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General conditions for pneumatic circuits

- it is necessary to follow the appropriate safety rules, instructions, recommendations and specified parameters (temperature, pressure etc.), when setting products into operation
- areas, which are pressurized even after closing of the main air supply, should be specially marked in the pneumatic circuits
- it is necessary to take into account the failure of the product, or emergance of dangerous situations due to wrong operation, age or failure
- we recommend to mark with a special sign the whole pneumatic circuits, where the high caution during service is necessary
- we do not recommend to weld by electric arc on machinery, where pneumatic cylinders are mounted
- end users must take sufficient preventive steps to prevent injuries on material and health of employees

Conditions of use and operation of pneumatic cylinders

- disassembly of single-acting cylinders must be done very cautiously, because the inside spring is mounted with a preload
- working medium is modified compressed air
- we recommend to use our pneumatic oil for air lubrication, or some oil listed on the recommended oil list, to renew lifetime grease, use grease SAP-FML2A
- using other than recommended oils leads to the damage of O-rings and sealing built-in not only into cylinders, but also in other components used in the pneumatic circuit
- if the speed of piston rod extension is lower than 1 ms^{-1}, the compressed air needn't be lubricated; if the speed is higher, we recommend to lubricate air using a lubricator and pneumatic oil (see above); we also recommend to lubricate air, when the dew point of compressed air is lower than -20°C
- we offer special surface treatment, material change (stainless steel) or use of dust covers on our cylinders for environments with hard conditions and aggressive surroundings
- other special designs, material or sealing changes, etc. are possible after consultation with our technical dept.
- it is necessary to follow the correct mounting of cylinders and correct guiding of the piston rod to avoid radial forces (except for versions which are specifically designed to capture radial forces such as guide unit H)
- we recommend to use hydraulic shock absorbers, when heavy mass and high piston rod speed may occur - the machinery lifetime will be significantly extended

Stroke tolerance of pneumatic cylinders

Stroke of a cylinder may have positive tolerance accordingly to DIN ISO 6431, DIN ISO 6432 and VDMA 24562. The amount of tolerance is given by manufacturing tolerances and it depends on diameter and stroke as follows:

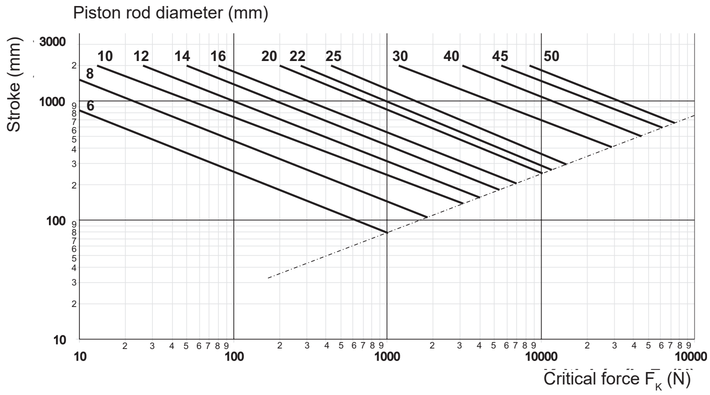
Standard	Piston diameter [mm]	Stroke [mm]	Allowable tolerance [mm]
DIN ISO 6432	8, 10, 12, 16, 20, 25	0 to 500	+1.5
DIN ISO 6431 VDMA 24562 NF E 49003.1	32, 40, 50	0 to 500	+2.0
		501 to 1250*	+3.2**
	63, 80, 100	0 to 500	+2.5
		501 to 1250*	+4.0**
	125, 160, 200, 250, 320	0 to 500	+4.0
		501 to 1250*	+5.0**

*) For strokes bigger than 1250 mm, the tolerance depends on an agreement between the producer and the customer
**) This value is not listed in standard VDMA 24562, or NF E 49003.1 and it is valid only for standard DIN ISO 6431

For large strokes, it is necessary to check, that the piston rod will not fail

Critical strength of piston rod (buckling length)

by buckling, even if the cylinder would withstand the load according to its diameter. Quick check can be done by reading the graph below:



For exact calculation of the critical force, use the following formula (F_K must be higher than load to prevent piston rod damage):

Where: F_K is critical force on piston rod [N]

$$F_K = \frac{\pi^2 \times E \times J}{l^2 \times k}$$

E is stress modulus $2.1 \cdot 10^5$ MPa
J is quadratic moment of cross section [mm^4]
l is critical length (=twice the stroke) [mm]
k is safety coefficient (in practice about 4)

Conditions of use and operation of pneumatic valves

- it is necessary to keep in mind, that the valve spool can be in an undefined position before first activation and that uncontrolled movements can occur
- when 5/3 valves or non-return valves are used, it is necessary to keep in mind that some parts of the circuit can always be pressurized - high caution during service is necessary
- it is necessary to follow listed technical data, especially pressure, air purity and solenoids voltage
- exhaust ports on valves should be equipped with silencers to prevent intrusion of junk into the valve
- valves can work on either lubricated or non-lubricated air (for more information, see chapter Modified compressed air)

Short form port designations:

Port	Designation to ISO 5599	Designation to DIN*	Designation to ANSI*
Supply port	1	P	P
Working line	2	A	B
Exhaust line	3	R	EB
Working line	4	B	A
Exhaust line	5	S	EA
Pilot line	12	Z	CA
Pilot line	14	Y	CB

*) Designation by letters shouldn't be used anymore.

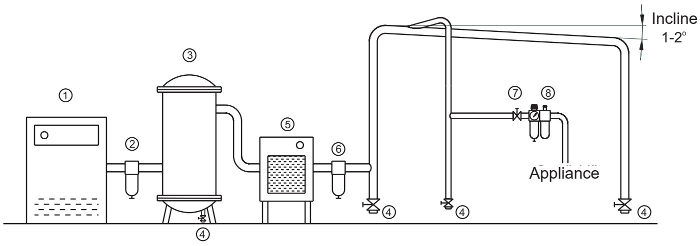
Protecting contacts when electromagnetic coils are used

Electromagnetic coil is a coil, which opposes any voltage change. It is thus possible, that a voltage spike or electrical ark will occur when voltage is switched on or off. This can then lead to damage to the isolation or to contacts burning. There are at least four ways to eliminate this danger:

- for serial connection of RC circuit, it is necessary to calculate values of resistance and capacity for each application separately
- for DC voltage, a diode can be used, it is necessary to calculate the value of the diode for each application
- Zener diode can be used for both AC and DC voltage, it is necessary to calculate the size of the diode for each application
- varistor can be used for AC and DC voltage and it is commonly built into a connector of a valve (see connectors for valves)

Distribution of compressed air

The operational reliability and service life of a pneumatic system depend, to a large extent, on the preparation of compressed air. Impurities in the compressed air such as scale, rust and dust as well as the liquid constituents in the air, which deposit as condensate can cause a great deal of damage in pneumatic systems. These contaminants accelerate wear on sliding surfaces and sealing elements, adversely affecting the functionality and service life of the pneumatic components. Pressure fluctuations occur as a result of switching the compressor on and off, these have an unfavourable effect on the functioning of the system. In order to eliminate these effects, compressed air service units must be installed in every pneumatic system.



Example of air distribution:
Compressed air goes from a compressor through a coarse filter to an a pressure vessel. Then the air is led into an air dryer and another filter, which should catch junk, collected in the pressure vessel and air dryer. The air dryer is used only in substantiated cases. Then distribution in plastic or metal tubes follows, the tubes should be inclined by 1-2° to allow drainage of possible condensed water. Individual branches to appliances should come out of the main distribution diagonally upwards. If there are intense pressure shocks during compressed air consumption, it is useful to use another smaller pressure vessel between the main distribution and appliance. This vessel should balance the pressure shocks. Finally, the standard FRL unit or only some of its modules is connected.

Legend:
1) compressor
2) coarse filter
3) pressure vessel
4) condensate drain
5) air dryer
6) filter
7) shut off valve
8) standard FRL unit

Modified compressed air

Modified compressed air = filtered air without solid particles and liquids, optionally lubricated.
All our produced pneumatic items are greased with special grease, so it isn't necessary to lubricate air under standard conditions. However, we recommend to regularly check the lifetime grease level and if you observe a decline, renew the grease filling. Careful, these items cannot be exposed to air polluted by water or oil, because the lifetime grease level would be flushed out. If that happens, the air has to be lubricated, or the lifetime grease filling must be renewed. Special grease for lifetime filling is available, please see chapter Air preparation or contact our sales dept. If the pneumatic circuit is stressed and heavy duty, we recommend to lubricate air to increase the lifetime of the pneumatic items.

The operational reliability and service life of pneumatic systems depend among others on the quality of incoming compressed air.
Junk and moisture contained in the air increase surface wear of parts and sealing, which decreases economy and lifetime of the pneumatic items. Air preparation thus consists of liquid removal (mainly water and oil), suitably dimensioned filtration of solid junk and appropriate air lubrication.

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Air must be so clean after the modification as to not cause any damage to the pneumatic system and sequentially damage to machinery. Using a filter reduces the maximum flow capacity since it builds up resistance that obscures air flow. Filter should have a filter element, that produces air of sufficient quality but keeps in mind economy of the system. If high quality of compressed air is required, the air should be filtered in several steps. If we only use a fine filter that ensures the requested air quality, we have to expect a serious decrease in its lifetime.
The compressed air quality is expressed by quality classes, that are described in ISO 8573-1 standard as well as the acceptable values of junk.

Quality classes according to ISO 8573-1

Class	Solid junk			Max. pressure dew point [˚C]	Max. oil concentration [mg/m³]
	Particle size 0,1 to 0,5 [µm]	Particle size 0,5 to 1,0 [µm]	Particle size 1,0 to 5,0 [µm]		
1	≤ 20 000	≤ 400	≤ 10	-70	0.01
2	≤ 400 000	≤ 6 000	≤ 100	-40	0.1
3	unstipulated	≤ 90 000	≤ 1 000	-20	1
4	unstipulated	unstipulated	≤ 10 000	+3	5
5	unstipulated	unstipulated	≤ 100 000	+7	> 5

Recommended way of using the quality classes

Area	Solid junk		Water		Oil	
	Max. class	Max. particle size [µm]	Max. class	Max. dew point [˚C]	Max. class	Max. concentration [mg/m³]
Pneumatic cylinders	5	40	4	+3	4	5
Pneumatic valves	3 to 5	5 to 40	4	+3	4	5
Fine regulators	3	5	4	+3	3	1
Measuring equipment	2	1	4	+3	3	1
Other industry	5	40	3 to 7	-20 to +10 and more	3 to 5	1 to 25

Mounting, operation and service of air preparation units

It is necessary to pay attention to the direction of flow, which is marked by arrows or labeled IN/OUT, when mounting the units. The following sequence of units should be adhered to: shut off valve, particulate filter, coalescing filter, regulator, lubricator. Bowls of the individual units must always point vertically downwards. Lubricator should be as close to the appliance as possible (max. 5 to 10 m).

Condensated water level in the bowl mustn‘t exceed level of bottom of filter element or mark on a bowl. For drain, there is connection for tube on the bottom of bowl. Automatic drain doesn‘t practically need service, but if semi-automatic drain is used, it is necessary to regularly check level of condensed water in bowl and expel it always if level of water achieve filter element or mar on the bowl. Semi-automatic drain automatically expels water if the primary pressure drop under 0.05 MPa. If it is necessary to expel water immediately, there are 2 systems: one has got button - pressing the button the water is removed. The second system is without button - for removing the water simply push the tube connection towards to the bowl. If the filter element is polluted, it must be changed. Before disassembling shut off air supply and depressurize the filter, remove bowl (release safety lock on side of bowl or push the bowl towards to the unit, turn it off 45° and pull it out). Then unscrew the baffle and remove filter element. Procedure at assembling is the same, but in reverse order.

If lubricator is used, it is necessary to keep sufficient level of oil. Oil refilling is possible directly into bowl when air supply is shut off, or by button head fill nut during operation. Before disassembling shut off air supply and depressurize the lubricator, remove bowl (release safety lock on side of bowl or push the bowl towards to the unit, turn it off 45° and pull it out). Fill in bowl (see level mark on the bowl) and mount bowl back. Procedure at assembling is the same, but in reverse order. It is necessary to use only recommended oils.

Some bowls are made from polycarbonate and could be cleaned only with household soap and water. Do not use any solvent (alcohol), bowls may crackle.

Recommended oils for compressed air lubricating

Primarily we recommend to use our pneumatic oil with order code 2995 0101 0000 0000, which composition was specially designed for this purpose. It is oil, which is foamless, nonaggressive to gaskets and has suitable mechanical characteristics (viscosity etc.).

In case of need, the following oils could be used too:

Supplier	Designation
Stránský a Petržík	**Pneumatic oil, order code 2995 0101 0000 0000**
Shell	Tellus Ol 10
Mobil Oil	Velocite Oil No. 6
BP	Energol HLP10
Esso	Spinesso 10, Nutto H5, H10
Aral	Vitamol GF10, DE 10, Sumorol CM5, CM10

Supplier	Designation
Fuchs	Renolin MR1, MR3
Optimol	Ultra 10
Agip	OSO10
Elf	Spinelf 5, 10
Total	Azolla 10
Fina	Cirkan 10

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Compressed air consumption

Calculation of air consumption for pneumatic cylinder:

$$Q = Z \times (qp + qz) \times n \times 0{,}1$$

where
Q is air consumption [l/min]
Z is stroke [mm]
qp is air consumption for 10 mm of stroke when thrust [l]
qz is air consumption for 10 mm of stroke when retract [l]
n is number of complete strokes (thrust+retract) in a minute

Table of air consumption sp / sz [l] for 10 mm of stroke:

Piston diameter	Piston area	Working pressure [MPa]										
mm	mm²		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
8	50	qp	0.0010	0.0015	0.0020	0.0025	0.0030	0.0035	0.0040	0.0045	0.0050	0.0055
	38	qz	0.0007	0.0011	0.0015	0.0019	0.0023	0.0026	0.0030	0.0034	0.0038	0.0041
10	79	qp	0.0015	0.0024	0.0031	0.0039	0.0047	0.0055	0.0063	0.0071	0.0079	0.0086
	66	qz	0.0013	0.0020	0.0026	0.0033	0.0040	0.0046	0.0053	0.0059	0.0066	0.0073
12	113	qp	0.0023	0.0034	0.0045	0.0056	0.0067	0.0078	0.0089	0.01	0.0111	0.0123
	90	qz	0.0018	0.0027	0.0036	0.0045	0.0054	0.0063	0.0072	0.0081	0.009	0.0099
16	200	qp	0.004	0.006	0.008	0.01	0.012	0.014	0.016	0.018	0.02	0.022
	170	qz	0.0034	0.0051	0.0068	0.0085	0.012	0.0119	0.0136	0.0153	0.017	0.0187
20	314	qp	0.0063	0.0094	0.0126	0.0157	0.0188	0.022	0.0251	0.0283	0.0314	0.0345
	260	qz	0.0052	0.0078	0.0104	0.013	0.0156	0.0182	0.0208	0.0234	0.026	0.0288
25	491	qp	0.0098	0.0147	0.0196	0.0245	0.0295	0.0344	0.0393	0.0442	0.0491	0.054
	410	qz	0.0082	0.0123	0.0164	0.0205	0.0246	0.0287	0.0328	0.0369	0.041	0.0451
32	804	qp	0.016	0.024	0.032	0.04	0.048	0.056	0.064	0.072	0.08	0.088
	691	qz	0.014	0.021	0.028	0.035	0.042	0.049	0.056	0.063	0.07	0.076
40	1256	qp	0.025	0.038	0.05	0.063	0.076	0.088	0.1	0.113	0.126	0.138
	1002	qz	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1	0.11
50	1963	qp	0.039	0.059	0.079	0.089	0.118	0.137	0.157	0.177	0.196	0.216
	1708	qz	0.034	0.051	0.068	0.085	0.102	0.12	0.137	0.154	0.17	0.188
63	3116	qp	0.062	0.093	0.125	0.156	0.187	0.218	0.249	0.28	0.312	0.343
	2726	qz	0.055	0.072	0.109	0.136	0.164	0.191	0.218	0.245	0.273	0.3
80	5024	qp	0.1	0.15	0.2	0.25	0.301	0.351	0.402	0.452	0.502	0.552
	4644	qz	0.093	0.139	0.186	0.232	0.279	0.325	0.372	0.418	0.464	0.51
100	7850	qp	0.157	0.236	0.314	0.382	0.471	0.549	0.628	0.706	0.785	0.862
	7144	qz	0.143	0.214	0.286	0.357	0.429	0.5	0.571	0.643	0.714	0.786
125	12266	qp	0.245	0.368	0.49	0.613	0.736	0.859	0.981	1.104	1.226	1.349
	11559	qz	0.231	0.347	0.462	0.578	0.694	0.809	0.925	1.04	1.156	1.272
160	20096	qp	0.402	0.603	0.804	1.005	1.206	1.407	1.608	1.809	2.01	2.211
	18840	qz	0.377	0.565	0.754	0.942	1.13	1.319	1.507	1.696	1.884	2.072
200	31400	qp	0.628	0.942	1.256	1.57	1.884	2.198	2.512	2.826	3.14	3.454
	30144	qz	0.603	0.904	1.206	1.507	1.808	2.11	2.412	2.713	3.014	3.316
250	49063	qp	0.981	1.473	1.964	2.455	2.946	3.437	3.928	4.419	4.91	5.401
	47100	qz	0.942	1.413	1.884	2.355	2.826	3.297	3.768	4.239	4.71	5.181
320	80425	qp	1.609	2.413	3.217	4.021	4.826	5.630	6.434	7.238	8.042	8.847
	77308	qz	1.546	2.319	3.092	3.865	4.639	4.412	6.185	6.958	7.731	8.504

Corresponding compressed air flow rates [l/min] as a function of pressure:

Pressure [MPa]	Port size					
	G1/8“	G1/4“	G3/8“	G1/2“	G3/4“	G1“
	Hose size at the length app. 2 to 2.5 m					
	Js 5	Js 6	Js 8	Js 11	Js 14	Js 18
0.2	126	227	357	797	1416	2213
0.4	212	377	593	1328	2361	3689
0.6	297	529	826	1860	3306	5163
0.8	382	680	1062	2391	4250	6640
1.0	468	830	1299	2923	5194	8115

Values of flow rate are applied at standard conditions at 20˚C and absolute pressure 0.1 MPa.

Action force

Calculation of force on piston rod of pneumatic cylinder:

$$F = (Sp \text{ (or } Sz) \times p) - T$$

where
F is force on piston rod of pneumatic cylinder [N]
Sp is piston area at thrust [mm^2]
Sz is piston area at retract [mm^2]
p is working pressure [MPa]
T is friction force (about 10% in practice)

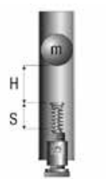
Table of retract force on piston rod of pneumatic cylinder [N]

Piston diameter [mm]	Working pressure [MPa]											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
8	4.5	9.0	13.6	18.1	22.6	27.1	31.7	36.2	40.7	45.2	49.8	54.3
10	7.1	14.1	21.2	28.3	35.3	42.4	49.5	56.5	63.6	70.7	77.8	84.8
12	10.2	20.4	30.5	40.7	50.9	61.1	71.2	81.4	91.6	102	112	122
16	18.1	36.2	54.3	72.4	90.5	109	127	145	163	181	199	217
20	28.3	56.5	84.8	113	141	170	198	226	254	283	311	339
25	44.2	88.4	133	177	221	265	309	353	398	442	486	530
32	72.4	145	217	290	362	434	507	579	651	724	796	869
40	113	226	339	452	565	679	792	905	1018	1131	1244	1357
50	177	353	530	707	884	1060	1237	1414	1590	1767	1944	2121
63	281	561	842	1122	1403	1683	1964	2244	2525	2805	3086	3367
80	452	905	1357	1810	2262	2714	3167	3619	4071	4524	4976	5429
100	707	1414	2121	2827	3534	4241	4948	5655	6362	7068	7775	8482
125	1104	2209	3313	4418	5522	6627	7731	8835	9940	11044	12149	13253
160	1810	3619	5429	7238	9048	10857	12667	14476	16286	18095	19905	21714
200	2827	5655	8482	11309	14137	16964	19791	22619	25446	28274	31101	33928
250	4418	8835	13253	17671	22089	26506	30924	35342	39760	44177	48595	53013
320	7238	14476	21714	28952	36190	43428	50666	57904	65142	72380	79618	86856

Hydraulic shock absorber selection

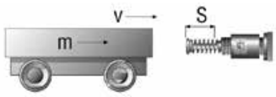
Five basic criteria are required for sizing the shock absorbers:
a) impacting mass m (kg)
b) impact speed v (m/s)
c) additional external forces acting on the mass e.g. propelling force F (N)
d) number of strokes of the shock absorber per hour X (1/h)
e) number of parallel shock absorbers

Free falling mass



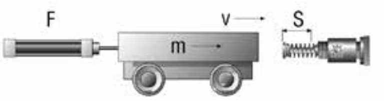
1. $W_k = m \cdot g \cdot H$
2. $W_A = m \cdot g \cdot S$
3. $W_{kg} = W_k + W_A$
4. $W_{kg/h} = W_{kg} \cdot X$
5. $m_e = \frac{2 \cdot W_{kg}}{v_e^2}$
6. $v = v_e = \sqrt{2 \cdot g \cdot H}$

Mass without propelling force



1. $W_{kg} = \frac{m \cdot v^2}{2}$
2. $W_{kg/h} = W_{kg} \cdot X$
3. $v = v_e$
4. $m_e = \frac{2 \cdot W_{kg}}{v_e^2}$

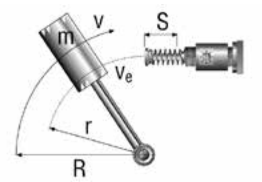
Mass with propelling force, horizontal



1. $v_e = \frac{v}{K1}$
2. $W_k = \frac{m \cdot v_e^2}{2}$
3. $W_A = F \cdot S$
4. $W_{kg} = W_k + W_A$
5. $W_{kg/h} = W_{kg} \cdot X$
6. $m_e = \frac{2 \cdot W_{kg}}{v_e^2}$

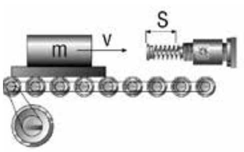
Movement downward: $W_A = (F + m \cdot g) \cdot S$
Movement upward: $W_A = (F - m \cdot g) \cdot S$

Swinging mass without propelling force



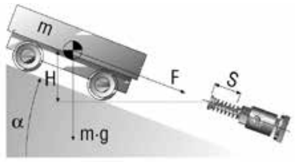
1. $W_k = \frac{m \cdot v^2}{2} = \frac{J \cdot \omega^2}{2}$
2. $W_A = \frac{M \cdot S}{r}$
3. $W_{kg} = W_k + W_A$
4. $W_{kg/h} = W_{kg} \cdot X$
5. $v_e = r \cdot \omega = \frac{v \cdot r}{R}$
6. $m_e = \frac{2 \cdot W_{kg}}{v_e^2}$

Mass on driven rollers



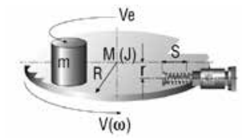
1. $W_k = \frac{m \cdot v^2}{2}$
2. $W_A = m \cdot g \cdot S \cdot \mu$
3. $W_{kg} = W_k + W_A$
4. $W_{kg/h} = W_{kg} \cdot X$
5. $v = v_e$
6. $m_e = \frac{2 \cdot W_{kg}}{v_e^2}$

Mass on incline



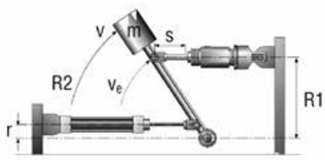
1. $W_k = m \cdot g \cdot H$
2. $W_A = m \cdot g \cdot \sin\alpha \cdot S$
3. $W_{kg} = W_k + W_A$
4. $W_{kg/h} = W_{kg} \cdot X$
5. $v = v_e = \sqrt{2 \cdot g \cdot H}$
6. $m_e = \frac{2 \cdot W_{kg}}{v_e^2}$

Rotary table with propelling force



1. $W_k = \frac{m \cdot v^2}{2} = \frac{J \cdot \omega^2}{2}$
2. $W_A = \frac{M \cdot S}{r}$
3. $W_{kg} = W_k + W_A$
4. $W_{kg/h} = W_{kg} \cdot X$
5. $v_e = r \cdot \omega = \frac{v \cdot r}{R}$
6. $m_e = \frac{2 \cdot W_{kg}}{v_e^2}$

Swinging mass with propelling force



1. $W_k = \frac{m \cdot v^2}{2}$
2. $W_A = \frac{M \cdot S}{R1} = \frac{F \cdot r \cdot S}{R1}$
3. $W_{kg} = W_k + W_A$
4. $W_{kg/h} = W_{kg} \cdot X$
5. $v_e = R1 \cdot \omega = \frac{v \cdot R1}{R2}$
6. $m_e = \frac{2 \cdot W_{kg}}{v_e^2}$

Formulae

Effective mass

$$m_e = \frac{2 \cdot W_{kg}}{v_e^2}$$

Counter force

$$F_G = \frac{W_{kg} \cdot 1.2^*}{S}$$

Deceleration time

$$t = \frac{2 \cdot S}{v_e} \cdot 1.2^*$$

Deceleration time

$$a = \frac{v^2}{2 \cdot S} \cdot 1.2^*$$

Stroke

$$S = \frac{v^2}{2 \cdot a} \cdot 1.2^*$$

*) Calculation for optimum setting. Allow a safety margin!

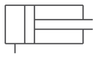
Used values and variables

W_k	[Nm]	kinetic energy
W_A	[Nm]	propelling force energy
W_{kg}	[Nm]	total energy
$W_{kg/h}$	[Nm·h⁻¹]	total energy per hour
m	[kg]	mass
m_e	[kg]	effective mass
v	[m·s⁻¹]	impact speed
v_e	[m·s⁻¹]	effective speed
X	[h⁻¹]	number of strokes per hour
S	[m]	stroke
F	[N]	propelling force
F_p	[N]	pneumatic drive force
K_1	[1]	correction factor for pneumatic drive force (K_1=0.65)
M	[Nm]	torque
R, r	[m]	radius
H	[m]	height
g	[m·s⁻²]	acceleration due to gravity
J	[kg·m²]	moment of inertia
ω	[s⁻¹]	angular velocity
μ	[1]	coefficient of friction (steel=0.2)
a	[°]	angle
a	[m·s⁻²]	acceleration / deceleration
t	[s]	deceleration time
F_G	[N]	counter force

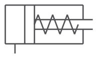
Summary of the pneumatic symbols based on DIN ISO 1219

Energy conversion

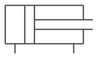
Single acting cylinder, return movement by external force



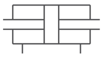
Single acting cylinder, return movement by spring



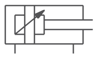
Double acting cylinder



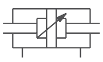
Double acting cylinder with double-ended piston rod



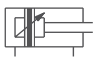
Double acting cylinder with adjustable cushioning at end of stroke



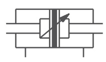
Double acting cylinder with double-ended piston rod and adjustable cushioning at end of stroke



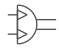
Double acting cylinder with adjustable cushioning at end of stroke and magnetic piston



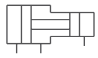
Double acting cylinder with double-ended piston rod and adjustable cushioning at end of stroke and magnetic piston



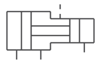
Pneumatic motor with limited range of swivel



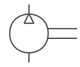
Pressure intensifier for the same fluid



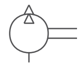
Pressure intensifier for air and liquid



Compressor

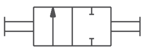


Vacuum pump

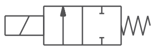


Directional control valves

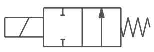
2/2-way valve, manually actuated



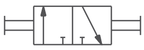
2/2-way valve, normally closed, solenoid actuated



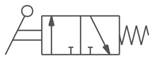
2/2-way valve, normally opened solenoid actuated



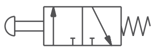
3/2-way valve, manually actuated



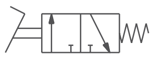
3/2-way valve, actuated by lever



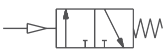
3/2-way valve, actuated by pushbutton



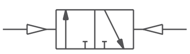
3/2-way valve, actuated by pedal



3/2-way valve, pneumatically actuated, monostable



3/2-way valve, pneumatically actuated, bistable

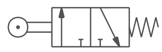


5/2-way valve, pneumatically actuated, bistable

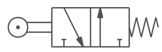
5/2-way valve, indirect solenoid actuated, monostable

5/2-way valve, indirect solenoid actuated, bistable

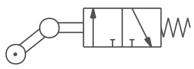
3/2-way valve, normally closed, actuated by roller lever



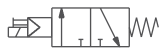
3/2-way valve, normally opened, actuated by roller lever



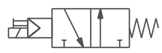
3/2-way valve, normally closed, actuated by roller lever with idle return



3/2-way valve, normally closed, indirect solenoid actuated



3/2-way valve, normally opened, indirect solenoid actuated



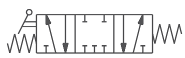
5/2-way valve, actuated by lever

5/2-way valve, actuated by pushbutton

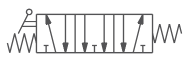
5/2-way valve, actuated by pedal

5/2-way valve, pneumatically actuated, monostable

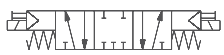
5/3-way valve, actuated by lever, centre position closed



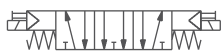
5/3-way valve, actuated by lever, centre position exhausted



5/3-way valve, indirect solenoid actuated, centre position closed



5/3-way valve, indirect solenoid actuated, centre position opened



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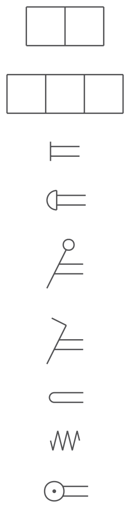
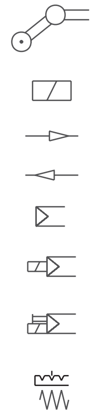
Directional control valves generally and control mechanisms

- 2 positions
- 3 positions
- Manual control - general
- Pushbutton
- Lever
- Pedal
- Plunger
- Spring
- Roller lever

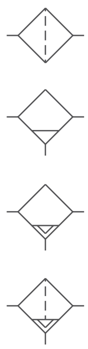


- Roller lever with idle return
- Direct solenoid
- Direct application of pressure
- Direct application by pressure relief
- Indirect by application of pressure (pilot)
- Solenoid and pilot valve
- Solenoid and pilot valve with manual override
- Detent for 3 positions

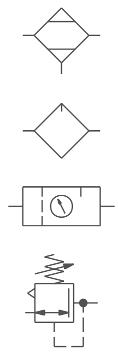


Air preparation

- Filter
- Water separator
- Water separator with automatic drain
- Filter with water separator with automatic drain

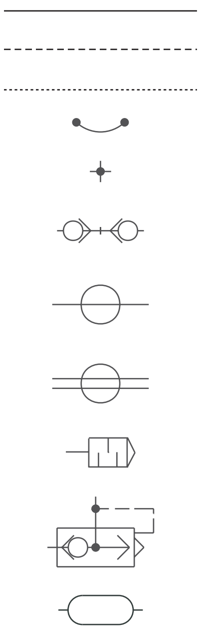


- Dryer
- Lubricator
- Standard unit (filter pressure regulator with gauge, lubricator), simplified representation
- Pressure regulator



Energy transmission, valves

- Working line
- Control line
- Exhaust line
- Flexible pipeline
- Line connection
- Quick coupling with mechanically opened non-return valves, coupled
- Rotary connection with 1 path
- Rotary connection with 2 paths
- Silencer
- Quick exhaust valve
- Pneumatic capacitor



- Gauge
- Pressure source
- One-way flow control valve, adjustable
- Bidirectional flow control valve, adjustable
- Pressure switch
- Check valve with spring
- Piloted check valve
- OR disjunction (logical sum)
- AND conjunction (logical product)