengatur arah 3/2-way dengan aktuasi push button dan pegas balik

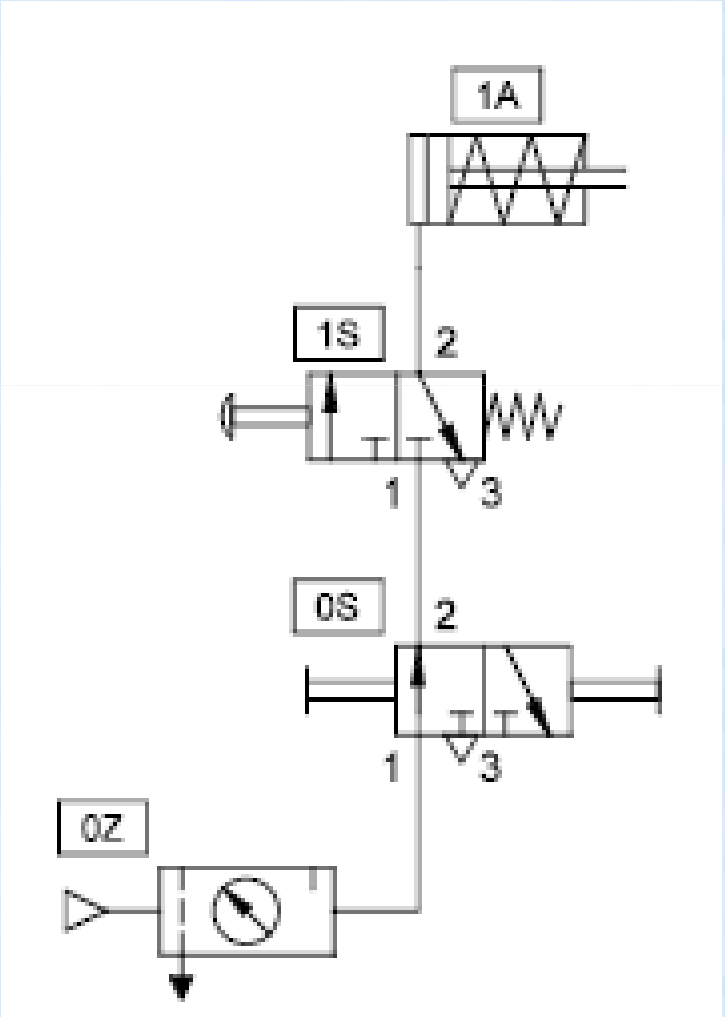
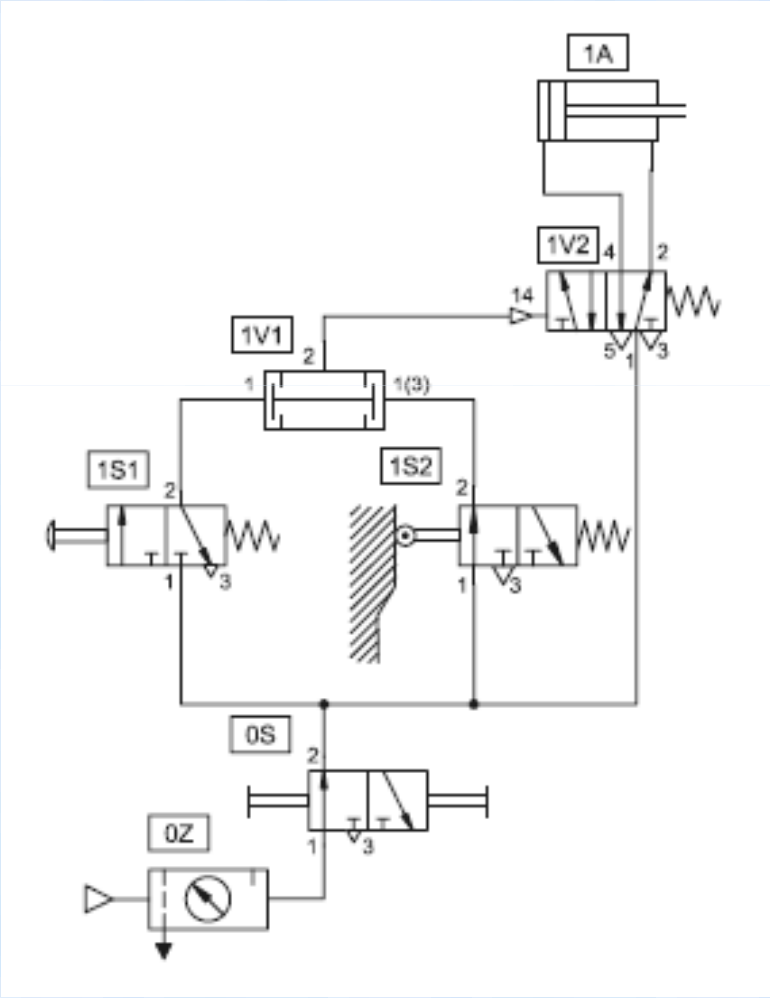


Diagram Rangkaian

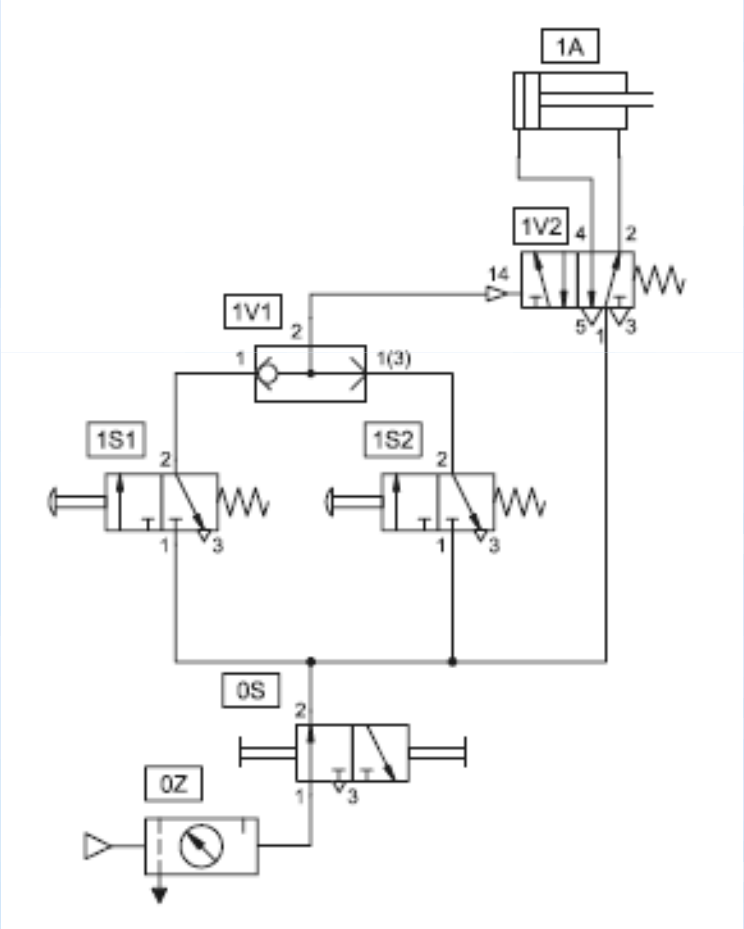
Logika AND



- Dual pressure valve (1V1) digunakan untuk fungsi logika AND
- Piston silinder double acting akan maju jika katup tuas roller 3/2-way dan katup push button 3/2-way diaktuasi
- Jika salah satu dari kedua katup dilepas, silinder akan kembali ke posisi semula

Diagram Rangkaian

Logika OR



- Shuttle valve digunakan sebagai fungsi logika OR
- Piston silinder double acting akan maju jika salah satu dari dua katup push button diaktifkan
- Jika push button dinon-aktifkan maka silinder kembali ke posisi semula

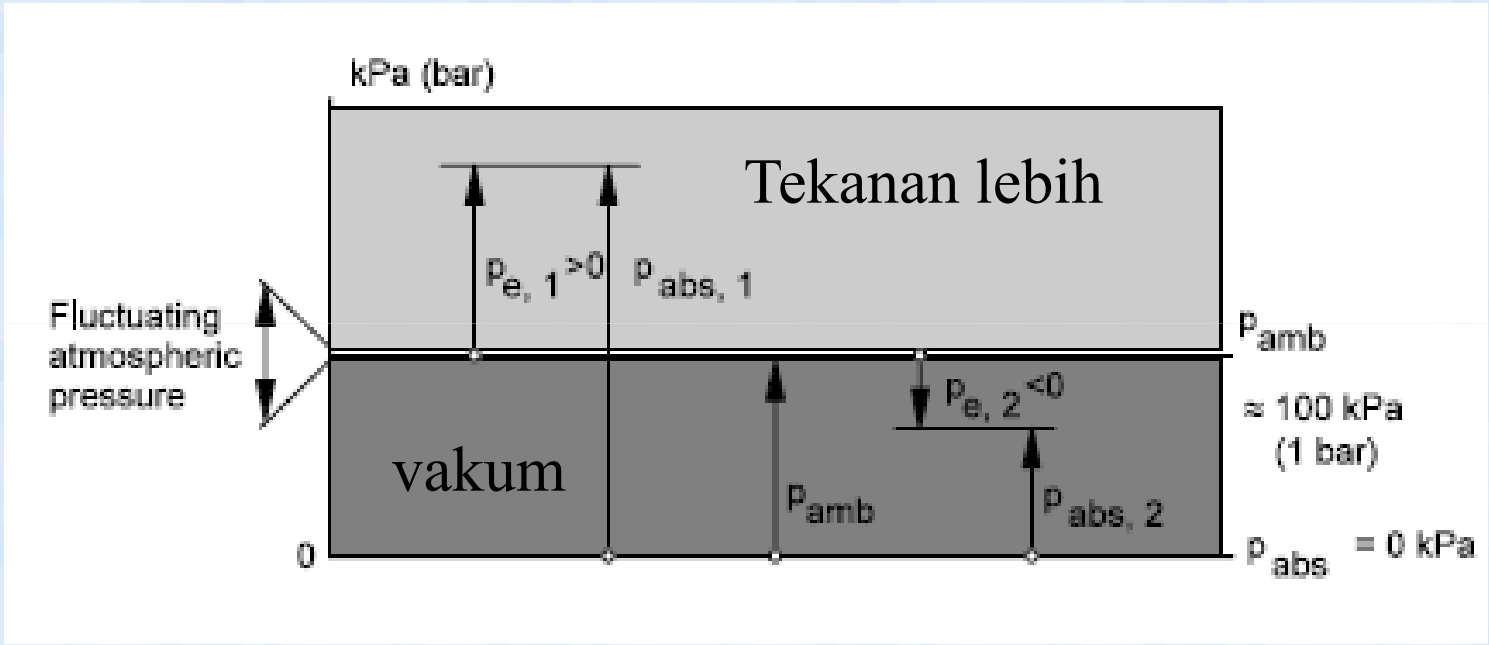
Dasar-dasar pneumatik

Basic units	**Quantity**	**Symbol**	**Units**
	Length	L	Meter (m)
	Mass	m	Kilogram (kg)
	Time	t	Second (s)
	Temperature	T	Kelvin (K, 0 °C = 273.15 K)
Derived units	**Quantity**	**Symbol**	**Units**
	Force	F	Newton (N) = 1 kg • m/s^2
	Area	A	Square metre (m^2)
	Volume	V	Cubic metre (m^3)
	Flowrate	q_v	(m^3/s)
	Pressure	p	Pascal (Pa) 1 Pa= 1 N/m^2 1 bar = 10^5 Pa

Hukum Newton : F=m.a

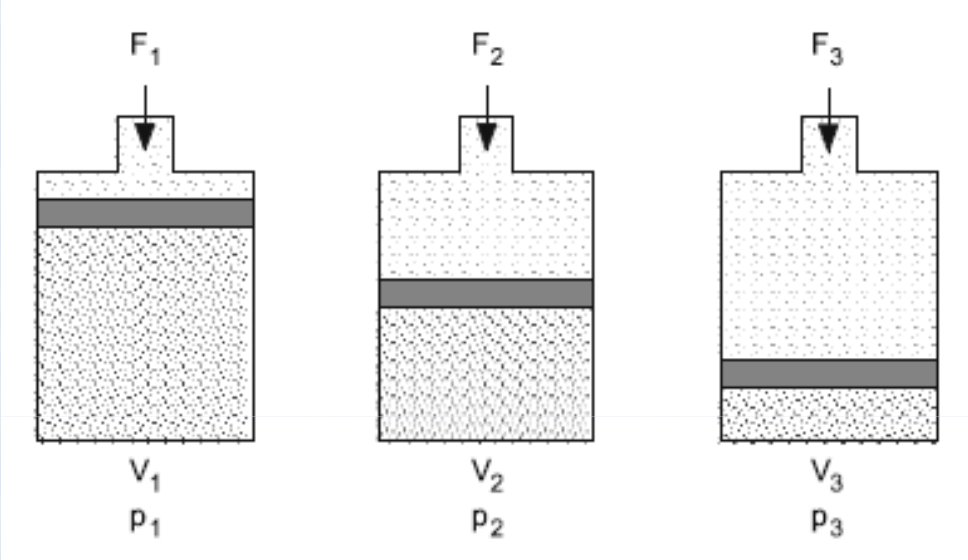
Tekanan: 1 Pascal setara dengan tekanan tetap pada luas permukaan $1m^2$ dengan tekanan vertikal 1N

Tekanan udara



- Standard temperature $T_n = 273.15$ K, $t_n = 0$ °C
- Standard pressure $p_n = 101325$ Pa = 1.01325 bar

Karakteristik Udara



Udara dapat ditekan

Hukum Boyle-Mariotte

$$p_1 \bullet V_1 = p_2 \bullet V_2 = p_3 \bullet V_3 = \text{Constant}$$

Pada temperatur tetap

Ilustrasi

Udara pada tekanan atmosfir ditekan oleh kompresor hingga 1/7 volumenya. Berapakah tekanan terukur udara tsb jika diasumsikan temperatur tetap selama proses tsb?

$$p_1 \bullet V_1 = p_2 \bullet V_2$$

$$p_2 = p_1 \bullet \frac{V_1}{V_2}$$ Note: $V_2 / V_1 = 1/7$

$p_1 = p_{amb} = 100$ kPa $= 1$ bar

$p_2 = 1 \bullet 7 = 700$ kPa $= 7$ bar absolute

$$p_e = p_{abs} - p_{amb} = (700 - 100)\ \text{kPa} = 600\ \text{kPa} = 6\ \text{bar}$$

Jadi kompresor yg menghasilkan tekanan 600kPa harus mempunyai tekanan kompresi 7:1

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Ekspansi Udara

Udara mengembang 1/273 volumenya pada tekanan tetap, temperatur 273K untuk kenaikan temperatur 1K
Hukum Gay-Lussac: volume suatu massa gas sebanding dengan temperatur absolut selama tekanan tidak berubah

$$\frac{V_1}{V_2} = \frac{T_1}{T_2}$$ V_1 = Volume at T_1, V_2 = Volume at T_2

$$\frac{V}{T} = \text{Constant}$$

$$\Delta V = V_2 - V_1 = V_1 \bullet \frac{T_2 - T_1}{T_1}$$

$$V_2 = V_1 + \Delta V = V_1 + \frac{V_1}{T_1}(T_2 - T_1)$$

Ilustrasi

Udara dengan volume 0,8m^3 pada temperatur T_1=293K dipanaskan hingga T_2=344K. Seberapa banyak udara tsb mengembang?

$$V_2 = 0.8m^3 + \frac{0.8m^3}{293K}(344K - 293K)$$
$$V_2 = 0.8m^3 + 0.14m^3 = 0.94.m^3$$

Maka udara mengembang sebesar 0,14m^3

Udara pada volume tetap

Jika volume dijaga tetap saat kenaikan temperatur maka

$$\frac{p_1}{p_2} = \frac{T_1}{T_2}$$

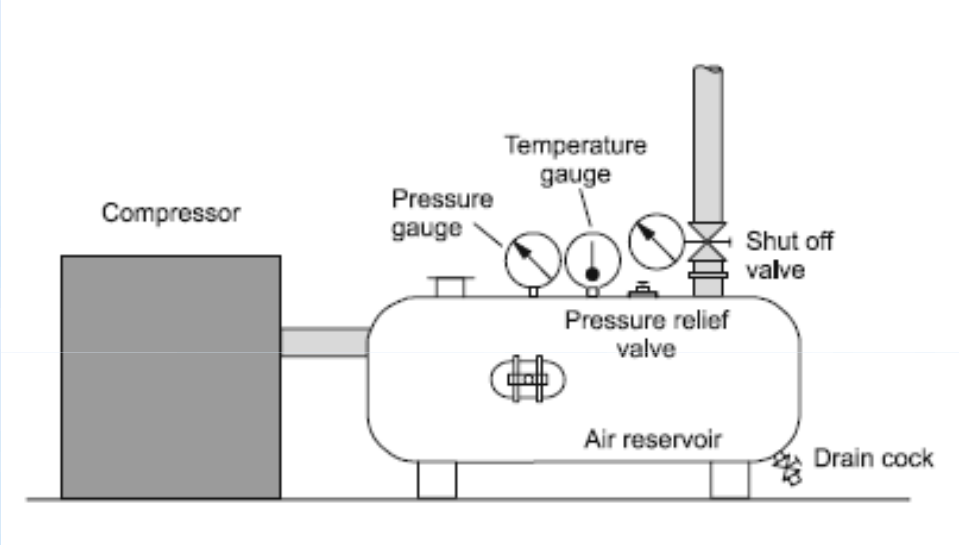
$$\frac{p}{T} = \text{Constant}$$

Hukum Gas Umum

$$\frac{p_1 \bullet V_1}{T_1} = \frac{p_2 \bullet V_2}{T_2} = \text{Constant}$$

Tekanan p tetap : isobar
Volume V tetap : isochore
Temperature T tetap : isothermal

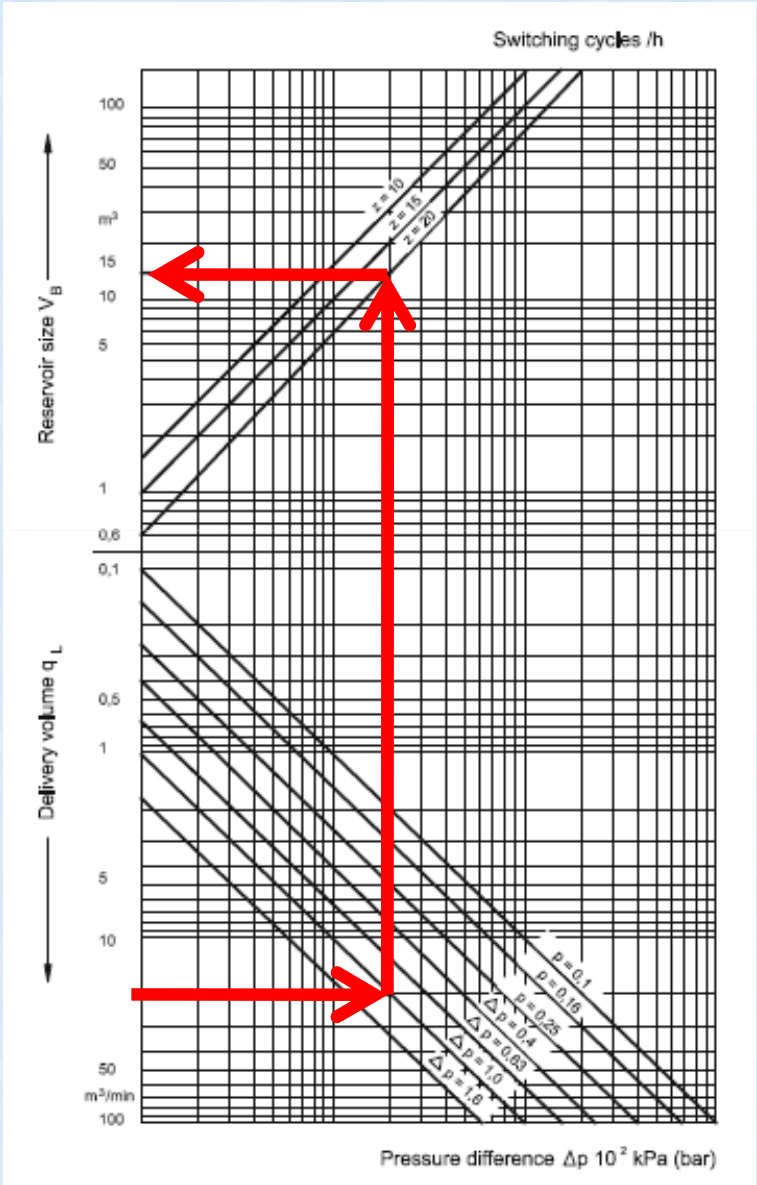
Penyediaan dan distribusi udara: reservoir/receiver



Ukuran reservoir udara bertekanan tergantung dari :

- Volume yg disuplai oleh kompresor
- Konsumsi udara untuk aplikasi pneumatik
- Ukuran jaringan pneumatik
- Jenis pengaturan siklus kompresor
- Penurunan tekanan yg diijinkan pada jaringan pneumatik

Volume reservoir



Contoh:
Volume suplai dari kompresor: 20m^3/min
Siklus kompesor per jam:20 /h
Penurunan tekanan : Δp=100kPa (1bar)
Dari grafik
Ukuran reservoir V_B=15m^3

Performansi Silinder Pneumatik

$F_{th} = A.p$

Di mana
F_{th}=gaya piston teoritis
A=Luas piston efektif
p= tekanan operasi

$$F_{eff} = (A \bullet p) - (F_R + F_F)$$

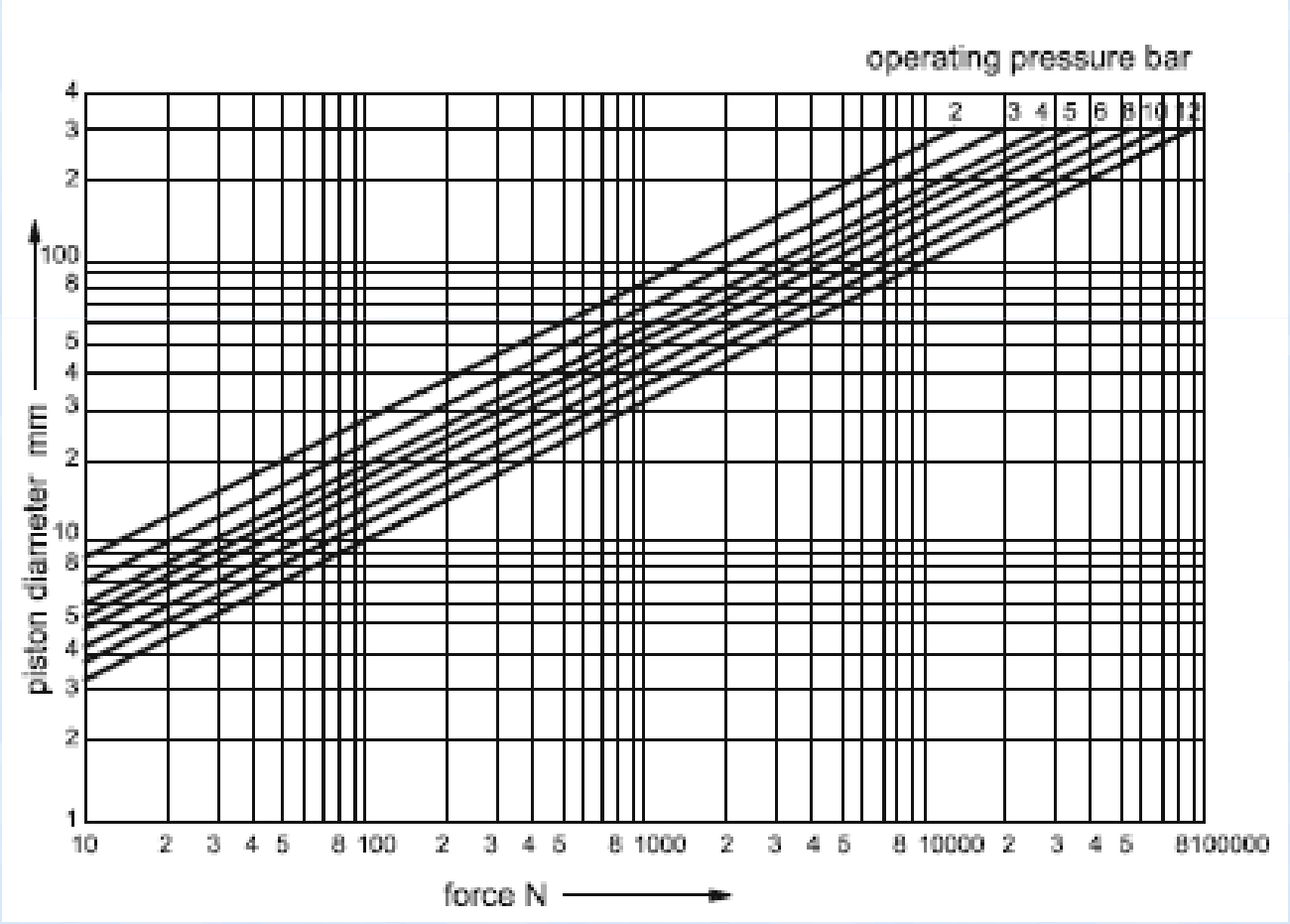
Silinder single acting

$$F_{eff} = (A \bullet p) - F_R \quad \text{Langkah maju}$$
$$F_{eff} = (A' \bullet p) - F_R \quad \text{Langkah balik}$$

Silinder double acting

F_{eff}	=	effective piston force (N)
A	=	useful piston surface (m^2)
	=	$(\frac{D^2 \bullet \pi}{4})$
A'	=	useful annular surface (m^2)
	=	$(D^2 - d^2)\frac{\pi}{4}$
p	=	Working pressure (Pa)
F_R	=	Frictional force (approx. 10 % of F_{th}) (N)
F_F	=	Return spring force (N)
D	=	Cylinder diameter (m)
d	=	Piston rod diameter (m).

Diagram tekanan vs gaya



Panjang langkah piston

Panjang langkah piston untuk silinder pneumatik dibatasi hingga 2 m untuk menghindari bengkok/buckling batang piston

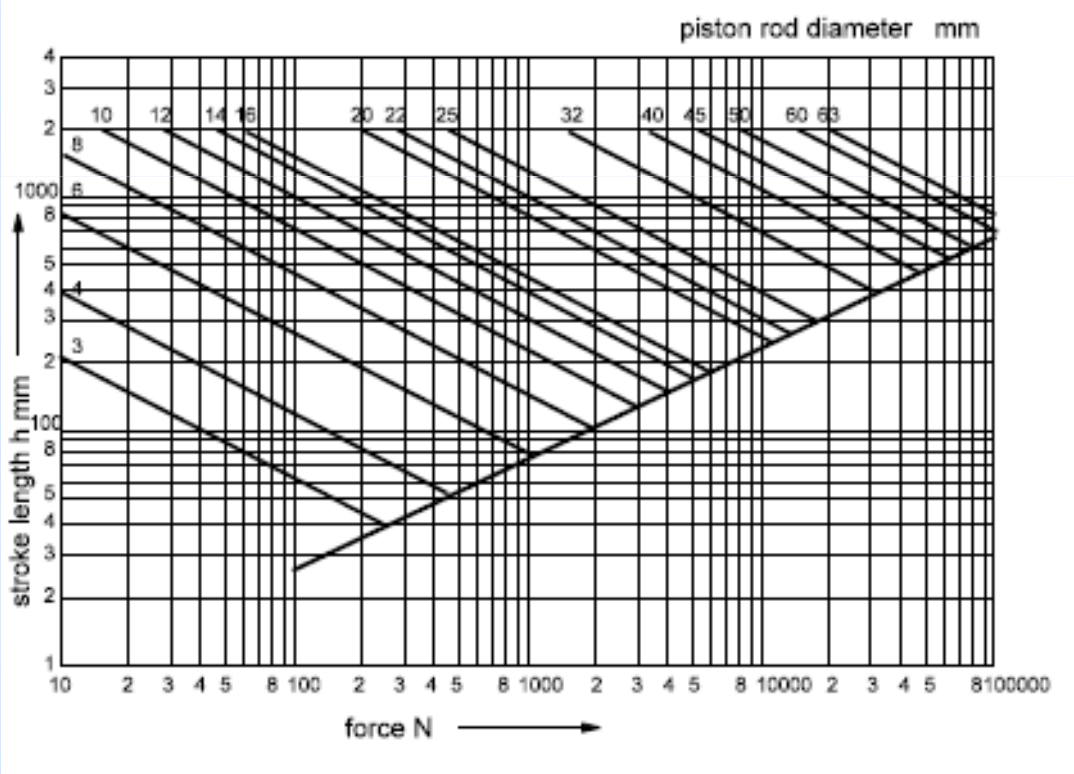


Diagram buckling

Konsumsi udara

Dalam penyiapan udara, konsumsi udara perlu diketahui

Konsumsi udara=rasio kompresi.luas piston.langkah.jumlah langkah per menit

Rasio kompresi=(101,3+tekanan operasi (dalam kPa))/101,3

Untuk silinder single acting, konsumsi udara

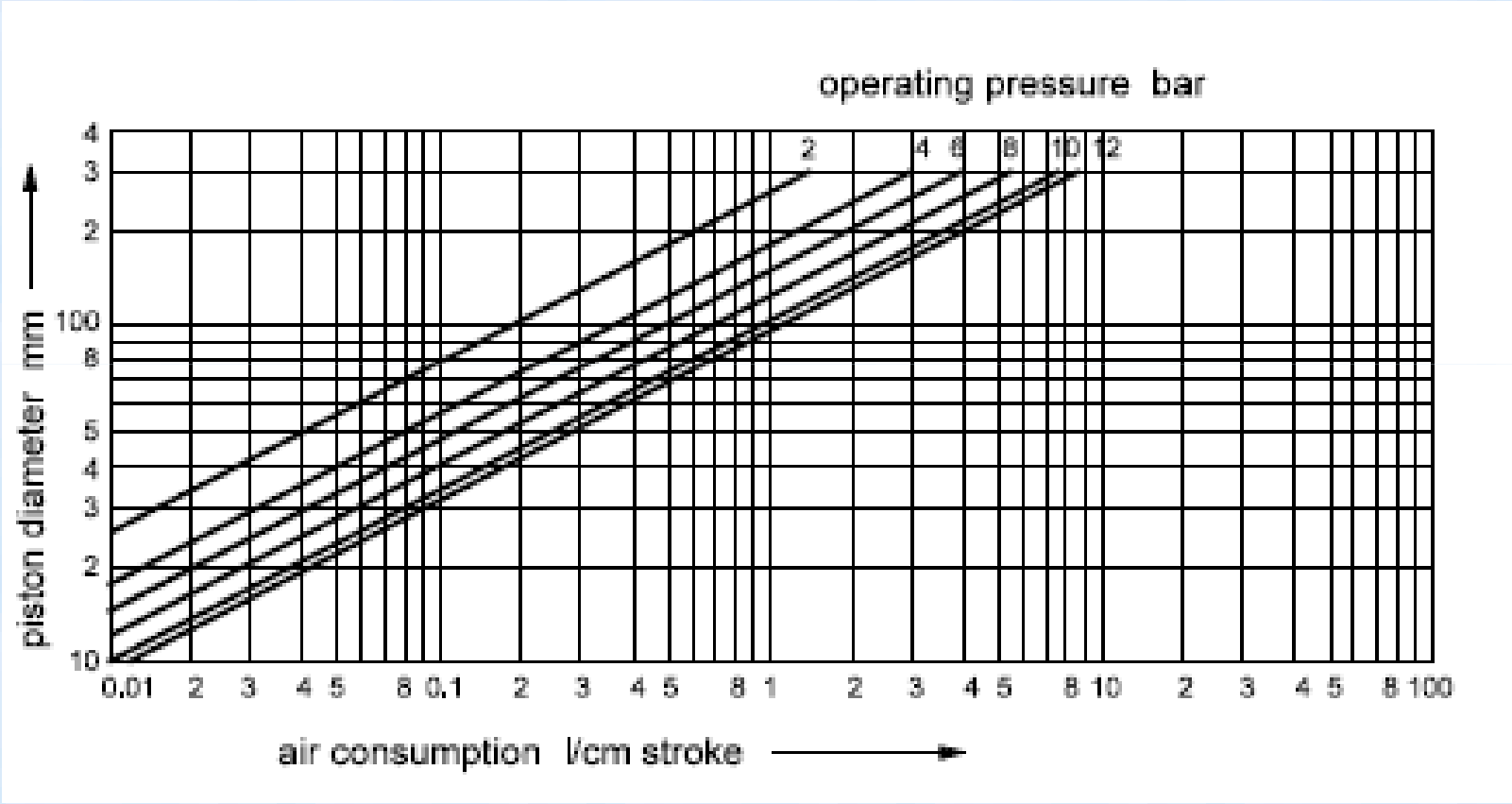
$$q_B = s \bullet n \bullet q_H$$

Untuk silinder double acting, konsumsi udara

$$q_B = 2 \bullet s \bullet n \bullet q_H$$

q_B	=	Air consumption (l/min)
s	=	Stroke (cm)
n	=	Number of strokes per minute (1/min)
q_H	=	Air consumption per cm of stroke (l/cm)

Grafik konsumsi udara



Perbandingan sistem